SLU

Terminal chipping of beech pulpwood

A study on chip terminals and chip transportation from the German state of Thüringen

(Internal report)

Terminalflisning av bokmassaved

En studie av terminalflisning och flistransport från delstaten Thüringen i Tyskland

(Intern rapport)

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Examensarbete nr 34
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Alnarp maj 2002

Preface

This thesis is the result of our work at the Department of Southern Swedish Forest Research Centre in Alnarp, belonging to the Swedish University of Agricultural Sciences. We got this task from Stora Enso Forest Central Europe in Düsseldorf in Germany and it corresponds to 20 weeks of full-time studies at the university.

We want to aim a special thanks to our supervisors Weine Genfors and Ralf Löbbermann at Stora Enso for making it possible to undertake this thesis. They have helped us investigate the costs that are included in our systems. They have also helped us to make assumptions of costs that are hard to track. A special thanks to our supervisor here at SLU, Bo Dahlin for helping us with the structure of the thesis and other advise.

We also want to thank all the other people that we have met and discussed our work with, including Lars-Ola Fritzon at Nymölla who has helped us with a lot of information about the pulpmill. Furthermore Allan Bruks at Bruks Biotec gave us a greater insight about chipping and screening equipment. The calculations on the stationary chipping system would never have been possible without his skilled help.

Thomas Agrell and Stellan Österberg at Sydved helped us to trace the different parts and costs of the logistic system from Germany to Sweden. The wood purchaser Uwe Kundt at HVG has shown us the railway terminal and the beech forests in Thüringen. Also many thanks to Dieter Fehring at Fehring Holzspäne for giving us information regarding railway wagons and the other issues that are related to railway transportation. We also want to thank all the people that were involved in one way or an other in the work with our thesis and helped us with valuable information. This includes the staff at the Southern Swedish Research Centre here in Alnarp. Many thanks for your time and efforts. You have given us good advice and opinions during the work with this thesis.

Alnarp, September 2001

Johan Norman & Andreas Oscarsson

Abstract

This is a comparative study of two logistic systems. One of the systems is the logistic system that exists today and the other system is an alternative new logistic system. The present logistic system includes the transportation of beech pulpwood from Thüringen Wald in Germany to Nymölla pulpmill in Sweden. This study has investigated the possibilities of making chips from beech pulpwood in Germany instead of making chips at the pulpmill in Sweden. Building a chipping terminal by the railway in Thüringen may prove to be an advantageous logistic solution. The main purpose of our research has been to reduce transport costs and to solve logistic problems for Stora Enso Forest Central Europe (SEFCE).

Information on different parts of the systems has been collected through discussions. After discussions and meetings a calculation model was constructed. Sensitivity analyses were made to try to assess the systems working potential in different situations.

The most interesting questions about the new system are: 1) Is the system viable in reality? 2) Is it profitable? 3) Which factors are the most important for the end result? A few factors affect the system more than others. The most significant factor affecting the result is the price that Nymölla is willing to pay for the chips. Other important factors that are affecting the cost per cubic metre are: 1) The Deutsche Bahn fare. 2) The density of the wood and the loading volume of the railway wagons. 3) The wood consumption rate and the utilisation of machines.

After having studied the results from the calculations and analyses the conclusion is that the new system is better compared to the present system, provided that the machines are optimally used. The debarker is the machine that has to be optimally used. However, calculations from the model show that the new logistic system is not profitable using the reference figures. If any of the factors above are affected in a positive direction the new system might be more profitable compared to the old.

There are also many others advantages in the new system that can save a lot of money. For example, one of the factors that is hard to predict is the consumption of wood in the pulpmaking process. If the wood is a little bit fresher the consumption per tonne would be reduced and a lot of money could be saved.

Sammanfattning

Det här är en jämförande studie av två logistiksystem. Ett av systemen är det system som existerar idag och det andra är ett, nytt alternativt logistik system. Det nuvarande systemet behandlar transporten av bokmassaved från den tyska delstaten Thüringen till Nymölla bruk i Sverige. Den här studien har undersökt möjligheterna att göra flis av massaveden redan i Tyskland istället för att göra det Sverige. Att bygga en flisningsterminal i Tyskland kan vara ett tänkbart alternativ. Det främsta målet med detta arbete är att reducera transportkostnaderna och lösa logistiska problem åt Stora Enso Forest Central Europe (SEFCE).

Fakta och information om de olika delarna i systemen har samlats ihop med hjälp av samtal och diskussioner. Efter insamling av data konstruerades en ekonomisk beräkningsmodell. Känslighetsanalyser gjordes också för att ta reda på hur systemen reagerar i olika situationer.

De mest intressanta frågorna att ta reda på i det nya systemet är: 1) Är det genomförbart i verkligheten? 2) Är det lönsamt? 3) Vilka faktorer är viktigast för slutresultatet? En del faktorer påverkar systemet mer än andra. Den faktor som påverkar resultatet mest är priset som Nymölla är villiga att betala för den sållade flisen. Andra mycket viktiga faktorer som påverkar kostnaden per kubikmeter är: 1) Deutsche Bahns taxa. 2) Vedens densitet och lastvolymen hos järnvägsvagnarna. 3) Maximalt utnyttjande av maskinerna och vedåtgång i massatillverkningsprocessen.

Resultaten från beräkningarna och känslighetsanalyserna visar att det nya systemet med flistransporter är billigare än det nuvarande förutsatt att de ingående maskinerna används optimalt. Barkningsmaskinen är den viktigaste maskinen att optimera. Det nya systemet är däremot är inte lönsamt om referenssiffrorna används. Om någon av ovan uppräknade faktorerna påverkas i en positiv riktning kommer det nya system att vara bättre än det nuvarande. Trots detta faktum kan utnyttjandegraden av maskinerna vara avgörande för resultatet. Om inte maskinerna utnyttjas maximalt kommer det vara svårt att uppnå lönsamhet.

I det nya systemet finns många andra fördelar förutom de rent ekonomiska där marginalen är relativt liten. Pengar kan sparas in på andra ställen som till exempel vedåtgången i Nymölla. Om vedkonsumtionen minskar med ett par procent så kommer mycket pengar sparas in. Detta är en av de faktorer i detta nya system som kan ge SEFCE framtida fördelar.

Contents

1 Introduction

1.1 Pulpwood and the Transportation of Forest Products

Transportation of wood and forest products is today mostly carried out by trucks, trains or by ferries. This makes the transportation of wood and forest products bulky and expensive. A total of 65 % of the annual harvested volume in Sweden is pulpwood and therefore pulpwood constitutes a large part of the total volume of forest products that are transported (Kassberg *et al.,* 1998). The pulpmills are located along the coast and the forest in the inland and this often makes the transport distance long.

Pulpwood, seen in a historical context, has only been transported as solid roundwood. There have been some wood chip transports in Canada but these have can be seen as trials or have been conducted when bioenergy wood has been included. The systems are new and are still being developed.

1.2 Stora Enso

Stora Enso is an integrated forest products company producing magazine paper, newsprint, packaging board and fine paper. Stora Enso is a global market leader in these areas (www.storaenso.com, 2001).

Today Stora Enso's total sales are 13 billion EUR and the annual paper and board production capacity is approximately 15 million tonnes. In round numbers 45,000 persons are employed in more than 40 countries all over the world.

As an integrated company, Stora Enso is able to satisfy a significant part of its own raw material needs internally, ensuring continuity of production. The company owns approximately 2.6 million hectares of forest land in Finland and Sweden and some 0.3 million hectares in the United States as well as significant forest areas in Canada and Portugal. Power plants at Stora Enso's mills provide approximately 40% of the company's power requirements.

Stora Enso's environmental and social responsibility policy is committed to developing business towards ecological, social and economic sustainability. This is recognised as a shared responsibility, enabling the continuous improvement in operations.

1.2.1 Stora Enso Forest Central Europe (SEFCE)

A few years ago Stora Enso had five different organisations supplying wood to the central European mills (Genfors, pers. comm. 2001). Three organisations were operating on the German market. This was not desirable from Stora Enso's point of view and that is why this new organisation in Düsseldorf was created. Another reason was the growing market in Germany, which Stora Enso wanted to be part of. To do that a good organisation is needed.

Yet another reason is the increasing harvesting possibilities of German forests. Stora Enso believes that everyone will gain from a higher harvesting rate. With the new organisation SEFCE, forestry will be more effective. By optimising and organising the operations more effectively, a lot of money can be saved in the group.

Different strategic goals for SEFCE:

- SEFCE will continue to work with the key suppliers and partners with whom SEFCE already collaborate closely. Furthermore they will take steps to develop co-operation, although this does not necessarily mean that SEFCE will keep the same structure of suppliers and partners that they have today.

- SEFCE will start buying standing timber that they will harvest themselves. This task will be carried out together with key harvesting partner companies. However, the main supply, will as today be purchased at the roadside or the pulpmill.

- SEFCE aims to develop co-operation with other wood-based operations (such as local sawmills, board producers, etc.) with which SEFCE can find synergies.

- SEFCE will take over the purchasing responsibility for approximately 600,000 m^3 of saw logs from the German market that are needed for SEFCE Timber and will be prepared to develop and increase this volume further.

- SEFCE will try to develop a more cost-efficient logistical structure extending from the forest to the mills.

- SEFCE will further develop the supply structure for beech wood to Sweden with the aim of making it as cost-efficient as possible.

- SEFCE will build up the know-how and strength to be able to handle a larger wood supply volume if necessary.

1.3 Nymölla Pulpmill

Nymölla pulpmill is included in the Stora Enso group, which is one of the world leading forest-industry groups (Miljöredovisningen, 1999). Nymölla is a modern integrated factory that produces pulp and paper. They have around 1000 employees and the turnover in 1999 was approximately 2,5 billion SEK (10 SEK~1 USD). A total of 80% of the products are exported, mainly to Europe but also to other parts of the world.

All fine paper products are produced according to the Swedish environmental brand, "Svanen". Nymölla is located in north eastern part of the Southern Swedish province of Scania. It has a good location from a logistic point of view because it is close to the sea. Europe is close by train, boat or truck. Nymölla pulpmill is certified according to European Union Eco Management and Audit Scheme (EMAS), and according to the international standard ISO 14001. According to Nymölla's environmental principles (Miljöredovisningen, 1999) the company:

- Strives to have the lowest possible energy consumption and also uses as much renewal fuel as possible in relation to diminishing fossil fuel usage.

- Tries to create conditions for good transport solutions that contributes to minimising the total environmental charge of the products.

- While purchasing raw materials and other products, considers environmental implications. The environmental work of the suppliers and the contractors are also investigated.

Nymölla pulpmill used a total volume of 1 234 000 m^3sub in 1999. Imports from the Baltic region constituted 20 % of the volume. The imports are mostly beech and the annual volume is 395 000 m^3sub. But the pulpmill also uses hardwood and chips from sawmills (fig. 1).

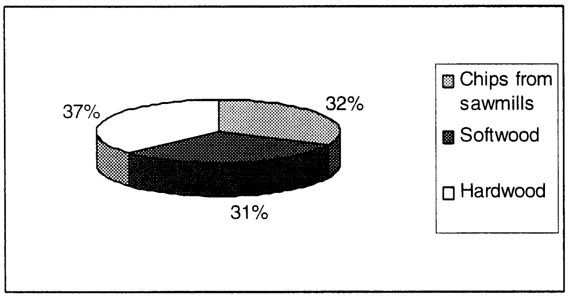


Figure 1. Different raw materials used at Nymölla pulpmill (Miljöredovisningen, 1999).

1.4 Problem Description and Delimitation

SEFCE wanted an analysis of the supply chain of beech pulpwood that is transported from Thüringen, Germany, to Nymölla, Sweden.

Germany exports approximately 295 000 m^3sub/year of beech pulpwood to Sweden (Genfors, pers. comm. 2001). The volume which is exported from Thüringen is today 50 000 m^3sub (Arnquist *et al.*, 2001). They now want to expand the supply area in southern Europe and increase the annual volume.

The logistics in this supply chain are interesting. In Central Europe longer transports with trucks are not a good alternative. The possible transportation with ferries along the rivers would probably be cut off many times and require reloading the pulpwood. Transport by rail could in this case be more appropriate. The ultimate solution would be a continuous flow of pulpwood from Germany to Sweden. The possibility to reach this goal by using railway is higher than with other means of transport. One problem with railway transports is the lack of wagons designed for the purpose. Another big problem is limited possibilities to return goods to the original destination when using ordinary timber wagons.

With a system with covered standard wagons the cost for the transport can be decreased. The company that owns the railway tracks in Germany (Deutsche Bahn, DB) prioritises passenger traffic on the railway and that creates small time windows for goods transportation. This can maybe be solved with standard wagons or other special wagons.

Today the pulpwood is transported by truck to terminals by the railway in Germany. The pulpwood is loaded on timber wagons and sent to Sweden and Nymölla. Before it arrives in Nymölla it is reloaded on trucks in Sölvesborg. The pulpwood is debarked, chipped and screened at Nymölla. An alternative solution could be to debark, chip and screen the pulpwood in Germany by the railway terminal. If this were possible SEFCE would be able to use other types of railway wagons. Maybe it is possible to use some type of standard wagon instead of the ordinary timber wagons. If standard wagons can be used the possibilities of return transports to Germany will increase.
According to SEFCE there could be a lot of advantages if the pulpwood could be debarked, chipped and screened directly by the railway, here are some examples:

- Chipping at the terminal in Germany gives the ability to screen the chips directly. The different fractions can be sold to customers who have different demands on the chips. This makes a product better. This may efficiently provide the right product for the right customer at the right time.

- Debarking at the terminal will create rest-products. The rest-products may be of interest to heating plants in Germany. The transported volume will be lower compared to the existing system.

- There may be possibilities to make new business partners through the development of a new chipping terminal. SEFCE wants to co-operate with local MDF (Medium Density Board) and OSB (Oriented Strand Board) mills.

- The chips are checked in Nymölla today. With the new system the quality and volume can be monitored at the terminal in Germany. In that way no unnecessary chips, fines or bark will be transported to Sweden.

- The new system provides a more convenient transport chain from Germany to Sweden. There can also be a more direct supply chain to Nymölla pulpmill.

- Today special wagons are used for the transportation of solid wood. A new system will have the ability to use standard wagons that are covered. The system with covered railway wagons increases the chance to have a return transport. If the return transport increases, the environmental stress decreases, which is good both for SEFCE and Nymölla pulpmill. An increase of the return transport will also decrease the logistic costs of this system.

1.5 Objective

The objective of this work is to analyse the possibilities to debark, chip and screen beech pulpwood at a railway terminal in Thüringen, Germany, instead of making chips at the pulp-mill in Sweden. Building a chipping terminal by the railway in Thüringen may prove to be an advantageous logistic solution It will also analyse the possibilities to transport the chips in an efficient way to Nymölla pulpmill in Sweden. Furthermore this study will present basic data for decision making to SEFCE and will also give advice of what to investigate further. The main purpose of the research has been to reduce transport costs and to solve logistic problems for SEFCE.

2 Background

2.1 Logistics

Logistics is about the control of flows of material in an efficient way (Lumsden, 1998). To be able to deliver the right products in the right time, of the right quality and to the right place, efficiency must be achieved. Another important issue is achieving the lowest possible cost.

There are many definitions of logistics. One of them is: "the way we approach and the principles according to which we struggle to plan, develop, co-ordinate, steer and control the flow of material from supplier to customer" (Ericsson, 1976). One of the more simple definitions is: "The science of effective flows of material" (Persson & Virum, 1996).

Logistics has always been important in businesslike activities. However, the interest in the topic has been fluctuating. Today the companies have more demands to be efficient and profitable. The flow of information is also better today than it was before. In the 80's the most important thing was to prevent capital from being bound in storage. In the 90's the logistics has become more time-oriented (Lumsden, 1998).

Good logistics is a way for a company to save a lot of money. There are three main ways to increase the profitability in the company: reducing the costs, decreasing the capital bound in storage and to generate new incomes. Logistic efficiency in a company can be explained by the "logistic goal mix" (Lumsden, 1998). The logistic goal mix consists of three parts: bond of capital, delivery service and the cost of the logistics (fig. 2).

If the costs for the logistics are decreased some other part of the goal mix may be affected. For example, decreasing the transport costs can increase the revenues. In this way the delivery service will suffer. If the delivery service gets worse it can result in a loss of clients in the future. The capital bond in storage will increase when the costs for the logistics are decreased. That is not a good thing either.

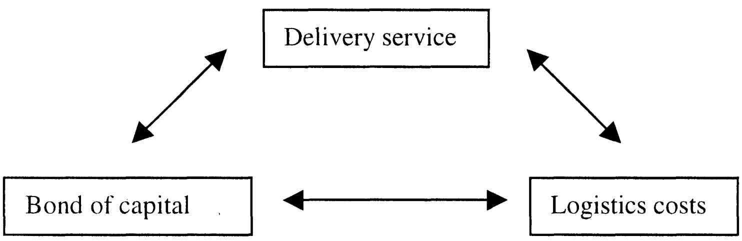


Figure 2. "The logistic goal mix" (Lumsden, 1998).

The delivery service is a very important matter in logistics. This is the part where big revenues can be made. But if the delivery service gets better it will affect the logistics costs and the bond of capital. A good delivery service would probably increase the incomes in a longer perspective. The delivery time is very important for the customer. A short delivery time gives the company a good reputation (Lumsden, 1998).

The task will be to try to decrease the logistics costs by investigating the possibilities to use another type of railway wagon. The delivery times will be reduced if the return transport back to Germany from Sweden is faster. Trying to improve the logistics in the supply chain can reduce the storage of wood. The biggest problem today is the storage of pulpwood in the forest.

2.1.1 Transportation

Transportation can have a physical or economical description. The traditional way of describing transportation is describing it as a physical flow of goods. Nowadays the bond of capital has a greater value than the physical flow of goods. A couple of definitions are used for a transport (Lumsden, 1998):

Physical flows:	Tonnes × kilometres = tonne kilometres Volume × kilometres = volume kilometres Board-metre × kilometres = board-metre kilometres (the board of a truck)

The definitions above just consider the flow of goods, not the value of the goods. One tonne of wood chips and one tonne of diamonds will correspond to the same transport. Therefore a definition that considers the value of the goods can be used (Lumsden, 1998):

Capital flow = SEK × kilometres = SEK kilometres.

The bond of capital is affected by the time, not by the transportation distance. Therefore a definition that considers the time is needed (Lumsden, 1998).

Bond of capital = SEK × hours = SEK hours.

When the time is considered the cost for personnel also will be included. One of the disadvantages of this definition is that is hard to compare the efficiency between the different means of transport. The slowest means of transport will not stand a chance against the faster ones. These difficulties have resulted in that the “old” definitions still are used to describe transportation (tonne kilometres). This measurement is quite similar to the one that is used in passenger traffic, but that will not be described in detail (Lumsden, 1998).

The trend today is for ferries and the railways to lose market shares to trucks. The railway still has a big market share when it comes to heavy, long-distance transports (Lumsden, 1998). When choosing a means of transport the value of the product is very important (table 1).

Table 1.The value of transported goods for different means of transport (SIKA, 1996).

Means of transport	Value
Ferry	6 SEK/kg
Railway	6 SEK/kg
Truck	22 SEK/kg
Aeroplane	708 SEK/kg

Wood and timber are examples of products with a low value per kilogram. Hence the best means of transport are ferry or railway. Only products with a very high value will be transported by aeroplane.

2.1.2 Railway Transportation

The basic idea of railway transportation is to take advantage of the low friction between the railway track and the metal wheels of the wagon (Lumsden, 1998). The contact surface is small compared with the contact surface between rubber tires and asphalt. It takes seven times the amount of power to haul a truck than to haul a railway wagon with a comparable amount of cargo.

This phenomenon makes it interesting to form convoys of several railway wagons. These big transport units are called goods trains. The goods trains can be driven with a minimum of personal and with minimum hauling power. However big flows of rather heavy goods will be needed to make this kind of transport efficient.

One other important issue is the co-operation with other means of transport. Other means of transport are in this case trucks that can leave and pick up goods at railway terminals. One step towards greater efficiency is to diminish the marshalling. Marshalling of only one railway wagon can cost up to 100 DEM (Lumsden, 1998). Big continuous flows of goods and few marshalling operations make a whole train a good alternative. Our definition of a whole train is when 20 to 30 railway wagons are filled and driven directly to the final destination without marshalling. On longer distances this kind of railway transportation will be more effective and cheaper. Whole trains can also be prioritised before other trains on the railway tracks (Lumsden, 1998).

Another type of train is the system train. The system train is quite similar to the whole train. The only difference is that the system train has a unique solution for the current client. The train works as an integrated part of the production in the company. To motivate the usage of system train solution some criteria have to be fulfilled (Lumsden, 1998):

- A continuous flow of goods.
- Whole train sets.
- The volume of wagons has to be used optimally.
- Quick route times for the wagons and the locomotives must be employed.

The wagons are combined at a terminal and are kept together throughout the whole distance. The sender and the receiver belong to the same company. The system trains are often working independent of the timetables and other trains. Just like the whole train the system train is just going between two destinations/terminals. When it comes to system trains the railway terminals often belong to the same company as the one that performs the transport (Lumsden, 1998).

If a chipping terminal was built in Germany Stora Enso would own the chipping terminal and the pulp mill in Sweden. A continuous flow of wood is desirable. This is not the case today. Stora Enso is able to lease special wood chip wagons from the wood logistics company Fehring in Germany. The travel time is today too long and this is mostly due to the lack of appropriate wagons. A system train that transports chips can be a solution.

There could be some problems or benefits with railway transports. Before the high speed trains were introduced all the railway tracks were built to handle all different types of wagons (Lumsden, 1998). Now the tracks that are made for high speed trains can't handle the same axle load as the tracks that were made for goods trains. One advantage for the goods trains is that there will probably be more lots available for them on the railway tracks when the faster trains are using the newer tracks. This is not a certainty however. In countries like Sweden the railway tracks just are upgraded to handle high speed trains and will not give the goods trains any more space.

2.2 Debarking

There are different methods to debark logs. A short description of some of them will be needed. The methods differ a bit from each other. The final result depends on the choice of debarking method. It is foremost the quality of the wood chip that decides the debarking method. The three different debarking methods that are described are drum debarking, knife debarking and chain flail debarking.

Quality in the debarking process is synonymous with the percentage of bark in the "accept chips". If the bark content is to high the pulpmill will not accept the chips. According to Nymölla's demands the bark content can't be over 0,3 % (Fritzon, pers. comm. 2001). It is not easy for some debarking systems to reach that kind of quality. Chain flail debarking, drum debarking and debarking with knives will give different bark content results in the accept chips. Kassberg has suggested three reasons for the proper debarking of pulpwood (Kassberg *et al.*, 1998):

- Too much bark will result in "unclean" pulp.
- Too much bark will increase the consumption of chemicals in the cooking- and bleaching process.
- Bark is a valuable fuel for heating electricity that is replacing oil at the pulpmills.

2.2.1 Drum Debarking

Drum debarking is the most common way to debark the logs in the pulp industry. A drum debarker is a big cylinder of steel. It can have a diameter of 4-5,5 m and a length of 20-39 m (Kassberg *et al.*, 1998). The drum debarker has strips of steel on the inside that lifts the wood inside the cylinder. The drum rotates with a speed of 6-8 r/min and it has openings where the loose bark falls through.

The logs are washed before they go into the debarking drum. In the drum the logs hit each other and as well as the walls and this process tears the bark off the logs. After the debarking drum are the logs washed again to rid the logs of any remaining bark. Increased tumbling movements improves the debarking result, but if the logs are too thin they will break (Kassberg *et al.*, 1998).

Tree species have different debarking qualities. One of the easiest species to debark is pine and one of the most difficult species is birch. All species are more difficult to debark in the wintertime (Kassberg *et al.*, 1998). Beech is quite similar to birch and is one of the most difficult species to debark (Fritzon, pers. comm. 2001). The drum debarker at Nymölla pulpmill can produce chips with a bark content of approximately 0.2 % (Fritzon, pers. comm. 2001).

2.2.2 Knife Debarking

The Finnish company Valon Kone AB and the Swedish company Söderhamn Eriksson Cambio AB use this system. A machine that debarks the roundwood by feeding it lengthways through a rotating ring with blunt knives is used. The knives grab the bark and twist it until it is removed. This is a very common debarking system in sawmills all over the world (Skogsencyklopedin, 2000). Curved logs are not successfully debarked using this method and frozen logs are harder to debark (Westerlund, pers. comm. 2001).

2.2.3 Chain Flail Debarking

Chain flail debarking is the most common method when using mobile chippers. In a chain flail debarker the bark is beaten off the log with rotating chains. The chains are mounted on rotating axles in the machine. The number and the length of the chains can vary. There may also be different numbers of axles. Factors that can affect the debarking result positively are (Franklin, 1992):

- More chains
- Faster rotation speed of the chains
- Low infeed conveyor speed

The result is not so dependent on the shape of the log. However the chain flail debarker will give some loss of wood. The more careful the debarking is, the greater the loss of wood.

The tree species is very important for the result. According to an investigation made in New Zealand in 1991 it is much easier to debark pine than to debark hardwood with the chain flail system (Watson, 1991). The same investigation shows that the difference isn't that big when a drum debarker is used. Frozen logs are harder to debark (Franklin, 1992). According to Watson's report the amount of fines will be reduced with the chain flail debarking, but the amount of overs will increase. Figure 3 shows what the inside of a chain flail debarker can look like.

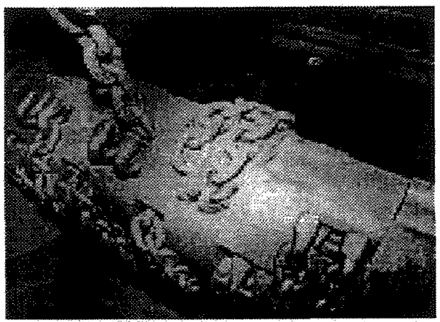


Figure 3. Chain flail debarker, axle with chains (www.morbark.com, 2001)

2.3 Chipping and Screening

To be able to use the roundwood, the logs must be converted into chips. The reason why the chipping is done, is to facilitate for water, chemicals and heat to penetrate the wood. The pulp process demands chips that are 20-40 mm long and 5-8 mm thick (Kassberg *et al.*, 1998). Nymölla prefers the chips to be 25-28 mm long and 5-7 mm thick (Fritzon, pers. comm. 2001).

2.3.1 Chippers

The chipper is a big rotating disc with skew knives. All systems use disc chippers. Disc chippers are like a gigantic food processors. They are often large, powerful and demand a large energy consumption. A chipper can have an engine effect of 2500 kW (3400 hp).

The logs are fed into the disc chipper by gravity or by a conveyor. The gravity fed chipper has a sloping feeder where the logs slide into the chipper. The conveyor fed chipper has a horizontal feeder and needs an electric conveyor to feed the logs into the chipper. There are also so-called drum chippers. Drum chippers also come in gravity- and conveyor fed models. They are more suitable for chipping waste from sawmills and joineries. The tuning of the knives affects the result. If the chipper knives are not tuned, more work will be needed in the screening process. It is preferable to achieve an even chip quality from the start.

2.3.2 Screens

The chipper will produce wood chips of different sizes. Some are smaller than the ones that are needed (fines) and some of them are oversized (overs). The thickness of the chips is also important. Chips that are larger and thicker than the requested size will inhibit the release of the lignin (Kassberg *et al.*, 1998). In the cooking process the big chips will not mature at the same time as the accept chips. The pulp quality will be low and problems can occur in the straining process. If there are too many fines in the pulp, problems will also occur in the straining process because of the density of the pulp.

There are two different types of screens, the "hole screen" and "the plate screen". The "hole screen" sorts the chips by size and the "plate screen" sorts the chips by thickness.

The "hole screen" has perforated plates in two storeys. The screen moves continuously to keep the chips in motion, to ensure they fall through the holes in the perforated plates.
The first plate has holes as big as the chips that are accepted. The second plate has smaller holes, where the fines and dust enter. The overs are hindered at the first plate and are returned to another chipper that reduces their size and sends them back to the screen (fig. 4).

The "hole screen" will only sort the chips by size, not thickness. The over thick chips are identified in the plate screen. The plate screen contains plates mounted on axles (fig. 5). The spacing between the plates is set so that the accept chips will fall through. The overs do not pass and enter another chipper. Fines are not usually used in the pulp, but sometimes a little controlled amount of dust and fines can be used in the process (Kassberg *et al.*, 1998).

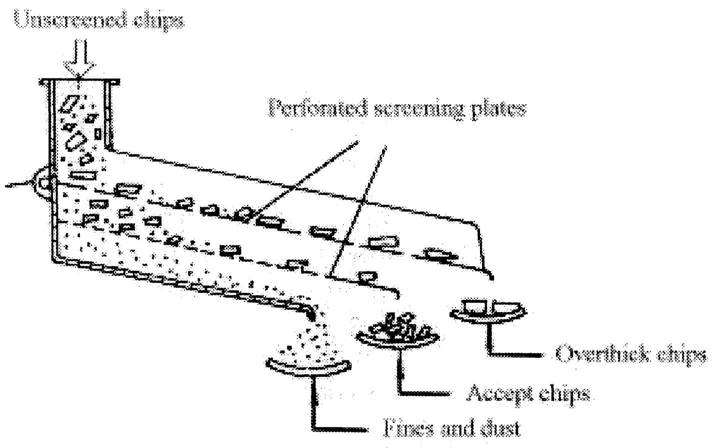


Figure 4. The principles of a "hole screen" (Kassberg *et al.*, 1998)

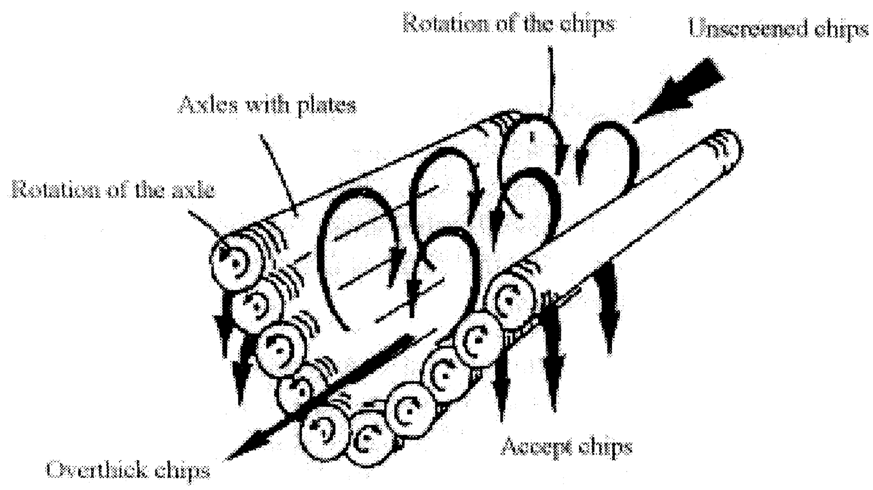


Figure 5. V-shaped "plate screen" (Kassberg *et al.*, 1998).

2.4 Trends

One modern trend in forestry is to try to decrease the storage of wood, especially in the forests. In Germany there are problems created by the short harvesting season. On occasions the wood is left lying in the forest for a year and this storage costs money. Also in Sweden there are traditions to store wood in the forest. One cultural reason could be the extinct log driving methods used on rivers (Westerlund. pers. comm. 2001).

Today the forest industry has to adapt to their customers and try to reduce the storage. The forest industry in Finland is very good at this. In some places in Finland the harvesters work almost directly towards an order from a customer. The focus on the customer creates a new demand on higher flexibility in the forestry. Unfortunately this increases the costs for the logistics (Lumsden, 1998).

The use of bio-fuels is going to expand in the world (Bruks, pers. comm. 2001). The environmental debate is intense and many countries are trying to reduce the use of fossil fuels. In Germany the market for bio-fuels is growing. This trend could relate to the increased prices for oil and coal. (Wizemann, 2000).

3 Materials and Methods

3.1 Methods

We have used a method called systems analysis to analyse the problem. Systems analysis is a tool that we have used to find out how different parts in the system operate. In today's society there are increasing demands on efficiency and better structures in all areas. In this way systems analysis may be a good tool to solve and analyse problems (Gustafsson *et al.,* 1982). Examples of the usage of systems analysis in different situations:

- A methodology to describe things. An easier way to describe a complicated system.
- A formulation of a goal or a definition of a criterion to help solve the problem according to them.
- A methodology of analysis. Analyses are made from the constructed system.
- A tool for planning. The systems analysis can be basic data for decision-making.

The systems analysis may not present all these answers. One issue of importance is to get a general impression of the system. Of course the different parts of the system are important too. To get a general impression of the system a model that is similar to the system is constructed. There are no true models, just models that are more or less suitable to the specific situation. A systems analytic study must have an obvious purpose. The purpose will in many ways decide what the system and the model will look like. The result from the study should not be considered as an answer to all questions. Many other factors have to be considered, human factors for example. That is why the result of a systems analytic study should be regarded as basic data for decision-making.

In this case the method is chosen because systems analysis suits the problem. An economic system is studied and many changes are made in the system along the way, mostly sensitivity analyses. To make a sensitivity analysis certain factors are changed in the system. This is done to see how different factors will affect the price of pulpwood in DEM/m^{3}sub.

Our research could not cover constructing a new system every time a single factor changed. However the analysis clarifies the situation and enables the assignor (SEFCE) to undertake further analytic studies.

3.1.1 The System-Concept

The general definition of a system: *"An amount of components that are joined together to one entity"* (Gustafsson *et al.,* 1982).

The purpose of the study decides how the system is restricted. The system can be divided into smaller systems, so-called subsystems. In this study there is one subsystem. The stationary chipping system from Bruks is a subsystem and it contains a debarker, a chipper and a screen.

A system can have a lot of different properties, but this system is more like an economic calculation containing one subsystem. This system could be seen as an internal and an external system. The most interesting thing to see is how the price of beech pulpwood will be affected by changes in annual volume. It is also interesting to see how the different parts of the system influence each other and how they are affected by changes in the system.

3.1.2 The Model-Concept

A general definition of a model: *"A system that we have chosen to reproduce the essential properties of another system"* (Gustafsson *et al.,* 1982).

The model is a reproduction of the system and the reality. In that way the same conclusions can be made from the system and the model. One common theme is that that the model has fewer components than the system. Fig. 6 shows the relation between the system and the model.

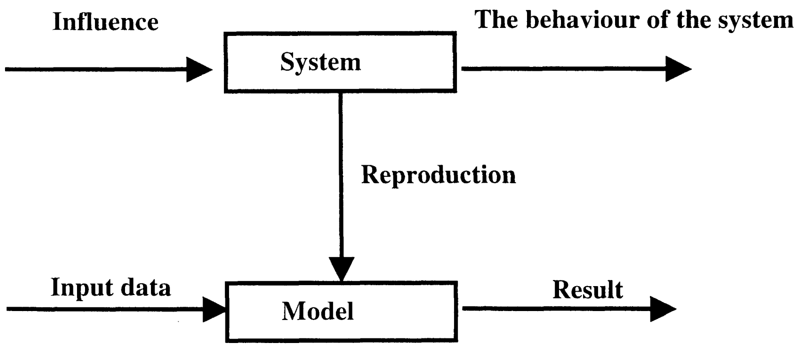


Figure 6. The connection between the system and the model (Gustafsson *et al.*, 1982).

3.1.3 Method of Gathering Information

To gather the information regarding the system, telephone calls have been made. E-mail and ordinary mail have also been used to gather information. In some cases personal meetings and discussions were necessary.

3.2 Material

3.2.1 Gathering of Information

The information about the system was mostly collected through phone calls. The Internet and e-mail were also used to get in touch with people. The Internet was a successful tool in identifying companies of interest. Once we had found the telephone number we called and asked a few questions. An important question was to ask the company for permission to send e-mail with further questions. In this case a written answer decreases the risk of misunderstandings and is therefore preferable.

Personal meetings with people that were involved in this project were arranged. A trip was made to Düsseldorf, Germany. We went there to find out some more about our task. In Germany we met our supervisors at SEFCE, Weine Genfors and Ralf Löbbermann. The figures in the different systems were discussed.

We had a meeting with Uwe Kundt in Thüringen. Uwe Kundt is a wood purchaser and is employed by HVG. HVG provides SEFCE with wood in Thüringen and the surrounding area. Uwe Kundt showed us what the beech forest in Germany could look like. The most interesting feature was the quality of the beech stems. The thickness of the branches and the shape of the stem affect the result of the debarking.

After the meeting with Uwe Kundt we went to meet Dieter Fehring, the president of Fehring Holzspäne company. We met him to investigate the costs involved while transporting wood chips with the special wagons that he owns.

Back in Sweden a meeting with Tomas Agrell and Stellan Österberg at Sydved was arranged. Sydved operates as a supplier of pulpwood for Nymölla. Volumes and transport costs were discussed at Sydved.

A meeting with Lars-Ola Fritzon at Nymölla pulpmill was arranged. The discussion was principally about the possible investments at the pulpmill.

When all the information was gathered the construction of the model in Microsoft Excel could start. More information about the different parts in the system is found in chapter 3.3, system description.

3.2.2 Compilation of the Information

To construct the model and the system description Microsoft Excel was used. In the model the different parts of the system have one worksheet each in the workbook. The first page is a worksheet where the input data and the conditions of the problem are outlined. At the end there is a worksheet called "result". The result sheet is connected with all the other sheets and will respond to changes that are made in the model. There is also a result sheet that contains diagrams.

3.3 System Description

3.3.1 Present Logistic System

The present logistic system is also described in figure 7.

Forest

The forest of interest is located around the area Thüringen in Germany (former East Germany). This area has a high density of beech forests. These favourable conditions are very much related to the fact that the government owned all forests in former East Germany (Kundt, pers. comm. 2001).

Today the beech is harvested in certain periods because of restrictions from the government (bird nesting and sap period) (Genfors, pers. comm. 2001; Kundt, pers. comm. 2001). The harvesting period is between the first of September and last day in March (Kundt, pers. comm. 2001). This results in a large storage of wood in the forests. The problem is that the wood ages and is damaged. Nymölla and Stora Enso have the ambition to achieve an even flow and with this kind of restriction it will be hard to achieve that goal.

The wood that comes from Thüringen has a diameter between 10 cm and 60 cm. The lengths of the logs are 3 or 6 metres (Kundt, pers. comm. 2001). When the logs are in 3-meter lengths the whole stack is measured. In 6-meter lengths all logs are measured one by one.

Truck Transportation

The trucks are loaded in the forest and transport the wood to different terminals, railway terminals or seaports. The truck transportation from the forest to the terminal costs 17 DEM/m^3sub in the system today. This cost will increase with an increased annual volume (Genfors & Löbbermann, pers. comm. 2001). A German company called HVG buys and controls the transportation of beech wood for SEFCE.

Terminal

Today the wood is transported to different loading points or terminals depending on distance and/or costs. At the terminals the unloading and loading of railway wagons is conducted. Occasionally it is problematic to load and stack the wood. This is mainly due to the multiple choice of wagons (Österberg, pers. comm. 2001). It is very important that weight and the volume are maximised. Sometimes wagons weigh too much and they are stopped. This is costly to the company and in trying to control this fault special "load controllers" are used that check the wagons at the terminal.

Present logistic system

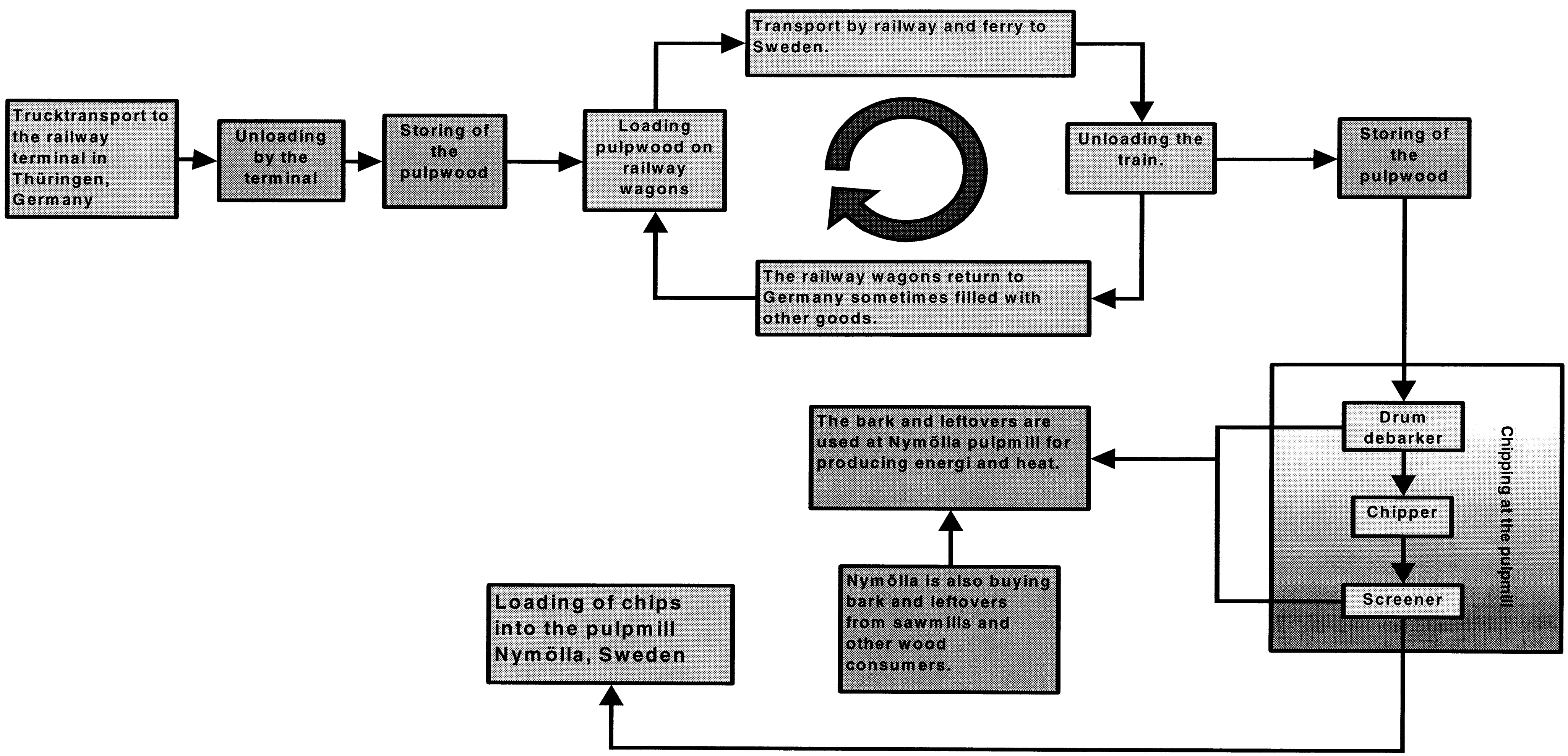


Figure 7. Description of the present logistic system

Railway and Ferry Transportation

The train wagons are loaded and then hauled to a harbour in Germany where the goods are handled before further transportation by ferry and train. The goods then reach Sölvesborg in Sweden (Agrell, pers. comm. 2001).

Because of the lack of wagons to transport wood from Germany to Nymölla different types of wagons are used. The two different types of wagons are the open wagons, "Rungenwagen" and the covered wagons, "Kastenwagen". The "Rungenwagen" is an ordinary timber wagon used for the transportation of wood while the "Kastenwagen" is a covered wagon which is very hard to load and unload which increases the cost with 8-10 DEM/m^3sub (Arnquist *et.al.*, 2001). The "open" wagons are open on the sides and the "covered" wagons are closed on the sides. The covered wagon is like a box and because of that it is hard to unload. The open wagon has pillars that facilitate the unloading.

The cost to transport 1 m^3sub of beech wood from Nordhausen, Germany, to Nymölla, Sweden, is 53 DEM (Arnquist *et.al.,* 2001). The cost includes railway- ferry and truck transportation to Nymölla pulpmill. The purchase price for the wood is not included in this figure.

Sölvesborg

The trains final destination is Sölvesborg, as Nymölla has no railway tracks (Arnquist *et al.*, 2001; Agrell, pers. comm. 2001) The train is unloaded and the wood is loaded on trucks for further transport to the pulpmill.

Truck Transportation

The trucks transport the wood from Sölvesborg to the pulpmill in Nymölla. In Nymölla the trucks are unloaded and sent back to Sölvesborg. The cost for the transport from Sölvesborg to Nymölla is 7 DEM/m^3sub (Arnquist *et al.,* 2001).

Nymölla

In Nymölla the wood is unloaded and stacked in large wood piles. The storage volume in Nymölla is 10 000 m^3sub (Fritzon, pers. comm. 2001). After a while the logs are loaded into a drum debarker. The debarker uses water in the drum and can achieve a bark content below 0,3 %. After debarking the logs are chipped and screened. The wood chips are transported with a conveyor to a big stack where they are stored before the cooking process.

3.3.2 New Logistic System

The new logistic system is described in figure 8 and the stationary system (Bruks) is described in figure 9. The figures that have been used are presented in more detail in appendix I.

Forest

The same forest in Thüringen is studied.

Truck Transportation

Because of the higher volume that will be used in the new system the supply area will be increased. This fact is changes the truck transportation costs. After discussion with Genfors and Löbbermann we decided that an increased supply area with 20 km would be enough (from 100 to 120 km) to ensure the higher demand of wood (150 000 m3sub/year). With an increased radius the cost increases with 4 DEM/m^3sub (from 17 to 21 DEM/m^3sub).

Terminal

The terminal is complex and it is divided into different, simplifying the description. The different stations are for: measurements, unloading/loading, debarking, chipping, screening and other investments.

The debarking, chipping and screening are also described through the machine descriptions that have been selected for this study. The included machines are Peterson pacific machine, DDC 5000-G, Morbark machine, 2755 flail chiparvestor and one stationary system. The stationary system contains two different debarkers, Valon Kone debarking machine 820/5 and Cambio 90-80 debarker. The chipper and screener come from the Swedish company Bruks. The type of chipper we use is 2500 R and screen BS7 (appendix I).

Three persons except the person that works in the measurement station are needed to run this terminal (Genfors, pers. comm. 2001; Bruks, pers. comm. 2001).

The terminal of interest is a terminated railway station in Hohenebra in Thüringen. The loading length of the track is 255 metres and a yard with an area of 1380 m^2 is included (Kundt, pers. comm. 2001). There are also some other areas currently are for rent. Approximately 10 000 m^2 is available for the cost of 1000 DEM/year. The ground is covered with asphalt, concrete or gravel. There are also some empty buildings that can be used for different purposes. The company that rents this terminal will be required to clean up the debris on the ground before the terminal can be used (appendix IX).

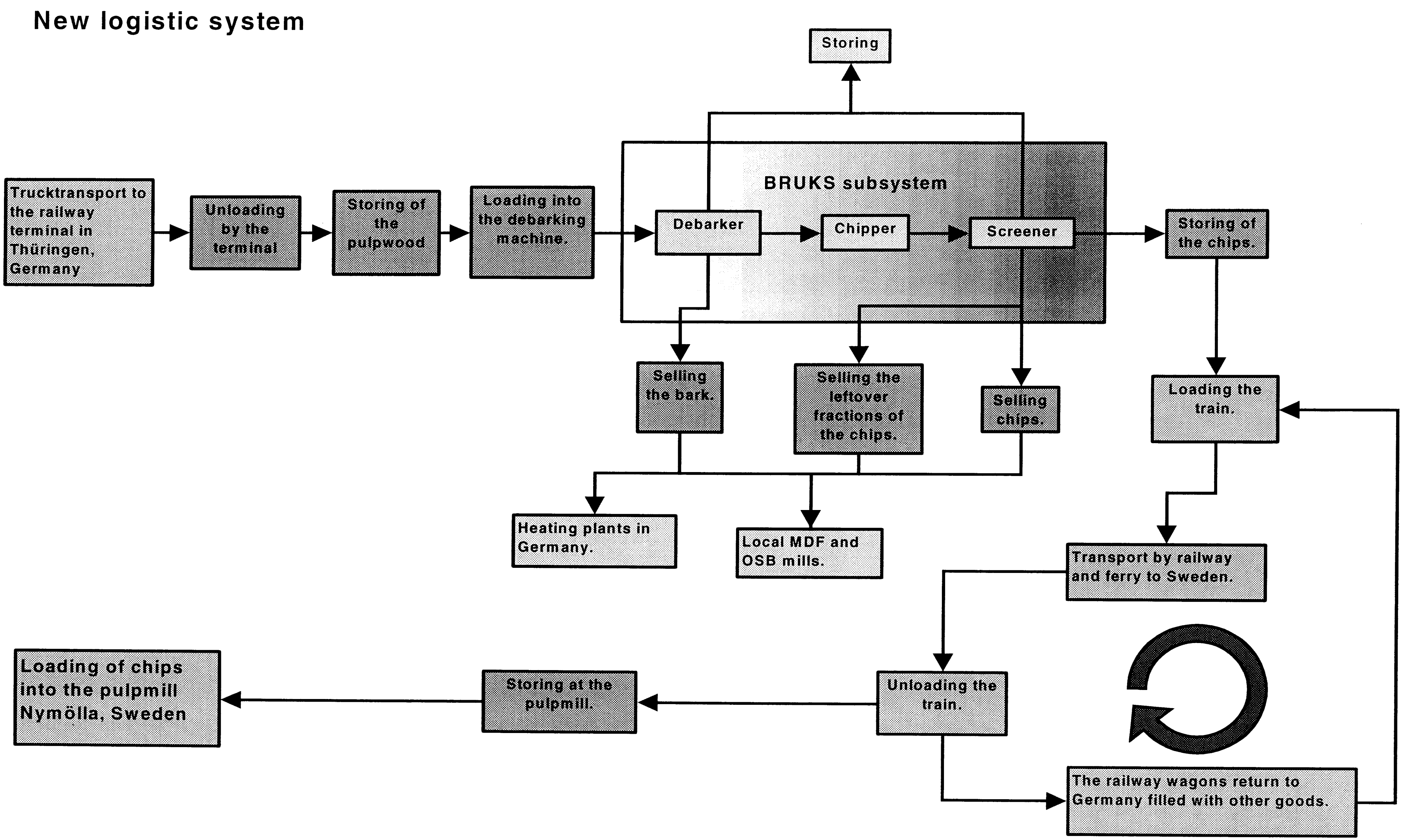
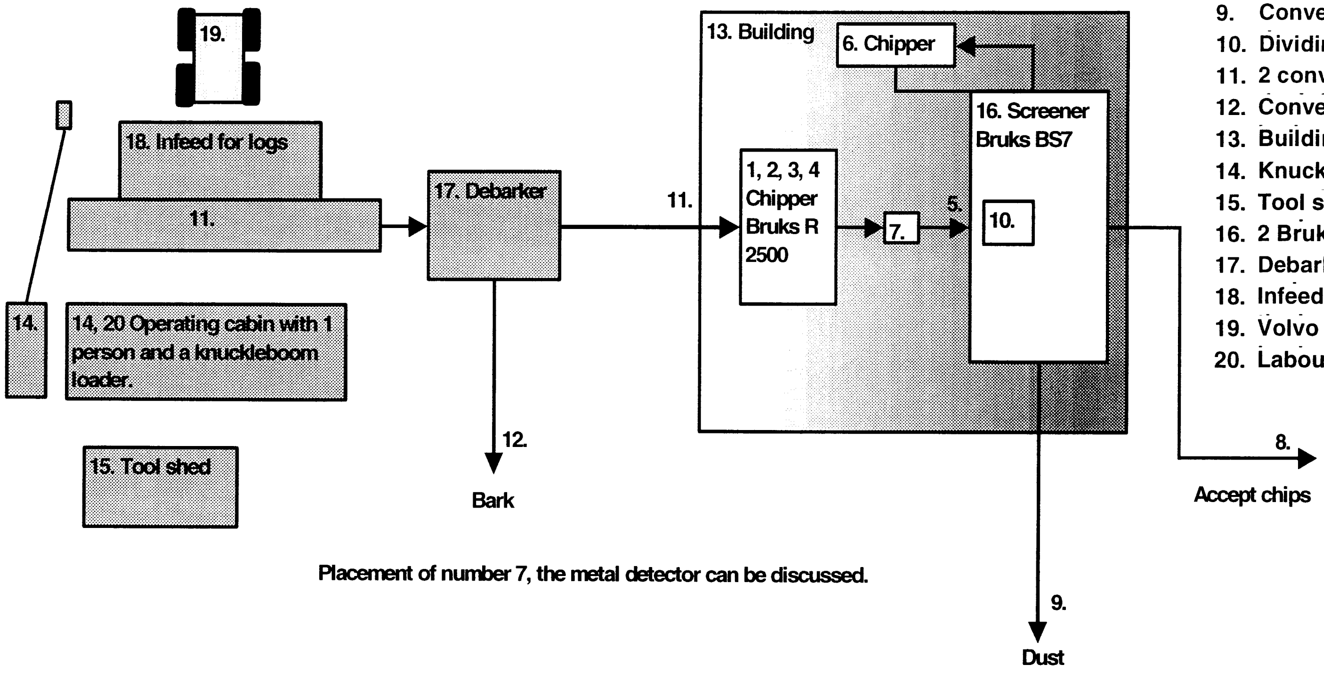


Figure 8. Description of the new logistic system.

BRUKS subsystem



1. Bruks chipper R
2. Electric
3. Transmission between chipper
4. Starting
5. Infee
6. Fine chipper with
7. Metal
8. Outfeed
9. Conveyor for
10. Dividing screw for
11. 2 conveyors for trash (under
12. Conveyor for
13. Building
14. Knuckleboom loader and
15. Tool shed and sharpening
16. 2 Bruks BS7
17. Debarker Valon Kone 820/5 with infeed
18. Infeed and loading pocket for
19. Volvo L120 wheel
20. Labour, 1

Figure 9. Description of Bruks subsystem

Measurement Station

The volume of the pulpwood is measured when the trucks drive into the terminal. It is harder to measure the wood after debarking, chipping and screening. Therefore a measurement station is needed. The wood is measured to establish the debt to the forest owner. This cost is hard to predict and it is estimated to 0.5 DEM/m^3sub. The figure includes the costs for personnel (Genfors & Löbbermann, pers. comm. 2001). This cost is fixed and it will not change with the annual input volume.

Unloading and Loading

The solid wood comes from the forest and is unloaded with a wheel loader. The same machine will perform the loading of the chips. The machine that is used in this study is a Volvo L 120 D (fig. 10). This machine can make a quick change from bucket to grapple. The big advantage is that the same machine can be used for loading the railway wagons and unloading the trucks. The purchase price is 456 000 DEM and the fuel consumption is 20 litres/hour (Haraldsson, pers. comm. 2001). The maintenance cost is about 65 000 DEM/year (appendix I, appendix V).

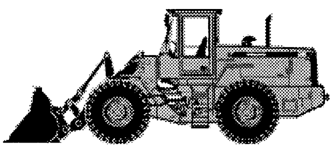


Figure 10. Unloading and loading machine Volvo L 120 D (www.swecon.se, 2001).

Debarking

The debarking process is important because of the strict demands at Nymölla. The bark content cannot be over 0,3 % in the accept chips (Fritzon, pers. comm. 2001). This creates problems for the debarking machines. The machines must be able to produce the annual volume with the right quality. The result also depends on the shape of the wood. Therefore three systems with two mobile systems have been picked out, one chain flail system and two stationary systems with knife debarkers. The different machines are described below. The stationary systems have a log-feeding pocket that feed the debarkers with one log at the time. The pocket is fed with a wheel loader.

Peterson pacific, DDC 5000-G is a mobile chipper and has a capacity of producing 100 tonnes of chips per hour (www.petersonpacific.com, 2001; Lang, pers. comm. 2001). It is a disc-chipper with a 167-cm disc and a 3 knife standard configuration. It can handle logs with a diameter from 5 to 58 cm. A chain flail debarking system is built in and according to Peterson Pacific it can achieve a bark content of 0,3%. The purchase price is 1 540 000 DEM and the maintenance cost is 104 DEM/hour. The calculated capacity for the machine is 60 tonnes/hour and the machine operates 3000 hour/year (appendix I, appendix VII). The machine has a knuckle boom loader that feeds the debarker. A wheel loader feeds the knuckle boom loader with logs.

Morbark, 2755 flail chiparvestor (fig. 11) is a mobile chipper and has a capacity of producing 100 tonnes of chips/hour (www.morbark.com, 2001; Kowallic, pers. comm. 2001). Chain flail debarking is used and it can manage logs with a diameter from 5 to 68 cm. The chipper disc has a diameter of 210 cm and a configuration of 3-6 knives. The purchase price is 1 480 000 DEM and the maintenance cost is about 104 DEM/hour. The calculated capacity is 60 tonnes/hour and the operating hours are 3000/year (appendix I, appendix VI). This machine has also a knuckle boom loader. A wheel loader will also be needed in this case.

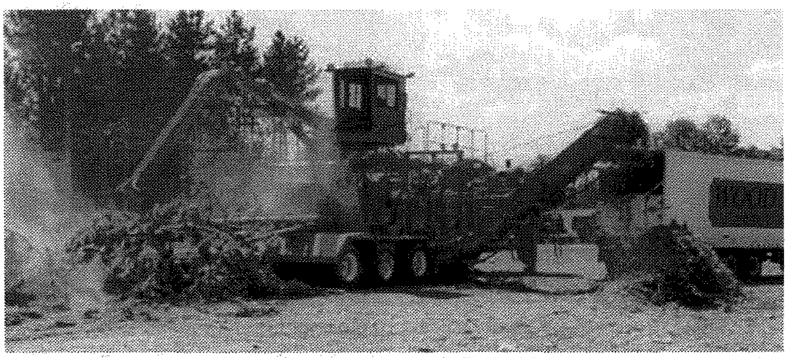


Figure 11. Morbark mobile chipper, 2755 flail chiparvestor (www.morbark.com, 2001).

Valon Kone 820/5 debarking machine is a knife debarker that can be fed with a speed from 40 to 64 metres/minute (Nilsson, 2001). It can manage a feeding speed of 75 m/min with approval from Valon Kone. With an annual volume of 150 000 m^3sub the feeding speed has to be 21 m/min. The max diameter is 820 mm and smallest 100 mm. The rotor opening is 835 mm. A bark content under 0,3% will be possible with this debarker (Nilsson, pers. comm. 2001). The purchase price for this machine is about 540 000 DEM because of the transport cost for the delivery.

The maintenance cost is set to 54 000 DEM/year (10 % of the purchase price) (appendix I, appendix III). The machine needs a feeding pocket that feeds it with one log at the time. The machine that feeds the pocket is the wheel loader from Volvo.

Söderhamns Eriksson CAMBIO 90-80 is also a knife debarker that can debark with a speed from 50 to 83 meters/minute (Viksten, pers. comm. 2001). The rotor opening is 794 mm and it can debark logs with a diameter from 80 mm to 700 mm. On a 6-metre log the height of the arc can not be more than 100 mm. The machine is fed with logs in the same way as Valon Kone's machine. The purchase price and the maintenance cost are the same as for Valon Kone's machine (appendix I, appendix IV).

Chipper

In the mobile chippers the chipping unit is built into the machine (see above or in the appendix).

The model of the chipper is called 2502 R (fig. 12) and has 2 x 8-knife configuration (Bruks, technical data, 2001). The diameter of the chipper disc is 2470 mm and the chipping capacity is 400 m^3loose/hour. The maximum diameter of the logs is 650 mm. The purchase price is about 390 000 DEM and the maintenance cost is 10 % of the purchase price (appendix I, appendix II). There are also some other investments related to the chipper. Those investments are described in section "other investments" in this chapter.

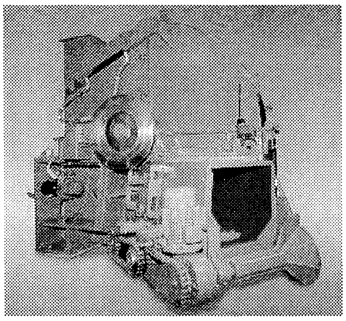


Figure 12. BRUKS 2502 R whole log chipper (www.bruks.com, 2001).

Screens

The screens that are used are from the manufacturer Bruks and the model are called BS7. One screen has a capacity of 225 m^3loose/hour (81 m^3sub/hour). This capacity is not enough for the terminal so two screens are used (Bruks technical data, 2001; www.bruks.com, 2001; Bruks, pers. comm. 2001). The screen is a free-swinging screen that gives a superior result for fines. The purchase price for these two screens is 217 000 DEM and the maintenance cost is approximately 10 % of the purchase price (appendix I, appendix II). More investments related to the screens are described in the section "other investments" in this chapter.

The wood chips are sorted into three different fractions: fines, accept chips and overs (Bruks, technical data, 2001). It is also possible to have four different fractions. The overs go back to a chipper for overs. That particular machine is included in "other investments" at the terminal.

Loader for Chips

The same machine unloads the trucks and loads the railway wagons. The machine is a wheel loader from Volvo and the model is called L 120D. It can make a quick switch between the bucket and the grapple (Haraldsson, pers. comm. 2001). More about this machine can be read in the section "Unloading and loading" in this chapter.

Other Investments

Other investments have to be made to make the system to work properly. These investments will be different if the system is stationary or mobile. Examples of investments at the terminal are: conveyors for the chips, buildings, montage, groundwork, insurance costs, electricity equipment etc. (Bruks, pers. comm. 2001) (appendix I).

Railway Transportation

After the train wagons are loaded with chips for Nymölla the system train leaves the terminal. The change of wagon type will have positive effects on the transports. The new wagon type (fig. 13) is a covered wood chip wagon from Fehring and it has the possibility to return more goods than the wagons that are used today (Fehring, pers. comm. 2001). The wagon is loaded from the top and unloaded from the side. A wheel loader with a plate pushes the chips from one side and out on the other. The maximum loading volume of the wagon is 182 m^3 and the maximum weight capacity is 51 tonnes. The length of the wagon is 28 metres. The length of one wagon is actually 14 metres but two wagons are always connected to each other (appendix VIII). The price for hiring one of these wagons from Fehring is 80 DEM/wagon/day.

Figure 13. A Railway wagon from Fehring is loaded with chips. (www.fehring.de, 2001)

During the trip between Hohenebra in Germany and Nymölla in Sweden a fee is paid to DB for using the tracks and a locomotive. The ferry transport over the Baltic Sea also costs money. The cost for the transport from Hohenebra to Nymölla is 3200 DEM/wagon/trip and that also includes the ferry transport (Löbbermann, pers. comm. 2001). To compare this figure with the present system, another railway terminal in Germany must be used. The terminal that is compared is Nordhausen. This results in a cost of 2300 DEM/wagon/trip instead of 3200 DEM/wagon/trip (Löbbermann, pers. comm. 2001).

There are some fractions that are not delivered to Nymölla, like fines and bark. They are sold to local companies as fiberboard and MDF-industries and to power plants. The price for bark is about 14 DEM/m^3sub and for fines and leftovers about 40 DEM/m^3sub (Genfors & Löbbermann, pers. comm. 2001).

Nymölla

When the train arrives in Sölvesborg in the present system the wood is reloaded onto trucks which drive to Nymölla. In the new system a railway track goes directly to Nymölla pulpmill and the wood yard. This investment is about 600 000 DM (Arnquist *et. al.*, 2001; Fritzon, pers. comm. 2001). When the train gets into the wood yard it has to be unloaded in an easy way. A "chip pocket" along with the railway track makes the unloading process easy. The chips have to be pushed out of the wagons as described before. The "chip pocket" has a conveyor that transports the chips directly to the boiler or to the stack. The investment cost for the chip pocket and the conveyor is estimated to 900 000 DEM.

Other Input Data

Apart from the information on machines other data is also used. The figures are used in the worksheet for input data (Andersson, pers. comm. 2001; Bruks, pers. comm. 2001; Fritzon, pers. comm. 2001; Genfors & Löbbermann, pers. comm. 2001; Walfridsson, pers. comm. 2001) (appendix I).

Table 2. Basic data and assumptions in the analyses.

Internal rent for the investments	10 %
Rest value of the investments	15 %
Depreciation time on investment	5 Years
Total input volume	150 000 m^3sub/year
Convert number	1 m^3loose = 1 m^3sub/0,36
Accept chips in process	80 %
Price for chips at Nymölla	100 DEM/m^3sub
Bark percent on the logs	9 %
Price for bark	14 DEM/m^3sub
Price for fines/leftovers	40 DEM/m^3sub
Density of the beech wood	1050 kg/m^3
Average diameter of the logs	23 cm
Fuel price (diesel)	1,1 DEM/litre
Electricity price	0,11 DEM/kWh
Wood consumption	3,6 m^3sub/tonne pulp
Pulp price	500 USD/tonne

4 Results

4.1 Results per Component

All the figures and results are also presented in appendix I. The results in this section are divided into the different parts of the system (table 3).

Table 3. Cost per m^3sub for the different investments.

Input volume = 150 000 m^3sub/year.	
	cost (DEM/m^3sub)
Trucktransport	21
Terminal	0.08
Measurement station	0.5
Loader and unloader	2.75
Morbark mobile chipper	9.13
Peterson Pacific mobile chipper	9.24
Valon Kone debarking machine	2.63
Bruks chipper	2.01
Bruks screens	0.59
Other investments (stationary system)	6.45
Other investments (mobile system)	2.22
Railway and ferry transport	49.34
Investments at Nymölla pulpmill	2.88
Insurances	0.22

4.2 Compiled Results

The cost/m^3sub for the different systems is different depending if it is Morbark, Peterson Pacific or Bruks. The revenues in the different systems will not be the same because of the opportunity to sell bark and fines at the terminal for the new system. The revenue for the whole system and the cost/m^3sub are investigated (table 4, fig. 14).

Table 4. The cost per m^3sub and the difference between the new systems compared with present system. Calculated on 150 000 m^3sub/year.

System	**Cost (DEM/m^3sub)**	**Difference (DEM)**	**Difference (%)**
Morbark	88,72	8,72	11
Peterson Pacific	88,83	8,83	11
Bruks	88,46	8,46	11
Present system	80	0	0

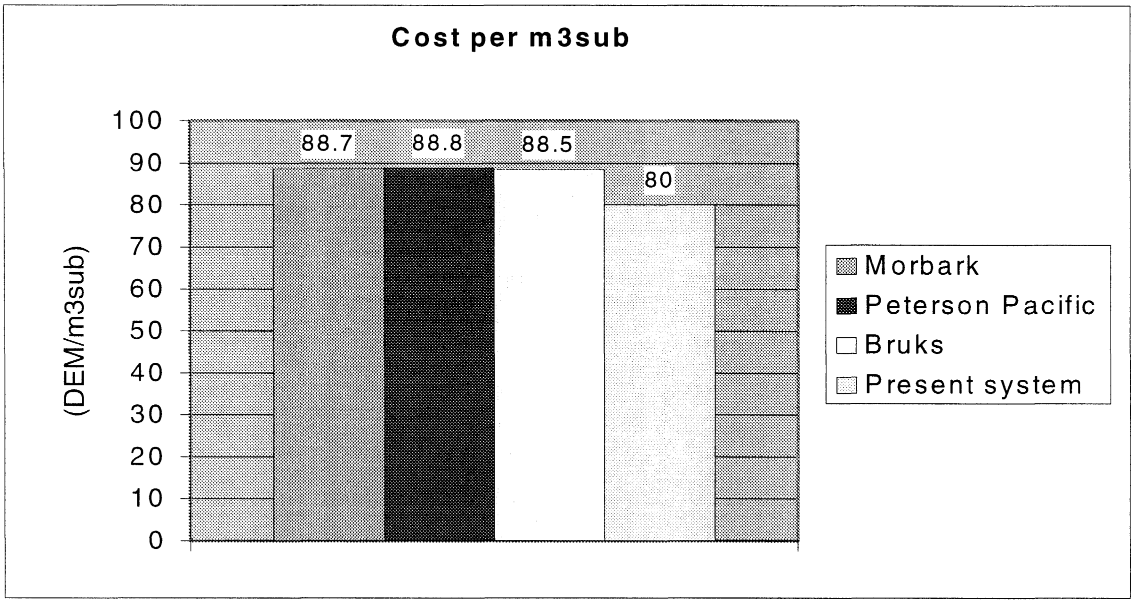


Figure 14. The cost per m^3sub for the different systems.

The income and cost for the new system and the existing system is different depending on the volume sold as leftovers and the volume delivered to Nymölla (table 5, 6, fig. 15)

Table 5. Income and cost for the different systems. Calculated on 150 000 m^3sub/year.

System	**Incomes from chips (DEM/year)**	**Incomes from lefto-vers (DEM/year)**	**Income from bark (DEM/year)**	**Transport cost (DEM/year)**
Morbark	13 500 000	600 000	189 000	11 275 875
Peterson Pacific	13 500 000	600 000	189 000	11 289 024
Bruks	13 500 000	600 000	189 000	11 244 946
Present system	15 000 000	0	0	12 000 000

Table 6. The revenues and differences between the new systems and the present system. Calculated on 150 000 m^3sub/year.

System	**Revenue (DEM/year)**	**Difference (%)**	**Difference (DEM/year)**
Morbark	2 113 125	-30	-886 875
Peterson Pacific	2 099 976	-30	-900 024
Bruks	2 144 054	-29	-855 946
Present system	3 000 000	0	0

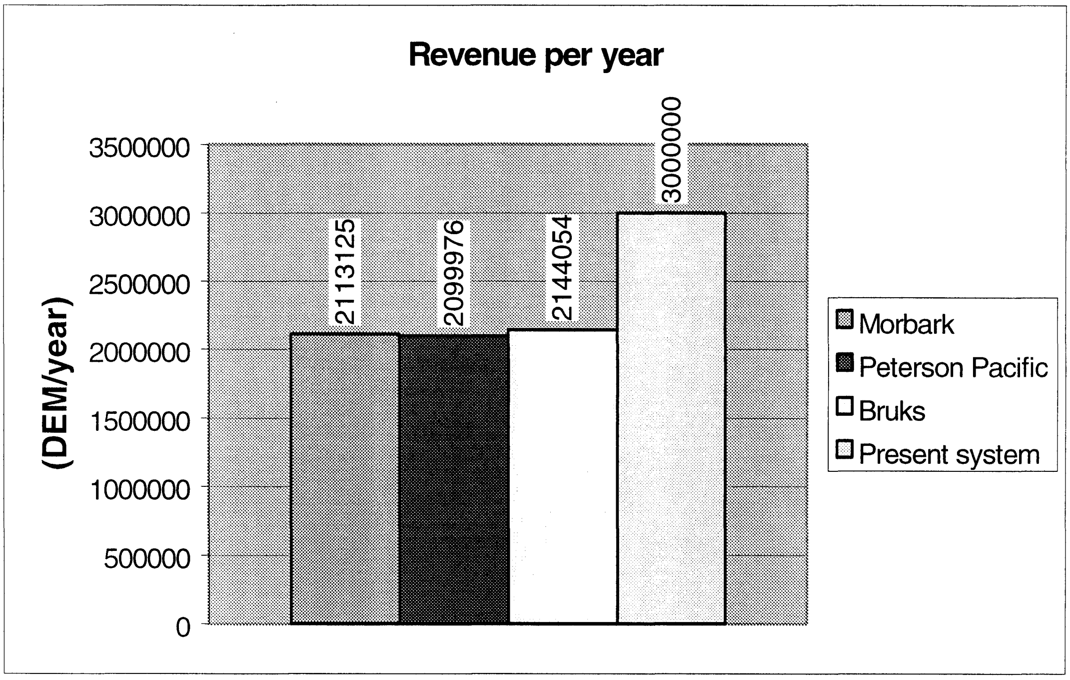


Figure 15. Revenue for the different systems. Calculated on 150 000 m^{3}sub.

The proportions of the transport and investment costs for the different models are shown below. The proportions of costs for the mobile chipper are just represented by Morbark because of the similarity between Morbark and Peterson Pacific (fig. 16-17). The stationary system is represented by Bruks (fig.18-19).

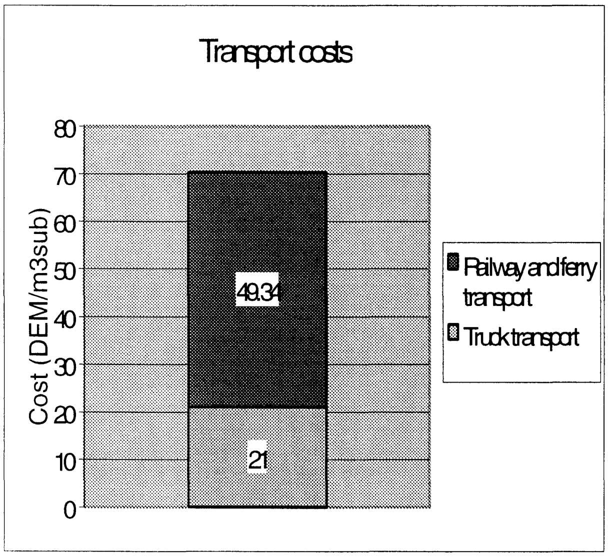


Figure 16. Transport costs for the mobile system.

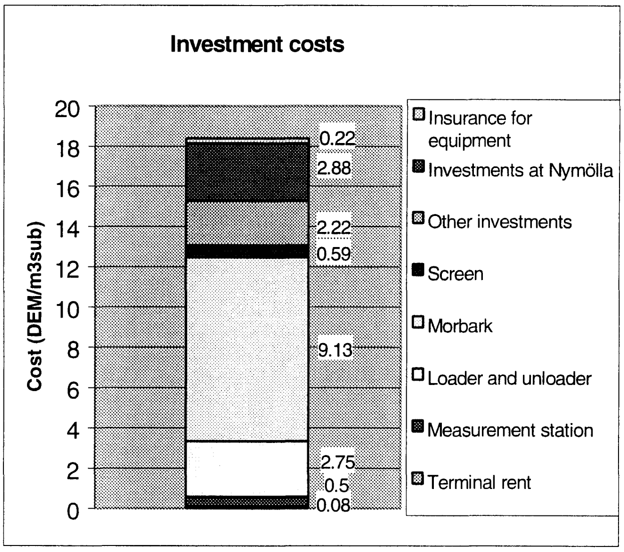


Figure 17. Investment costs for the mobile system.

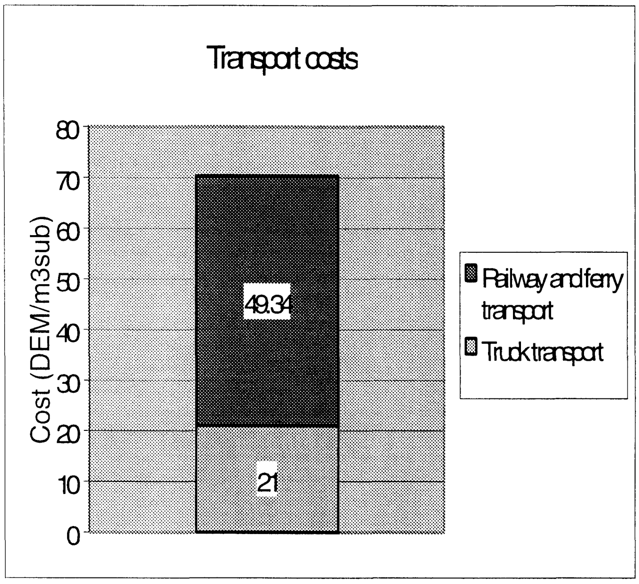


Figure 18. Transport cost for the stationary system.

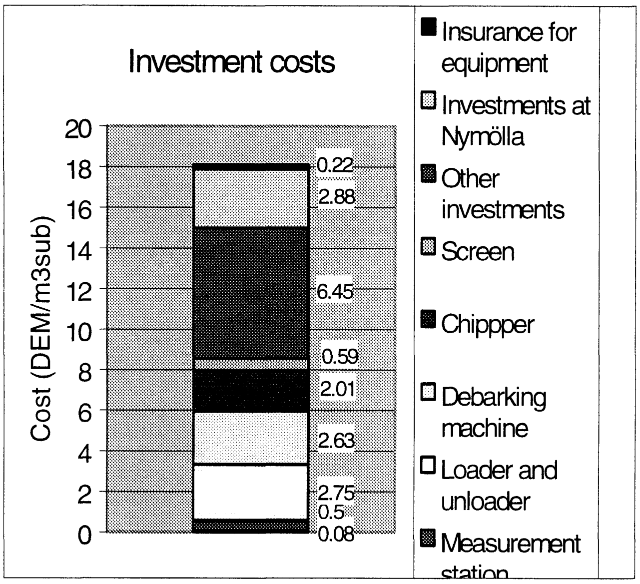


Figure 19. Investment costs for the stationary system.

4.3 Sensitivity Analyses

Sensitivity analyses has been performed by changing the following factors in different ways:

- Input volume
- Proportion of accept chips, the volume sold to Nymölla and the remains that are sold as leftovers
- Price for chips at Nymölla
- Price for the leftovers in Germany
- Density of the wood
- DB fee
- Loading volume of the railway wagons
- Depreciation time
- Wood consumption in the pulp-making process
- Maximum utilisation of the machines

Peterson Pacific and Morbark are similar and are represented by "mobile system". Bruks system is called "stationary system".

4.3.1 Sensitivity Analysis, Volume

The different volumes that are tested are: 50 000, 100 000, 150 000, 200 000, 250 000 and 300 000 m^{3}sub/year. The reference volume is 150 000 m^{3}sub/year. The result is shown in cost per m^{3}sub and in total revenue per year for the different systems (table 7, fig. 20-21).

Table 7. Sensitivity analysis of volume. There are two present systems, one with an increasing truck transport cost and one with a fixed truck transport cost.

Volume (m^{3}sub/year):	Truck transport cost (DEM/m^{3}sub)	Mobile system (DEM/m^{3}sub) (DEM/year)	Stationary system (DEM/m^{3}sub) (DEM/year)	Present system I, increasing cost (DEM/m^{3}sub) (DEM/year)	Present system II, fixed cost) (DEM/m^{3}sub) (DEM/year)
50 000	17	120 -52 5943	120 -495 014	76 1 200 000	77 1 150 000
100 000	19	95.7 89 3591	95.3 924 520	78 2 200 000	77 2 300 000
150 000	21	88.7 2 113 125	88.5 2 144 054	80 3 000 000	77 3 450 000
200 000	23	86.2 3 132 659	86.1 3 163 588	82 3 600 000	77 4 600 000
250 000	25	85.6 3 952 193	85.4 3 983 122	84 4 000 000	77 5 750 000
300 000	27	85.8 4 571 727	85.6 4 602 656	86.0 4 200 000	77 6 900 000
350 000	29	86.5 4 991 261	86.4 5 022 190	88 4 200 000	77 8 050 000
400 000	31	87.5 5 210 795	87.4 5 241 724	90 4 000 000	77 9 200 000

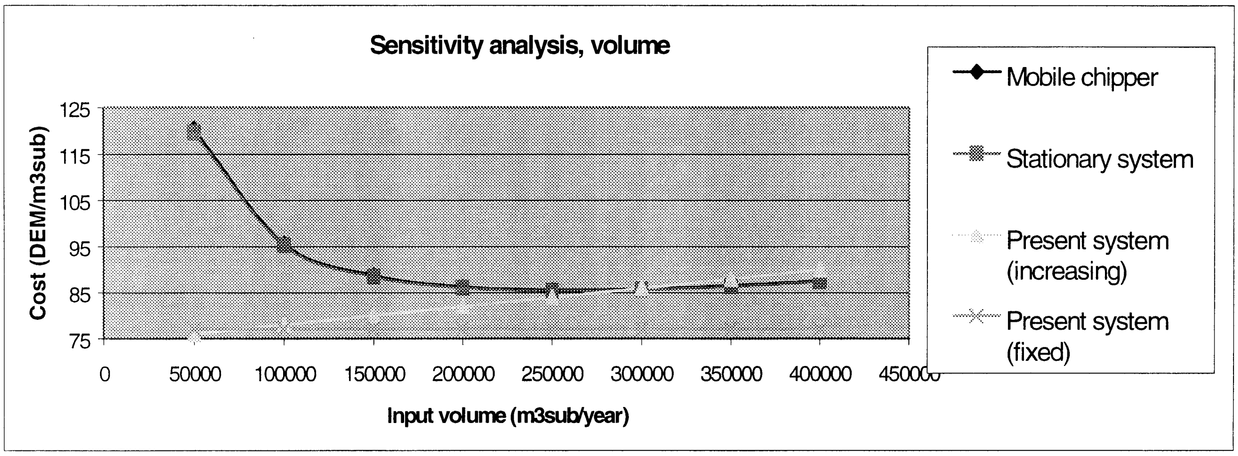


Figure 20. Sensitivity analysis, volume. Cost per m^{3}sub).

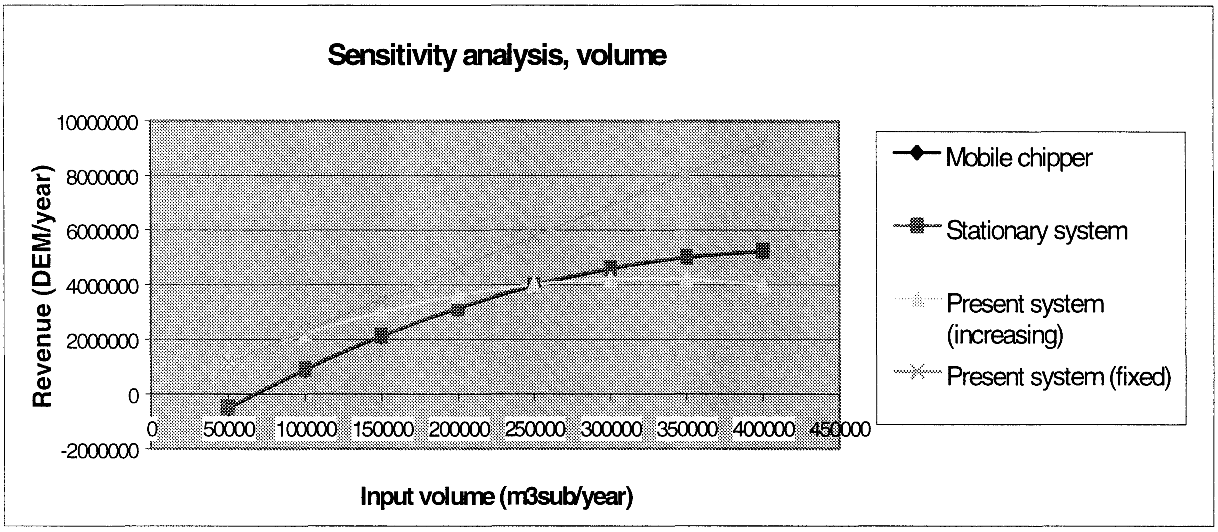


Figure 21. Sensitivity analysis, volume, revenue DEM/year.

4.3.2 Sensitivity Analysis, Accept Chips

The percentage of accept chips is changed from 20 % to 100 %. For example, 50 % means that the chipper produces 50 % accept chips and the rest are leftovers. It can also mean that the chipper produces 100 % accept chips but 50 % are sold as leftovers although they are accept chips. The sensitivity analysis shows how the revenue changes with different volumes delivered to Nymölla (table 8, fig. 22).

Table 8. Sensitivity analysis, accept chips (%) calculated on a volume of 150 000 m^3sub/year. Revenue per year.

Share of accept chips delivered to Nymölla (%)	Mobile system (DEM/year)	Stationary system (DEM/year)	Present system (DEM/year)
20	2 807 531	2 815 263	3 000 000
30	2 691 797	2 703 395	3 000 000
40	2 576 063	2 591 527	3 000 000
50	2 460 328	2 479 659	3 000 000
60	2 344 594	2 367 790	3 000 000
70	2 228 860	2 255 922	3 000 000
80	2 113 125	2 144 054	3 000 000
90	1 997 391	2 032 185	3 000 000
100	1 881 657	1 920 317	3 000 000

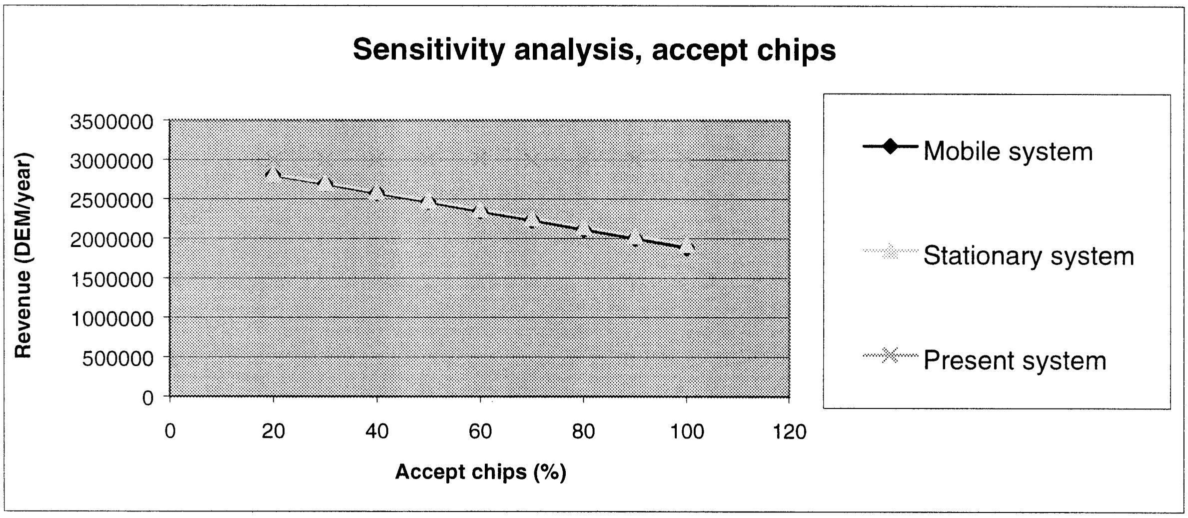


Figure 22. Sensitivity analysis, accept chips. Calculated on 150 000 m^{3}sub/year.

4.3.3 Sensitivity Analysis, Price for Chips at Nymölla

The price in Nymölla is an important factor for the sensitivity analysis, hence it has a substantial influence on the result. In the reference data the price is 100 DEM/m^{3}sub. The present system has a fixed price of 100 DEM/m^{3}sub (table 9, fig. 23).

Table 9. Sensitivity analysis, price for the chips at Nymölla. Revenue per year.

Price at Nymölla (DEM/m^{3}sub)	Mobile system (DEM/year)	Stationary system (DEM/year)	Present system (DEM/year)
80	-286 875	-255 946	3 000 000
90	913 125	944 054	3 000 000
100	2 113 125	2 144 054	3 000 000
110	3 313 125	3 344 054	3 000 000
120	4 513 125	4 544 054	3 000 000

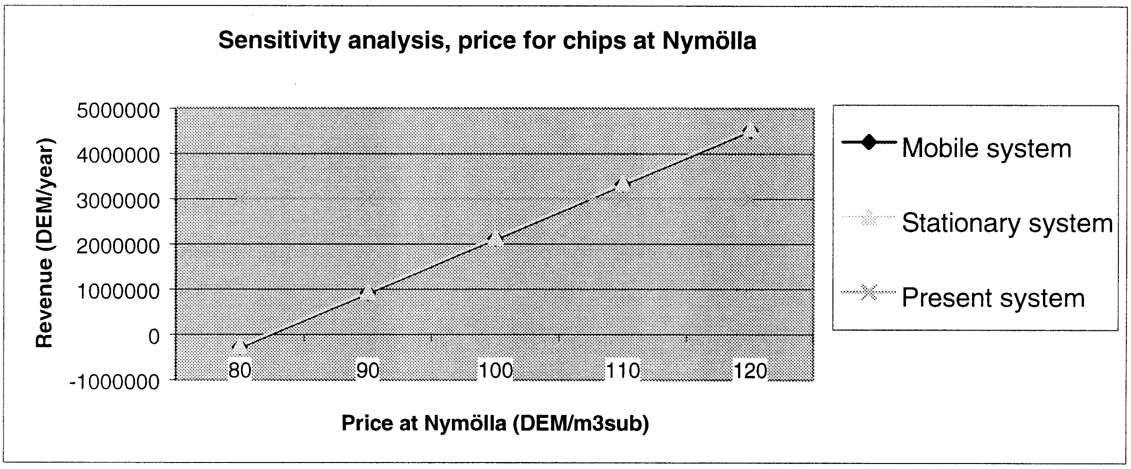


Figure 23. Sensitivity analysis, price for chips at Nymölla (DEM/m^{3}sub). Revenue per year.

4.3.4 Sensitivity Analysis, Price for Leftovers

This sensitivity analysis points out the importance the price for leftovers has. Of course the reference data of 80 % accept chips substantially affects this sensitivity analysis as well as the reference data that the leftovers are sold for 40 DEM/m^{3}sub (15 000 m^{3}sub). If the annual volume of leftovers would increase the result would of course be affected more (see chapter 4.3.2). In the present system all beech pulpwood is delivered to Nymölla (table 10 and fig. 23).

Table 10. Sensitivity analysis, price for leftovers, based on 20 % of the 150 000 m^{3}sub are sold as leftovers. Revenue per year.

Price for leftovers (DEM/m^{3}sub)	Mobile system (DEM/year)	Stationary system (DEM/year)	Present system (DEM/year)
20	1 513 125	1 544 053	3 000 000
30	1 813 125	1 844 054	3 000 000
40	2 113 125	2 144 054	3 000 000
50	2 413 125	2 444 054	3 000 000
60	2 713 125	2 744 054	3 000 000

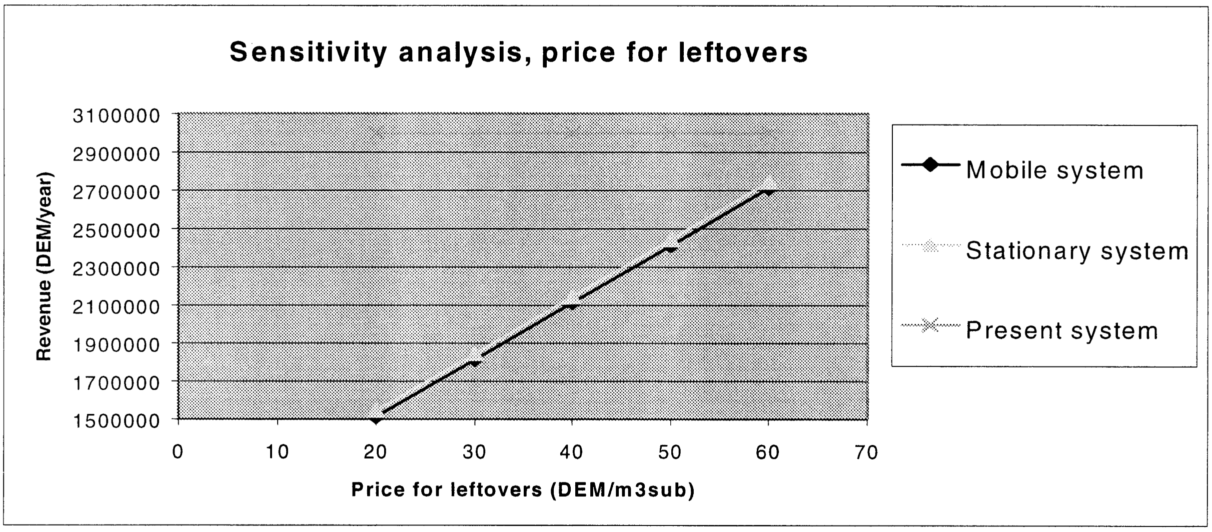


Figure 23. Sensitivity analysis, price for leftovers. Based on that 20 % of 150 000 m^{3}sub are sold as leftovers.

4.3.5 Sensitivity Analysis, Density

The density affects the weight of the cargo in the railway wagons. The railway wagons can carry a weight of 51 tonnes or 182 m^3 each. This will affect the number of wagons per year and the wagons are expensive to rent and to haul. The reference figure for the density is 1050 kg/m^3 (table 11, fig. 25-26).

Table 11. Sensitivity analysis, density. Based on a volume of 150 000 m^3sub/year.

Density (kg/m^3)	**Mobile system (DEM/m^3sub) (DEM/year)**	**Stationary system (DEM/m^3sub) (DEM/year)**	**Present system (DEM/m^3sub) (DEM/year)**
800	76.73 3 551 414	76.47 3 582 343	80 3 000 000
900	81.49 2 980 445	81.23 3 011 373	80 3 000 000
1000	86.27 2 407 046	86.01 2 437 974	80 3 000 000
1100	91.03 1 835 607	90.77 1 866 535	80 3 000 000
1200	95 1 310 360	95 1 341 288	80 3 000 000

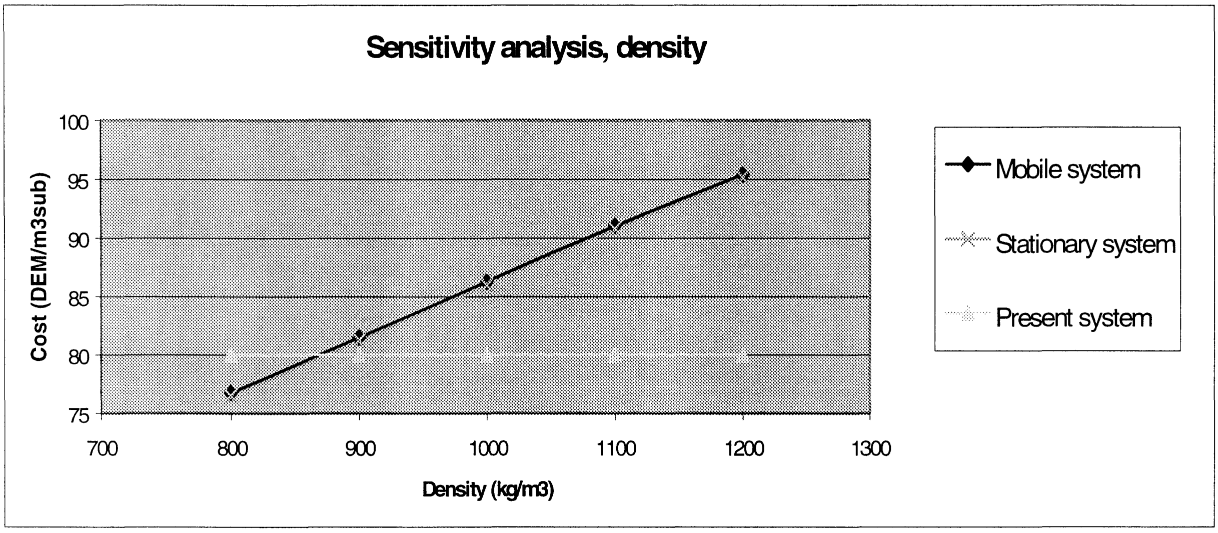


Figure 25. Sensitivity analysis, density. Based on a volume of 150 000 m^3sub/year.

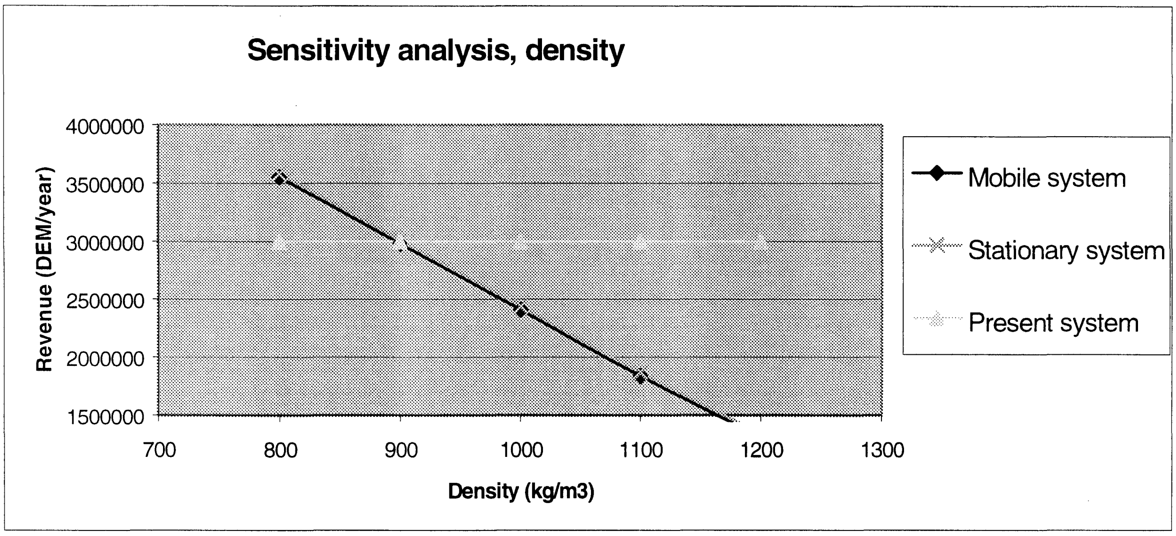


Figure 26. Sensitivity analysis, density. Based on a volume of 150 000 m^{3}sub/year.

4.3.6 Sensitivity Analysis, DB Fee

This is an important and expensive item in the calculations (fig. 14-17). This will affect the results in a significant way. The reference DB fee is 2300 DEM/wagon/trip. The results are presented in cost/m^{3}sub and revenue/year (table 12, fig. 27-28).

Table 12. Sensitivity analysis, DB fee. Based on a volume of 150 000 m^{3}sub/year.

DB fee (DEM/wagon/trip)	Mobile system (DEM/m^{3}sub) (DEM/year)	Stationary system (DEM/m^{3}sub) (DEM/year)	Present system (DEM/m^{3}sub) (DEM/year)
1900	80.42 3 108 150	80.17 3 139 079	80 3 000 000
2100	84.57 2 610 638	84.31 2 641 566	80 3 000 000
2300	88.72 2 113 125	88.46 2 144 054	80 3 000 000
2500	92.86 1 615 613	92.60 1 646 541	80.00 3 000 000
2700	97.01 1 118 101	96.75 1 149 029	80 3 000 000
2900	101.15 620 588	100.90 651 516	80 3 000 000
3100	105 123 076	105 154 004	80 3 000 000

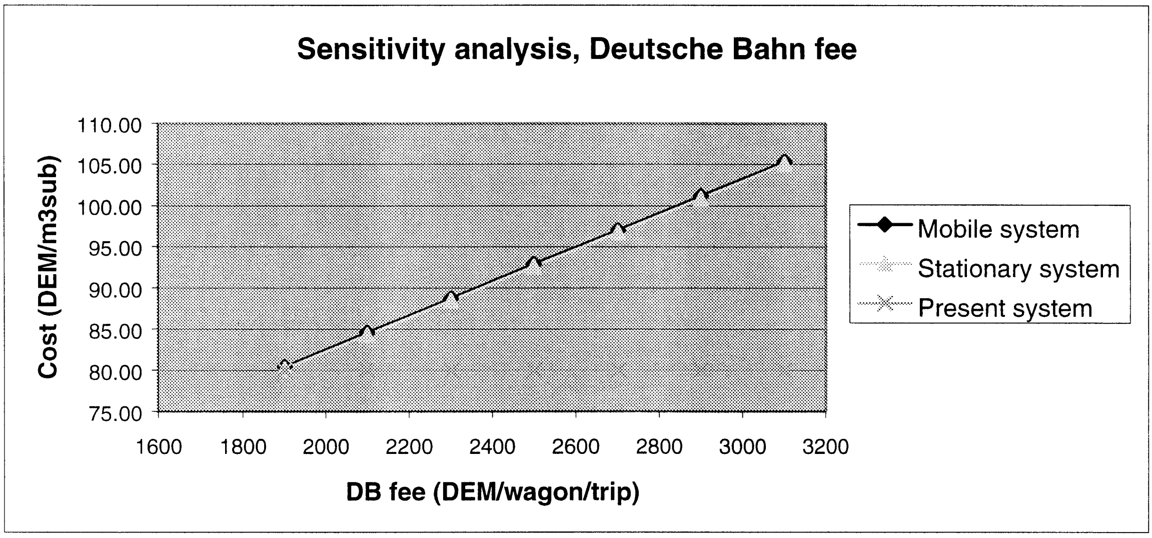


Figure 27. Sensitivity analysis, DB fee. Based on a volume of 150 000 m^3sub/year. Cost per m^3sub.

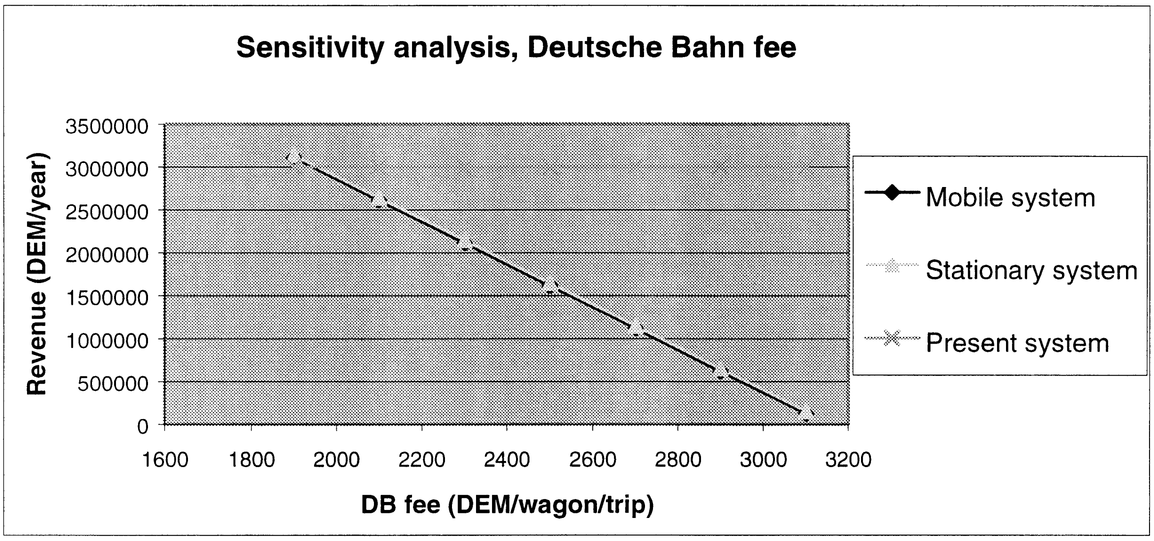


Figure 28. Sensitivity analysis, DB fee. Revenue per year. Based on a volume of 150 000 m^3sub/year.

4.3.7 Sensitivity Analysis, Loading Volume

The railway wagons cannot be loaded with the maximum volume. That makes it interesting to make a sensitivity analysis on the loading volume. How would the cost react if the wagons were loaded with more than they are allowed to carry? The maximum capacity of the wagons is 51 tonnes or a density of 1050 kg/m^3, 134 m^3. The capacity of one wagon is 182 m^3 which would enable a cargo of 68,8 tonnes in each wagon (table 13, fig. 29-30).

Table 13. Sensitivity analysis, loading capacity of the railway wagons. Based on a volume of 150 000 m^{3}sub/year.

Loading volume on the rail-way wagon (m3loose)	Cargo (tonnes)	Mobile system (DEM/m^{3}sub) (DEM/year)	Stationary system (DEM/m^{3}sub) (DEM/year)	Present system (DEM/m^{3}sub) (DEM/year)
100	37.8	105.49 100 190	105.23 131 118	80 3 000 000
120	45.36	94 1 422 412	94 1 453 341	80 3 000 000
140	52.92	86.60 2 366 857	86.34 2 397 785	80 3 000 000
160	60.48	80.70 3 075 190	80.44 3 106 118	80 3 000 000
180	68.04	76.11 3 626 116	75.85 3 657 044	80 3 000 000

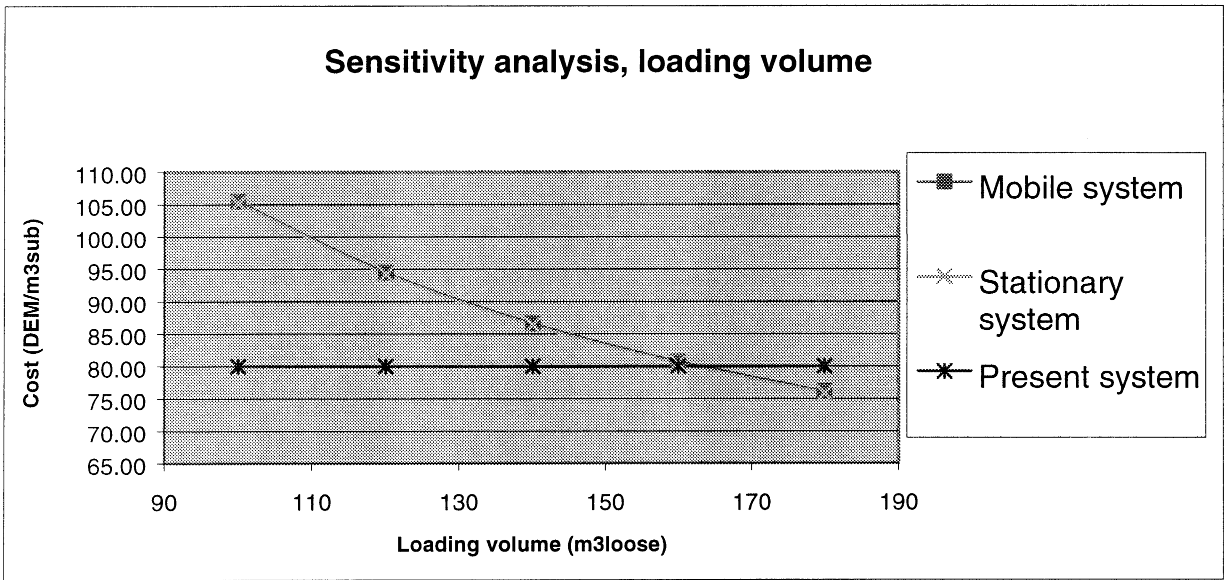


Figure 29. Sensitivity analysis, the loading capacity of the railway wagons. Cost per m^{3}sub.

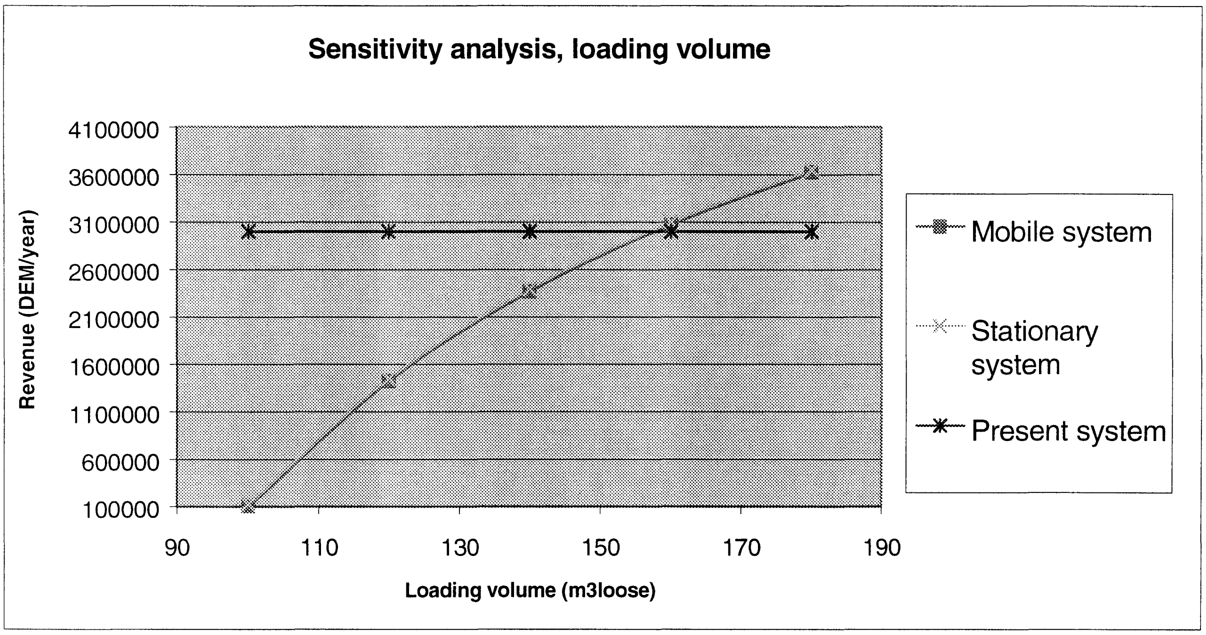


Figure 30. Sensitivity analysis, the loading capacity of the railway wagons. Revenue per year.

4.3.8 Sensitivity Analysis, Depreciation Time

Because of the short depreciation time for this investment it is interesting to investigate how this factor affects the result. It can also be interesting because big investments can be calculated with longer depreciation times, for example railway tracks, etc (table 14, fig. 31-32).

Table 14. Sensitivity analysis, depreciation time. Based on a volume of 150 000 m^3sub/year.

Depreciation time (years)	Mobile system (DEM/m^3sub) (DEM/year)	Stationary system (DEM/m^3sub) (DEM/year)	Present system (DEM/m^3sub) (DEM/year)
5	88.72 2 113 125	88.46 2 144 054	80 3 000 000
10	85 2 541 800	85 2 599 225	80 3 000 000
15	84.04 2 674 458	83.49 2 740 082	80 3 000 000
20	83.54 2 733 908	82.96 2 803 206	80 3 000 000
25	83.28 2 764 840	82.69 2 836 050	80 3 000 000

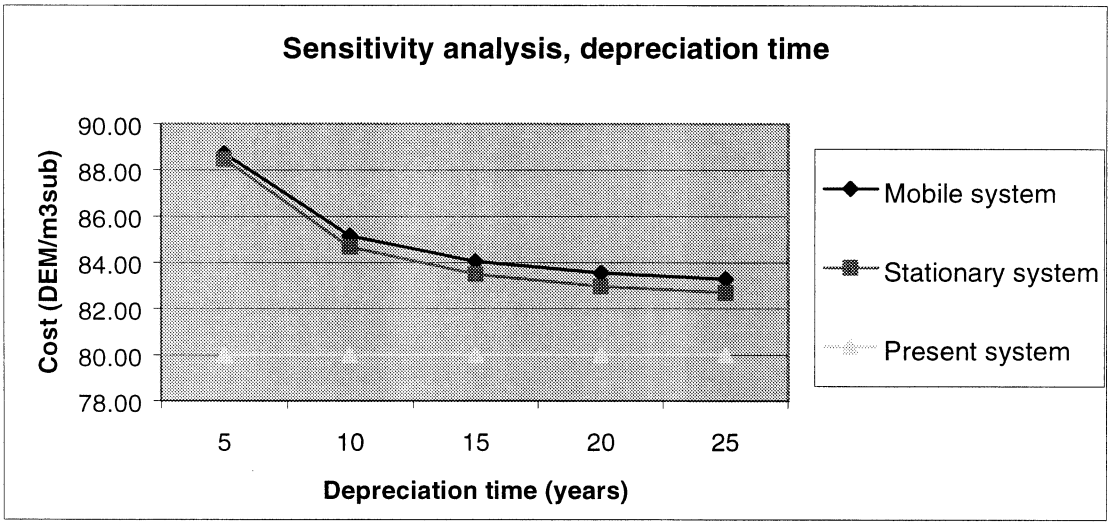


Figure 31. Different depreciation time affects the cost per m^3sub.

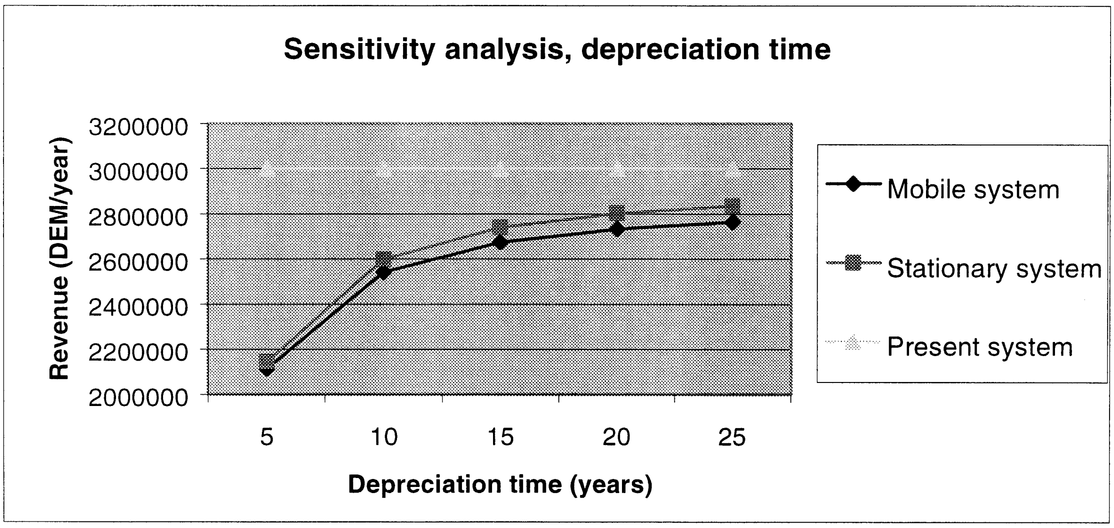


Figure 32. Different depreciation time affects the revenue per year.

4.3.9 Sensitivity Analysis, Wood Consumption

The freshness of the wood and chips effects the consumption of wood in the pulp-making process in Nymölla. Therefore, it is interesting to see how the system reacts to changes in the freshness of the wood. The consumption is calculated with a pulp price of 500 USD/tonne, a wood consumption of 3.6 m^3sub/tonne pulp and a volume of 150 000 m^3sub/year, (tab 15, fig 33-34).

Table 15. Sensitivity analysis, wood comsumption.

Wood consumption (m3sub/tonne pulp)	Total change from consumption-number 3.6 (DEM)	Mobile system (DEM/m^3sub) (DEM/year)	Stationary system (DEM/m^3sub) (DEM/year)	Present system (DEM/m^3sub) (DEM/year)
3.2	5 661 231	51.00 7 774 356	50.70 7 805 285	80 3 000 000
3.3	4 117 259	61 6 230 384	61 6 261 313	80 3 000 000
3.4	2 664 109	71.00 4 777 234	70.70 4 808 163	80 3 000 000
3.5	1 293 995	80.00 3 407 120	79.80 3 438 049	80 3 000 000
3.6	0	88.72 2 113 125	88.46 2 144 054	80 3 000 000

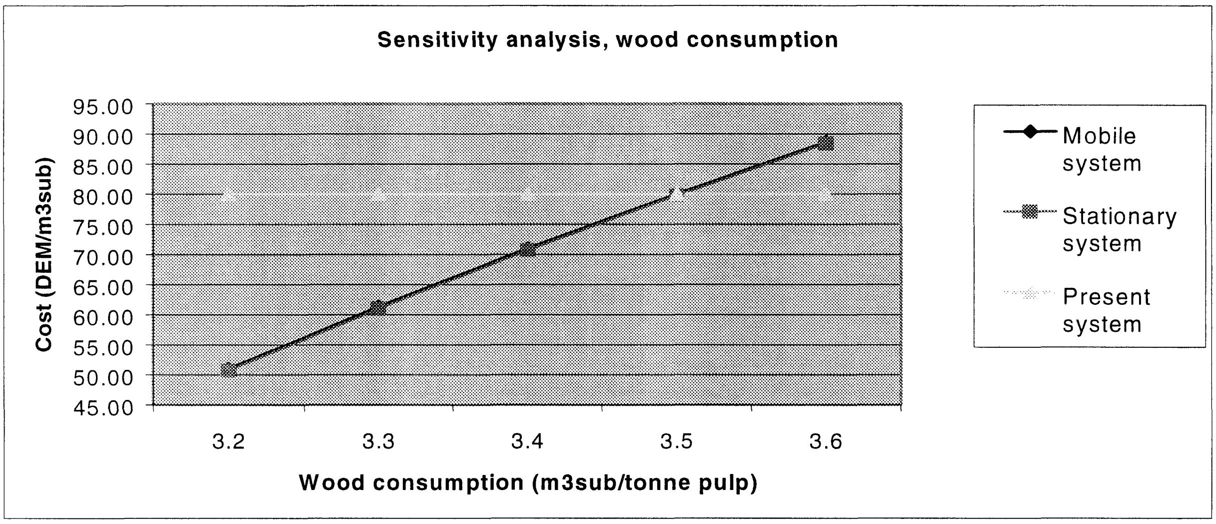


Figure 33. Sensitivity analysis, wood consumption. Based on a volume of 150 000 m^3sub/year. Cost per m^3sub

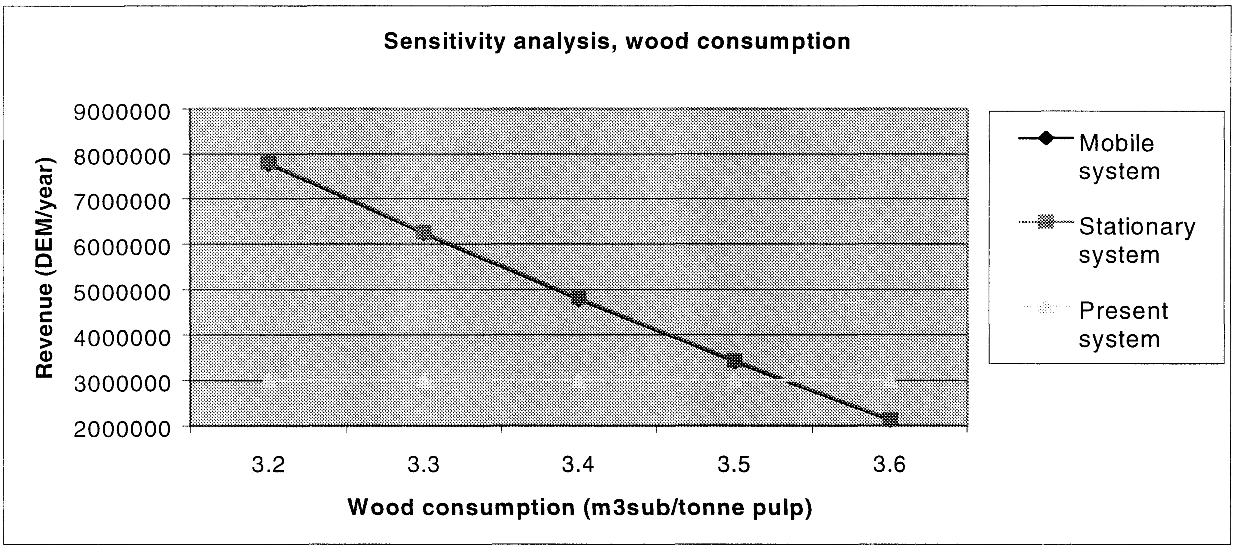


Figure 34. Sensitivity analysis, wood consumption. Based on a volume of 150 000 m^3sub/year. Revenue per year.

4.3.10 Sensitivity Analysis, Maximum Utilisation of the Machines.

Because of the small volumes in the system it would be interesting to see how the system, and in particular, the costs would react if the machines were utilised close to their maximum capacity (and this will be the case if the system was introduced in reality). In the mobile system the chipper is the limit for the system. In the stationary system the debarker limits the capacity. The new system can also be tested with different numbers of shifts and with other tree species than beech. This sensitivity analysis is based on earlier sensitivity analyses and will only show what will happen with the system in different scenarios (table 16-17).For the mobile chipper scenario IV is the only possible option. 150 000 m^3sub/year is the maximum capacity when the capacity is 85 tonnes/hour (it is almost possible in scenario III).

Table 16. Different scenarios for the new system.

	Scenario I	Scenario II	Scenario III	Scenario IV
Total input volume (m^3sub/year):	500 000	250 000	320 000	150 000
Volume beech (m^3sub/year):	250 000	150 000	150 000	150 000
Volume spruce (m^3sub/year):	250 000	100 000	170 000	0
Volume sold to Nymölla (m^3sub/year):	120 000	120 000	120 000	120 000
Number of shifts:	2	1	2	1
Working days/year:	220	220	220	220
Working hours/shift:	8	8	8	8
Truck transport cost (DEM/m^3sub):	25	21	21	21
Debarking speed (metres/min):	60	60	40	40
Average diameter (cm):	23	23	23	23

Table 17. The reactions on the different scenarios. The present system is calculated on 150 000 m^3sub/year. (* the capacity is not enough for this volume).

Scenario	Mobile system (DEM/m^3sub) (DEM/year)	Stationary system (DEM/m^3sub) (DEM/year)	Present system calculated on 150 000 m3sub/year. (DEM/m^3sub) (DEM/year)
I	* 78.97 8 853 095	78.70 8 886 160	80 3 000 000
II	* 76.36 5 622 315	76.49 5 605 988	80 3 000 000
III	* 77.31 6 931 851	76.87 6 985 280	80 3 000 000
IV	80 3 154 790	80 3 127 579	80 3 000 000

5 Discussion

5.1 Method

This study is based on an analysis of a constructed system. Most of the information about the system is collected through discussions with different people. Systems analysis suits this thesis well. One of the biggest problems is that the accuracy of some figures are not quite what we had hoped for. Sometimes they are just assumptions and are nearly correct. This can be a problem for a factor that has a large influence on the result. A sensitivity analyses tests different scenarios and in this case it was necessary to conduct many sensitivity analyses.

The discussions were time demanding and we had to be well prepared to have the right questions. A first contact was made via phone and then an individual questionnaire was sent. If necessary a personal meeting was arranged. In this case the personal meetings diminished the risks of misunderstandings. Sometimes the people that we talked to had problems answering questions because of ignorance or secrecy in the subject. Then the answers had to be approximated or found somewhere else.

The logistic system between Germany and Sweden is complex and has a lot of technical and economical parts. In this context it would not be advisable to change the system without analysing the possible outcomes. A system analysis is a good way to approach the problem. This analysis may be applicable for other systems when pulpwood and long transport distances are involved. But the model would probably require quite a lot of changes before it could be used in another situation.

5.2 Excel Program

The calculation program is constructed in Microsoft Excel and every worksheet contains formulas and calculations. The program is simple to run and it is easy to make assumptions and change the figures when needed. Every subsystem or machine forms a new worksheet and the data can be put introduced, e.g. maintenance costs, operating costs and fuel consumption. As an example deprecation time and internal rent are only shown and cannot be changed in one specific sheet.

A positive aspect is that the figures are easy to change in the sensitivity analysis. A disadvantage is that the model becomes rather complicated. It is hard to trace the errors in the model when all worksheets are connected. One small error in a formula can become large in scale if the editing is executed in one worksheet. The depreciation time and the internal rent can be changed in a special worksheet for general input data.

The Excel program can be a good tool if SEFCE wants to conduct further studies in this area or if other researchers want to do similar studies. Remember that the program is specifically designed for this situation and cannot be used in other situations without changes.

5.3 Technical Conditions

One of the main issues regarding the technical constraints in this problem is the debarking process. The result is highly dependent on the debarking result. Nymölla will not accept the chips if the bark content is over 0,3 %. The representatives from Morbark and Peterson Pacific say that their machines are capable to produce chips with a bark content of 0,3 %. Earlier studies show that chain flail debarking gives chips with a higher bark content compared to drum debarking (Watson, 1991). Chain flail debarking of hardwood will not give a satisfying result for the pulp industry. The only case when chain flail debarking can be used with a satisfying result is with pine in the summer time. (Watson, 1991)

Debarking with knives gives a satisfying result with both hardwood and softwood. It will be a little harder in wintertime but it works anyway. The mobile systems from Morbark and Peterson Pacific will not be an option in this case. One big problem with earlier studies in this area is that they are rather old, some even date from the late 60's. However it is possible that chain flail debarking has improved since then. Valon Kone and Cambio debarkers are well known machines and are used in many sawmills and pulpmills throughout the world. They will give a satisfying debarking result.

One disadvantage with the knife debarking is that the result is very dependent of the shape of the logs. It could be a problem in this case. The logs from Germany vary both in diameter and shape. Most of the wood comes from the later thinnings in beech forests, which explains the different shapes of the logs. However, the usage of chain flail debarking will reduce the importance of the shape.

One thing that is in favour for the stationary system is the capacity of the machines. The maximum capacity of the mobile machines is 60-100 m^3sub/hour. The stationary Bruks chipper can produce up to 400 m^3loose/hour (144 m^3sub/hour). If the use of biofuel increases in Germany, it can be a good investment to have overcapacity. Maybe a bigger amount of chips could be sold to heating plants and other customers in Germany.

The debarking machine in the stationary system sets the limits for the capacity. But it is no problem right now, the restricting volume for the debarking machines will be around 300 000 m^3sub/year. However the mobile machines are easier to move in the event of the terminal being forced to shut down.

There are other wagon types to transport wood chips in. Maybe it would be better to have a special wagon only for chips and transport the railway wagons between the destinations without any returning transports.

The specifications of the machines also have to be discussed. Many of the specifications are very precise, but some of them just are assumptions or rough figures. That is the case with the data about the machines from Peterson Pacific. After we studied the machine from Peterson Pacific and the machine from Morbark we decided that the machines were quite similar and we could assume that the specifications were similar too. The information from Peterson Pacific was not as in depth as the information from Morbark.

Wheel loaders from Volvo are well known machines and are very good for their purpose. But there are also some alternatives, Caterpillar for example. There might also be some alternatives to the chipping systems, such as the machines from the German company Doppstadt.

5.4 Results and Economic Conditions

The results for the different systems (Morbark, Peterson Pacific and Bruks) are quite similar considering the economy (table 4). The present system is 11 % better than the suggested system, which means that the cost will be around 8-9 DEM lower per m^3sub. The result is dependent on several large scale investments (fig. 17, fig.19). The cost for truck and railway transportation is 70 DEM/m^3sub in the new system, which is 7-10 DEM lower than the same cost in the present system. There are other costs in the new system that make it more expensive. For Morbark and Peterson Pacific the cost of the chipper presents the biggest share of the investment. In the Bruks system the largest costs are the other investments around the chipper, for example the debarker and screens. However the operating costs for the Bruks system will be a little bit lower.

The revenue per year has to be considered when comparing the systems. 150 000 m^3sub/year is a big volume and will generate a big volume of bark and leftovers. The bark and the leftovers can be sold in Germany. This fact can highly influence the end result. The difference in annual revenue between the two systems is 30 % in favour for the present system (table 6).

The investments are calculated on a high annual volume. If the annual volume is too small the new system will not be competitive compared to the present system. These results are calculated with the reference figures and will not give an optimal result. If the systems are optimised the costs will be reduced and the new system will be preferable (table 16-17).

The costs for the investments are equal or higher than the costs in the present system. Furthermore it is possible that the new system has more advantages than are shown here but this will discussed further in the section *"possibilities and problems"*.

5.4.1 The Sensitivity Analysis

The sensitivity analysis is interesting in many ways because of its complexity. Sometimes it is more important to look at the sensitivity analysis because it can describe a certain situation more accurately than the result. It shows where SEFCE can try to negotiate or try to change the figures. It also shows which factors are the most important for the end result.

Volume

Volumes between 50 000 m^3sub/year to 300 000 m^3sub/year were tested using the sensitivity analysis. The result is very interesting since there evidence of a decreasing cost per m^3sub from 50 000 m^3sub/year to 150 000 m^3sub/year (fig. 17). This shows the importance of volumes of 150 000 m^3sub/year or over.

There is one turning point on the curve where the cost per m^3sub increases with greater volumes. This is explained by a more expensive truck transport with extended volumes and supply areas. The curve turns at approximately 250 000 m^3sub/year. Changing volumes can distort the interpretation of the problem in the sensitivity analysis. A more accurate description would be that the machines do not have to operate longer spells with volumes like 50 000 m^3sub/year compared with volumes of 300 000 m^3sub/year. The machines do not work at maximum capacity compared with the operating hours in the sensitivity analysis (presented in the sensitivity analysis "*maximum utilisation of the machines*").

The present system is represented by two curves. One curve with a fixed truck transport cost and one curve with an increasing truck transport cost. Without this it would be difficult to compare the present system with the new. The truck transport cost increases with the volume but it is difficult to say by how much. At a certain volume the present system with increasing costs intersects the new system, meaning that, at a certain volume an investment in a chip terminal would be more profitable and hence advantageous (which is discussed further in "*possibilities and problems").* In the present system the fixed curve never intersects the curve of the new system because of the non-existing cost of increasing the volume of wood (figure 21).

Accept Chips

The sensitivity analysis of accept chips can be seen as the study of the percentage of chips that are produced and the volume of those that are sold as fines or leftovers. It can also be seen as the percentage of chips that are delivered to Nymölla.

The percentage of accept chips delivered to Nymölla affects the revenue per year (fig. 22). The result from the analysis shows it is better to sell the chips to local factories than delivering it to Nymölla in the new system. There are no possibilities to sell chips, leftovers and bark to local factories in the present system. The result is explained by the expensive transportation of chips and the price for the chips locally. There could be a dramatic change if the market price for leftovers and fines increased or decreased.

Price at Nymölla Pulpmill

The sensitivity analysis of the price at Nymölla has a big affect on the revenue because of the big volume that is delivered to Nymölla (fig. 23). It is only the revenue that is affected by a changing price at the pulpmill. The transport cost is not affected by a change of price. Already when Nymölla is paying 108 DEM/m^3sub (+8 %) the result is positive compared to the pres??ent system. A profit would be possible because of a higher chip refining grade and the possibility to save money and maintenance costs on machines (discussed in the section *"possibilities and problems").*

Price of Leftovers

The price of leftovers is difficult to predict. Therefore it is an interesting factor to analyse. The revenue, of course, depends on the amount leftovers and accept chips sold in the system. With the reference data of 20 % chips sold as leftovers, the price has to rise to about 70 DEM/m^3sub before profit could be made (fig. 24). If the price was 70 DEM/m^3sub the best solution would be to sell everything locally. This conclusion was already made in the analysis of accept chips at a price of 40 DEM/m^3sub.

The price of the leftovers has no major influence on the revenue per year. That can be explained from the small volume that is sold as leftovers (20 % = 30 000 m^3sub/year). Lets say that SEFCE sells 50 % (75 000 m^3sub/year) as leftovers and the price would raise to 47 DEM/m^3sub. The conclusion is that the new system is as good as the present system.

The analysis of the price of the leftovers shows how the profit changes with a changing price on the market. This could be of importance when SEFCE are seeking to find the best solution. If SEFCE could attain a good price for the leftovers from local factories, the possibilities of great profits would arise from the proposed system.

Density

The density was not expected to have such an important role. After the sensitivity analysis on the density was performed it turned out that the density was of greater influence than expected.

The density affects both the cost per m^3sub and the revenue per year (fig. 25-26), which can be explained by the railway wagons, which are not fully loaded. The wagons are full considering the capacity in tonnes but not when considering the capacity in cubic metres. When the wood is less dense there is an opportunity to load more cubic meters onto the railway wagons. This would make the transport per cubic meter cheaper (fig. 25).

The present system and the new systems are equal at a density of about 900 kg/m^3, which means that the costs and the profits are equal. The difference is not substantial compared to the reference number of 1050 kg/m^3. The density cannot be changed in reality and that is a problem. The only way is to let the wood dry before the transport. That is not either a good solution. It can be discussed whether the figure is correct in this case. The wood may have been lying in the forest for a long time, which leads to a decreased density of the pulpwood.

As stated above a density of 1050 kg/m^3 is used in the new system and the present system has a lower unknown density. What would happen if the wood was stored as long as today? Maybe the density would decrease so much that the new system would be equal to the present system. Hopefully the system would work so well that the wood would not have to lie in the forest for a long time. Because of the restrictions and laws in Germany there would be a period where the pulpwood would be stored. The pulpwood has to be cut during autumn and winter. The pulpwood that to be used during spring and summer has to be cut then as well. Therefore storage occurs and the density is reduced by drying of the wood.

DB Fee

The railway fee is a factor that may be changed by negotiations with DB. That is why it is interesting to look at the models reaction when altering the DB fee. The cost and the revenue are strongly affected by the DB fee (fig. 26-27).

The curves for cost and revenue intersect at approximately 1900 DEM/wagon. This figure can be useful when SEFCE negotiates the fee. The fee can vary within a large span, which is important to consider when using this figure.

Loading Volume

The loading capacity of a railway wagon is 182 m^3 or 51 tonnes. With a density of 1050 kg/m^3 the wagons can be loaded with 134 m^3 of chips. This is not an optimum and therefore it is interesting to see how the cost per m^3sub and revenue per year is affected with an increasing loading volume. (table 13, fig. 29-30).

The intersection between the new and the present system occurs at a volume of approximately 160 m^3. This volume has a weight of 60,48 tonnes which is nearly 10 tonnes more than what is allowed (with a density of 1050 kg/m^3). If it was possible to load more than 60,5 tonnes or 160 m^3 in each wagon SEFCE could make a profit on this investment.

Depreciation Time

The sensitivity analysis on the depreciation time shows how the systems are affected by four different depreciation times, 5, 10, 15 and 20 years. The large and long term investments are also of interest. A depreciation time of five years is used because of the risks involved in the project. There are investments in this project that can be calculated with an increased depreciation time, for example railway tracks, machines etc.

The result is not as substantial as we had as expected. The depreciation time does not severely affect the cost per m^3sub or the revenue per year and it flattens out at 10 - 15 years (fig. 31-32). The change between five to ten years presents the largest difference. There is almost a difference of 4 DEM/m^3sub or 450 000 DEM/year. This is a figure that could mean the difference between profit and loss in the system, something to keep in mind.

Wood Consumption

The wood consumption is defined as the volume of pulpwood it takes to make one tonne pulp. The wood consumption depends on how fresh the wood is. Today the pulpwood is rather old, sometimes two years old, which makes the wood consumption higher compared to fresh wood. The sensitivity analysis shows the financial savings made by decreasing the wood consumption. The volume of pulp is then multiplied with the price for one tonne pulp (500 USD/tonne pulp).

In the new system a new type of wagon would be used and the system will work with system trains. This will ensure the delivery service and therefore lead to fresher wood that will decrease the consumption number. The decreased consumption volume is hard to estimate without further studies. The wood consumption turned out to have a big effect on the cost and revenue in the system (table 15, fig. 33-34). If the consumption is reduced by 0,1 m^3sub/tonne pulp the result shows that it is profitable to change system. Due to the fresher wood in the new system, profit can be made. Storage will also occur in the new system but only during the sap-period (spring to summer) but hopefully the wood will be fresher compared to the present system.

Maximum Utilisation of the Machines.

The reference data may not always describe the truth in the best way. The reality is complex and hard to reconstruct and describe in a proper way. Many factors have to be included and sometimes it is difficult to evaluate the result. Therefore sensitivity analyses involves working with cases where some basic data is used and changed to fit the system. This may not be a proper way to compare the systems. For example, if this model was accepted and introduced in the real world the machines would probably be operated to the maximum in shifts.

The number of different cases could be more than four. The sensitivity analysis shows how changing assumptions can affect the result (table 16-17).

The result is interesting and shows what the reality could look like. The scenarios are discussed further below.

Scenario I: This scenario is optimised to the maximum volume that the stationary system manages. The capacity of the debarker is 60 m/min and operating two shifts per day it can manage to debark a volume of 500 000 m^3sub/year. The speed is a factor that is hard to predict. According to Valon Kone a speed of 60 m/min is manageable, but this is uncertain because of difficulties in debarking beech. When a volume of 500 000 m^3sub/year is achieved there are many possibilities to experiment with species and different volumes. The truck transport cost is hard to predict at different volumes and with different species. Here it is 25 DEM/m^3sub, but this figure can always be discussed.

The result shows a decreasing cost per m^3sub and big revenues each year. Meaning that the stationary system could be implemented without any changes to the costs or the revenues. The SEFCE gain on this system. The following questions could be asked: Is it possible to increase the volume to 500 000 m^3sub/year? What will happen with the prices and the market?

Scenario II: This scenario is also optimises the volume but the number of shifts are reduced from 2 to 1. This will decrease the volume of wood but also the truck transportation costs. The results show that the decreased costs for the truck transportation will affect the cost per m^3sub in a positive way. The revenues are less here because of the decreased volume.

Scenario III: The speed of the debarker is 40 m/min which will reduce the volume capacity of the system. There are 2 shifts and an annual volume of 320 000 m^3sub. This gives no dramatic changes to the cost/m^3sub.

Scenario IV: The shifts are reduced from 2 to 1. The feeding speed is still 40 m/min (ref. = 21 m/min). The volume is 150 000 m^3sub/year (reference data). The results show that the cost per m^3sub will be the same as in the present system. Meaning that the speed of the debarker has to be increased in the stationary system and that there will not be any changes to the cost per m^3sub.

5.5 Possibilities and Problems

General Possibilities

- The area in Thüringen has a high density of beech forests. This gives the opportunity to create a chipping terminal in the area.

- One big problem is the increasing annual volume of pulpwood at the terminal in Hohenebra. The expanded supply area radius makes the costs for the truck transportation greater. The transportation could be facilitated with new roads, built near the terminal in Hohenebra. In a few years there will be two autobahns and one bigger road close to the terminal. The road building will decrease the cost of truck transportation and will at the same time open a bigger supply area for SEFCE.

- The terminal will give opportunities for SEFCE to make business partners at local board factories, which is one of their strategic goals.

- The increasing volume of wood and the co-operation with local factories can give better control on the German market and possibilities for SEFCE to expand.

- The possibility to buy wood in different areas in Germany, especially in Thüringen where beech pulpwood is cheap.

- There are also possibilities to get subsidies from the German government when investing in projects in eastern Germany.

- The product gets a higher grade of refining in an earlier stage of the logistic chain.

- The new system means that SEFCE do not have to transport bark all the way to Sweden and the volume that is transported will have a higher value.

- The new type of wagon will be easy to unload and load. The present system does not have this advantage and sometimes SEFCE uses a type of railway wagon that costs 8 DEM/wagon more compared to the "normal" wagon.

- The new type of wagon is covered. The choice to use a covered wagon presents the prospect of returning trains transporting other goods. In this way the returning transports do not have to be solid wood.

- The usage of a system train will secure the delivery service and decrease the storage of pulpwood. The storage cost will be reduced.

- Chips can be sold to local heating plants that use bio-fuel.

Possibilities for Nymölla

- There will changes at the pulpmill. Money can be saved on spare parts for the loader, unloader, screen, chipper, and debarker. It can also lead to reducing the number of shifts used for cleaning work because of a smaller volume to debark, chip and screen. Water consumption and electricity costs are other things can be reduced in the new system

- Fresher wood saves money. The money saved by reduced wood consumption is hard to predict and it is discussed further in the sensitivity analysis.

- Fresher wood means less chemical oxygen consumption (COD) in the cleaning pool. That will save money and improve the environment around the pulpmill.

- The new system can also lead to lower bark content in the chips. Low bark content will lead to a smaller amount of bleaching chemicals in the cooking process. Money and environment can be saved.

- The new system includes investments in a railway track and a chip pocket with a conveyor. These investments may be useful for other things.

- The new system will use another type of railway wagons, which leads to an improved delivery service of wood.

Problems

- The debarker has to achieve a bark content of 0,3 % or less.

- The annual volume has to be big to keep the costs at a low level.

- Sound barriers have to be built to protect the people that live near the terminal from noise.

- Nymölla has to buy bark to replace the loss of bio-fuel.

- The machines might be too big to be driven on European roads. If that is the case the mobile machines are not so mobile anymore. The transportation between the terminals will be a problem.

- It may be problematic to sell the bark in Germany.

- There are factors that are uncertain such as the electricity price, DB fee, etc.

- What does the future market for beech pulpwood look like and for how many years will is the chip terminal operate?

6 Conclusions

After having studied the results from the analyses we have come to the conclusion that the new system is better compared to the present system, provided that the machines are optimally used. However there are some factors that will affect the profitability of the new system in a substantial way:

- A maximum utilisation of the machines in the new system will result in a profit for SEFCE. The new system will be profitable if the speed of the debarker is 40 or 60 m/min.

- The bark content will only reach an acceptable level with a stationary system, thus the only system of interest is the stationary Bruks system. If the chipping system does not achieve the demanded bark content then delivering wood chips to Nymölla will not be an option.

- It is very important to load the railway wagons to their maximum potential. Presently this is not the case, which proves costly. By loading 30 m^3 more in each wagon the result on the investments would be positive. This is only possible if the density of the wood is 850 kg/m^3 or less.

- The fee that DB takes to drive the system train from Germany to Sweden is a very important figure. If the cost was 450 DEM lower/wagon (reference figure 2300 DEM/wagon/trip) then investing in a new chipping terminal would be profitable.

- The density of the beech wood is also very important. Dry beech wood has a density of 650 kg/m^3 and fresh beech wood has a density of 1050 kg/m^3. A reduction of the density with 200 kg/m^3 (from 1050 kg/m^3 to 850 kg/m^3) will generate a positive result on the investments.

- If Nymölla is prepared to pay more for the chips then a chipping terminal in Germany would be of interest. If the price is 108 DEM/m^3sub instead of 100 DEM/m^3sub the new system would be profitable.

- If SEFCE can sell more of the chips in Germany to heating plants, OSB- and MDF mills and receive a good price, the revenues will increase since expensive transportation to Sweden is excluded.

- The annual input volume should be over 200 000 m^3sub to attain a positive result on revenues.

- Reducing the consumption of wood in the pulp cooking process can save a lot of money. A reduction from 3,6 m^3sub/tonne pulp to 3,5 m^3sub/tonne pulp will save approximately 1 300 000 DEM/year.

- This study has been conducted without considering returning transports in the different systems. A bigger profit can be made with more returning transports.

7 References

7.1 Literature References

Arnquist, R., Dircks, H., Genfors, W., Löbbermann, R., Müller, K., 2001. *Statement of Stora Enso Forest Central Europe GmbH concerning the inquiry industrial wood (beech) in Germany from Stora Enso Forest Sweden.* Internal report, Stora Enso Forest Central Europe, Düsseldorf.

Franklin, G.S. 1992. *Model 23 Flail Chiparvestor Delimber-Debarker-Chipper: Productivity And Chip Quality In Hardwood.* Technical Note TN-187. Wood Harvesting. Feric-report. Forest engineering research institute of Canada.

Genfors, W. 2001. *A short presentation.* External presentation. Stora Enso Forest Central Europe, Düsseldorf.

Gustafsson, L., Lanshammar, H., Sandblad, B. 1982. *System och modell en introduktion till systemanalysen.* Studentlitteratur, Lund.

Håkansson, M., 2000. *Skogsencyklopedin.* Forest encyclopaedia. ISBN 91-7646-041-X Sveriges skogsvårdsförbund..

Kassberg, M., Erlandsson, M., Gavelin, G., 1998. *Massa och papper- en grundbok.* ISBN-91-7322-233-X. Skogsindustrins Utbildning i Markaryd AB.

Lumsden, K., 1998. *Logistikens grunder.* ISBN 91-44-00424-9. Studentlitteratur, Lund.

Stora Enso, Nymölla Bruk. 1999. *Miljöredovisningen.* Nymölla Bruk, Nymölla.

Watson, W.F., Twaddle, A.A., Stokes, B,J., 1991. *Pulp chip quality from in-woods chippers coupled with chain flail delimbers-debarkers: does it match conventional woodyard quality?* Technical release. Vol. 13 No. 2. Logging Industry Research Association, New Zealand.

Wizemann, A., 2000. *Energy wood in Stora Enso Forest Central Europe.* Internal report. Stora Enso Forest Central Europe, Düsseldorf.

7.2 Personal Communications

Agrell, T., Virkeschef, Sydved, Jönköping, Sweden, May 2001.

Andersson, I., Virkesmätningsansvarig, VMF Syd, Jönköping, Sweden, May 2001.

Bruks, A., Senior consultant. Bruks BioTech AB. Stockholm. Sweden. June 2001.

Fehring, D., Dipl.-kaufmann/MBA, Fehring Holzpäne, Bielefeld, Germany, May 2001.

Fritzon, L-O., Vedhanteringsansvarig, Nymölla bruk, Nymölla, Sweden, May 2001.

Haraldsson, H-E., Säljare, SWECON anläggningsmaskiner, Jönköping, Sweden, June 2001.

Genfors, W. Vice president, Stora Enso, Düsseldorf, Germany, May 2001.

Kowallic, K., Sales administrator. Morbark, Winn. Michigan. USA. May 2001.

Kundt, U. Wood purchaser. HVG. Thüringen, Germany, May 2001.

Löbbermann, R. Logistics manager, Stora Enso Forest Central Europe. Düsseldorf, Germany, May 2001.

Lang, R., Sales administrator. Peterson Pacific. Eugene. USA. May 2001.

Nilsson, J., Säljare. Valon Kone AB. Bollnäs. Sweden. May 2001.

Walfridsson, E., Universitetsadjunkt. Sveriges Lantbruks Universitet. Institutionen för skogshushållning. Umeå. Sweden. June 2001.

Wiksten, K., Area manager. Söderhamn Eriksson Cambio AB. Söderhamn. Sweden. May 2001.

Österberg, S., Transport Manager import, Transports and wood supply, Sydved, Jönköping, Sweden, May 2001.

7.3 Internet Sources

Bruks product description. May 2001. http://www.bruks.com/ (3 July 2001.)

Fehring. May 2001. http://www.fehring.de/index-e.htm (4 July 2001.)

Morbark product description. May 2001. http://www.morbark.com/equipment_specs/2755flail.htm (3 July 2001.)

Peterson Pacific product description. May 2001. http://www.petersonpacific.com/5000.htm (3 July 2001.)

Stora Enso. May 2001. http://www.storaenso.com/content/index.asp?id=37&top=37 (4 July 2001.)

SWECON product description. May 2001. http://www.swecon.se/. (3 July 2001.)

Volvo product description. May 2001. http://www1.volvo.com/frameset.html?url=http://www1.volvo.com/volvoce/gis. (3 July 2001).

8 Appendices

Appendix I - IX

I. The structure of the system and the model that has been constructed.

II. Different machines from the Swedish manufacturer Bruks: whole log chipper, free-swinging screen and tubulator conveyors. The information is collected from brochures and from Bruks website (www.bruks.se).

III. Valon Kone debarking machine 820/5 from the Finnish manufacturer with the same name.

IV. Information about the debarking machine Cambio 90-80 from the Swedish manufacturer Söderhamn Eriksson. There are also some drawings of the machine attached in the appendix.

V. Wheel loader L120D from the Swedish manufacturer Volvo. This information was collected on Swecon's homepage (www.swecon.se).

VI. Information and facts about the mobile chipper from the American manufacturer Morbark. There are also some facts about the costs of running a machine like this.

VII. Information and facts about the mobile chipper from the American manufacturer Peterson Pacific.

VIII. Specifications about the railway wagons from Fehring Holzspäne that are used in the calculations.

IX. Drawings, maps and information from the suggested terminal in Thüringen in the eastern part of Germany.

Appendix I - IX

Appendix I:

- System construction.

Input data

(yellow=don't change, orange=change)

Internal rent:	10	%
Rest value:	15	%
Deprecitation time:	5	years
Total input volume wood:	150000	m3sub
Convert ("m3sub" to "m3loose"):	0.36	
Percent of accept chips:	80	%
Volume of chips:	120000	m3sub
Volume of chips:	333333.33	m3loose
Weight on chips/year:	126000000	kg
Weight/day:	345205.48	kg
Price for chips/m3sub:	100	DEM
Bark percent on the logs:	9	%
Volume bark:	13500	m3sub
Price for bark/m3sub:	14	DEM
Volume of rest chips:	30000	m3sub
Price for fines/m3sub:	40	DEM
Density of the wood:	1050	kg/m3
Average diameter of the logs:	23	cm
Fuel price/liter (diesel):	1.1	DEM
Electricity price/kWh	0.11	DEM

Railway and ferry transport

Route time:	7	days
Number of wagons/year:	2799	wagons
Number of wagons/week:	53.7	wagons
Number of wagons/day:	7.7	wagons
Number of wagons/trainset:	20	wagons
Number of trainsets/day:	0.4	trainsets
Number of trainsets/week:	2.7	trainsets
System capacity/week:	53.7	wagons
System capacity/week:	2.7	trainsets
System capacity/day:	7.7	wagons
Working hours/day:	10	hours
Working days/year:	365	days
Working hours/year:	3650	hours
Input volume:	150000	m3sub
Accept chips:	90	%
Remaining volume chips:	135000	m3sub
Cost/m3sub:	49.34	DEM
Cost/wagon/day:	80	DEM
Cost for the wagons/year:	6660448	DEM
Cost/tonne:	46.99	DEM
Deutsche bahn fee/wagon/route:	2300	DEM
Capacity/wagon:	51	tonnes
Capacity/wagon:	134	m3s
Capacity/wagon:	48.24	m3sub
Weight/wagon:	50.65	tonnes
Weight status:	-0.35	tonnes, ok!

Cost/m3sub: 49.34 DEM

Terminal in Thüringen, Germany

Rent/month:	1000 DEM
Investments cost:	0 DEM
Rate of interest:	10 %
Deprecitation time:	5 years
Rest value:	0 DEM
Input volume:	150000 m3sub
Accept chips:	80 %
Remaining volume:	120000 m3sub
Cost of investment/year:	12000 DEM
Total cost/m3sub/input volume:	0.08 DEM
Total cost/m3sub/remaining volume:	0.10 DEM

Measurement station

Cost/m3sub:	0.5 DEM

Truck transport

Distance (forest - terminal):	120 km
Cost/m3sub:	21 DEM
Cost/km:	0.18 DEM

Insurance for all equipment

The cost for insurance/year:	33000 DEM
Cost/m3sub input volume:	0.22 DEM

Investments in Nymölla

Investments for track in to Nymölla:	600000 DEM
Investments for handling the chips:	900000 DEM
Restvalue:	225000 DEM
Rate of interest:	10 %
Deprecitation time:	5 years
Input volume:	150000 m3sub
Accept chips:	80 %
Remaining volume of chips:	120000 m3sub
Total cost of investment/year:	432551 DEM
Total cost/m3sub/input volume:	2.88 DEM
Total cost/m3sub/remaining volume:	3.60 DEM

Wheel loader with grapple

Manufacturer:	VOLVO	
Model:	L120 D	
Purchase price:	456000	DEM
Rate of interest:	10	%
Deprecitation time:	5	years
Rest value:	68400	DEM
Number of workers:	1	
Labour cost/hour/person:	50	DEM
Labour cost/day:	500	DEM
Labour cost/year:	150000	DEM
Fuel cost/liter:	1.1	DEM
Fuel cost/hour:	22	DEM
Fuel cost/day:	220	DEM
Fuel cost/year:	66000	DEM
Fuel consumption/year:	60000	liters
Fuel consumption/day:	200	liters
Fuel consumption/hour:	20	liters
Working hours/day:	10	hours
Working days/year:	300	days
Working hours/year:	3000	hours
Operating cost/hour:	93.67	DEM
Operating cost/day:	936.7	DEM
Operating cost/year:	281000	DEM
Operating cost/m3sub:	1.87	DEM
Maintenance cost/year:	65000	DEM
Maintenance cost/day:	216.7	DEM
Maintenance cost/hour:	21.67	DEM
Capacity/year:	600000	m3sub
Capacity/day:	2000	m3sub
Capacity/hour:	200	m3sub
Cost of investment/year:	131495	DEM
Cost of investment/day:	438.32	DEM
Cost of investment/hour:	43.83	DEM
Total cost/year:	412495	DEM
Total cost/day:	1374.98	DEM
Total cost/hour:	137.50	DEM
Total cost/m3sub/capacity volume:	0.69	DEM
Total cost/m3sub/input volume:	2.75	DEM
Produktion status:	overcapacity!	
	450000	m3sub

Chipping system, Morbark

Manufacturer:	Morbark	
Model:	2755 Flail Chiparvestor	
Purchase price:	1483000	DEM
Rate of interest:	10	%
Deprecitation time:	5	years
Rest value:	222450	DEM
Number of workers:	2	workers
Labour cost/hour/person:	50	DEM
Labour cost/day:	1000	DEM
Labour cost/year:	300000	DEM
Fuel cost/liter:	1.1	DEM
Fuel cost/hour:	110	DEM
Fuel cost/day:	1100	DEM
Fuel cost/year:	330000	DEM
Fuel consumption/year:	300000	liters
Fuel consumption/day:	1000	liters
Fuel consumption/hour:	100	liters
Working hours/day:	10	hours
Working days/year:	300	days
Working hours/year:	3000	hours
Operating cost/hour:	264	DEM
Operating cost/day:	3140	DEM
Operating cost/year:	942000	DEM
Operating cost/m3sub/year:	6.28	DEM
Maintenance cost/year:	312000	DEM
Maintenance cost/day:	1040	DEM
Maintenance cost/hour:	104	DEM
Maintenance cost/m3sub:	1.28470588	DEM
Capacity/year:	255000	tonnes
Capacity/day:	850	tonnes
Capacity/hour:	85	tonnes
Capacity/year:	242857	m3sub
Capacity/day:	809.52	m3sub
Capacity/hour:	80.95	m3sub
Cost of investment/year:	427648	DEM
Cost of investment/day:	1425.5	DEM
Cost of investment/hour:	142.55	DEM
Total investment cost/year:	1369648	DEM
Total investment cost/day:	4565.5	DEM
Total investment cost/hour:	406.55	DEM
Total cost/m3sub/capacity volume:	5.02	DEM
Total cost/m3sub/input volume:	9.13	DEM
Produktion status:	overcapacity!	
	92857	m3sub

Chipping system, Peterson Pacific

Manufacturer:	Peterson Pacific	
Model:	DDC 5000-G	
Purchase price:	1540000	DEM
Rate of interest:	10	%
Deprecitation time:	5	years
Rest value:	231000	DEM
Number of workers:	2	workers
Labour cost/hour/person:	50	DEM
Labour cost/day:	1000	DEM
Labour cost/year:	300000	DEM
Fuel cost/liter:	1.1	DEM
Fuel cost/hour:	110	DEM
Fuel cost/day:	1100	DEM
Fuel cost/year:	330000	DEM
Fuel consumption/year:	300000	liters
Fuel consumption/day:	1000	liters
Fuel consumption/hour:	100	liters
Working hours/day:	10	hours
Working days/year:	300	days
Working hours/year:	3000	hours
Operating cost/hour:	264	DEM
Operating cost/day:	3140	DEM
Operating cost/year:	942000	DEM
Operating cost/m3sub:	6.28	DEM
Maintenance cost/year:	312000	DEM
Maintenance cost/day:	1040	DEM
Maintenance cost/hour:	104	DEM
Maintenance cost/m3sub:	1.82	DEM
Capacity/year:	180000	tonnes
Capacity/day:	600	tonnes
Capacity/hour:	60	tonnes
Capacity/year:	171428.57	m3sub
Capacity/day:	571.43	m3sub
Capacity/hour:	57.14	m3sub
Cost of investment/year:	444085	DEM
Cost of investment/day:	1480.3	DEM
Cost of investment/hour:	148.03	DEM
Total investment cost/year:	1386085	DEM
Total investment cost/day:	4620.3	DEM
Total investment cost/hour:	412.03	DEM
Total cost/m3sub/capacity volume:	7.21	DEM
Total cost/m3sub/input volume:	9.24	DEM
Produktion status:	overcapacity!	
	21429	m3sub

Debarker, Valon kone

Manufacturer:	Valon kone	
Model:	VK 820	
Purchase price:	540000	DEM
Rate of interest:	10	%
Depreciation time:	5	years
Rest value:	81000	DEM
Number of workers:	1	worker
Labour cost/hour/person:	50	DEM
Labour cost/day:	500	DEM
Labour cost/year:	150000	DEM
Electricity cost/kWh:	0.11	DEM
Electricity cost/hour:	11.66	DEM
Electricity cost/day:	116.6	DEM
Electricity cost/year:	34980	DEM
Electricity consumption/year:	318000	kWh
Electricity consumption/day:	1060	kWh
Electricity consumption/hour:	106	kW
Working hours/day:	10	hours
Working days/year:	300	days
Working hours/year:	3000	hours
Operating cost/hour:	79.66	DEM
Operating cost/day:	796.6	DEM
Operating cost/year:	238980	DEM
Operating cost/m3sub:	1.59	DEM
Maintenance cost/year (10% of investment):	54000	DEM
Maintenance cost/day (10% of investment):	180	DEM
Maintenance cost/hour (10% of investment):	18	DEM
Maintenance cost/m3sub:	0.18	DEM
Debarking capacity/year:	7200000	meters
Debarking capacity/day:	24000	meters
Debarking capacity/hour:	2400	meters
Debarking capacity/year:	298991	m3sub
Debarking capacity/day:	996.6	m3sub
Debarking capacity/hour:	99.66	m3sub
Cost of investment/year:	155718	DEM
Cost of investment/day:	519.1	DEM
Cost of investment/hour:	51.91	DEM
Total investment cost/year:	394698	DEM
Total investment cost/day:	1315.7	DEM
Total investment cost/hour:	131.57	DEM
Total cost/m3sub/capacity volume:	1.32	DEM
Total cost/m3sub/input volume:	2.63	DEM
Produktion status:	overcapacity!	
	148991	m3sub

Chipper, Bruks

Manufacturer:	Bruks	
Model:	Disc chipper R 2500	
Purchase price:	390000	DEM
Rate of interest:	10	%
Deprecitation time:	5	years
Rest value:	58500	DEM
Number of workers:	1	worker
Labour cost/hour/person:	50	DEM
Labour cost/day:	500	DEM
Labour cost/year:	150000	DEM
Electricity cost/kWh:	0.11	DEM
Electricity cost/hour:	0	DEM
Electricity cost/day:	0	DEM
Electricity cost/year:	0	DEM
Electricity consumption/year:	0	kWh
Electricity consumption/day:	0	kWh
Electricity consumption/hour:	0	kW
Working hours/day:	10	hours
Working days/year:	300	days
Working hours/year:	3000	hours
Operating cost/hour:	63	DEM
Operating cost/day:	630	DEM
Operating cost/year:	189000	DEM
Operating cost/m3sub/year:	1.26	DEM
Maintenance cost/year (10% of investment):	39000	DEM
Maintenance cost/day (10% of investment):	130	DEM
Maintenance cost/hour (10% of investment):	13	DEM
Maintenance cost/m3sub:	0.09	DEM
Capacity/year:	432000	m3sub
Capacity/day:	1440	m3sub
Capacity/hour:	400	m3loose
Cost of investment/year:	112463	DEM
Cost of investment/day:	374.9	DEM
Cost of investment/hour:	37.49	DEM
Total investment cost/year:	301463	DEM
Total investment cost/day:	1004.9	DEM
Total investment cost/hour:	100.49	DEM
Total cost/m3sub/capacity volume:	0.70	DEM
Total cost/m3sub/input volume:	2.01	DEM
Production status:	overcapacity!	
	282000	m3sub

Screener, Bruks

Manufacturer:	Bruks	
Model:	2 x Screener BS 7	
Purchase price:	217000	DEM
Rate of interest:	10	%
Deprecitation time:	5	years
Rest value:	32550	DEM
Number of workers:	0	
Labour cost/hour/person:	0	DEM
Labour cost/day:	0	DEM
Labour cost/year:	0	DEM
Electricity cost/kW:	0.11	DEM
Electricity cost/hour:	1.65	DEM
Electricity cost/day:	16.5	DEM
Electricity cost/year:	4950	DEM
Electricity consumption/year:	45000	kW
Electricity consumption/day:	150	kW
Electricity consumption/hour:	15	kW
Working hours/day:	10	Hours
Working days/year:	300	Days
Working hours/year:	3000	Hours
Operating cost/hour:	8.9	DEM
Operating cost/day:	89	DEM
Operating cost/year:	26650	DEM
Operating cost/m3sub/year:	0.177666667	DEM
Maintenance cost/year (10% of investment):	21700.0	DEM
Maintenance cost/day (10% of investment):	72.33	DEM
Maintenance cost/hour (10% of investment):	7.23	DEM
Maintenance cost/m3sub:	0.040185185	DEM
Capacity/year:	540000	m3sub
Capacity/day:	1800	m3sub
Capacity/hour:	500.00	m3loose
Cost of investment/year:	62575.7	DEM
Cost of investment/day:	208.59	DEM
Cost of investment/hour:	20.86	DEM
Total investment cost/year:	89225.7	DEM
Total investment cost/day:	297.42	DEM
Total investment cost/hour:	29.74	DEM
Total cost/m3sub/capacity volume:	**0.17**	**DEM**
Total cost/m3sub/input volume:	**0.59**	**DEM**
Produktion status:	**overcapacity!**	
	390000.00	**m3sub**

Investments at the terminal for Morbark and Peterson Pacific

Working hours/day:	10	hours
Working days/year:	300	days
Working hours/year:	3000	hours
Electricity cost/kWh:	0.11	DEM
Rate of interest:	10	%
Depreciation time:	5	years
Rest value:	61800	DEM

Morbark + Peterson Pacific:	Investment cost:	Electricity cost/year:
Metal detector:	43000 DEM	
Outfeed for transporter (10 kW):	65000 DEM	3300 DEM
Conveyor for dust (4 kW):	22000 DEM	1320 DEM
Screw, screener (15 kW):	43000 DEM	4950 DEM
Conveyor for rubbish (8 kW):	43000 DEM	2640 DEM
Conveyor for bark (7.5 kW):	22000 DEM	2475 DEM
Tool shed + sharpening machine (5 kW):	174000 DEM	1650 DEM
Total cost, investments and electricity:	412000 DEM	16335 DEM/year

Maintenance cost/year (10% of investment):	41200	DEM
Maintenance cost/day (10% of investment):	137	DEM
Maintenance cost/hour (10% of investment):	14	DEM
Operating cost/year	57535	DEM
Operating cost/m3sub/year:	0.38	DEM
Building, groundwork + construction:	543000	DEM
Restvalue on building + construction:	81450	DEM
Investment cost/year for the building:	156 583	DEM
Investment cost/year (excl. building):	118 807	DEM
Investment cost/day (excl. building):	396	DEM
Investment cost/hour (excl. building):	40	DEM
Total investment cost/year:	332926	DEM
Total investment cost/day:	300	DEM
Total investment cost/hour:	30	DEM
Total cost/m3sub/input volume:	2.22	DEM
Total cost/m3sub/remaining volume:	2.77	DEM

Investments at the terminal

Working hours/day:	10	hours
Working days/year:	300	days
Working hours/year:	3000	hours
Electricity cost/kWh:	0.11	DEM
Rate of interest:	10	%
Deprecitation time:	5	years
Rest value:	187500	DEM

Debarker + chipper + screener:

	Investment cost:	Electricity cost/year:
Electric engine (830 kW):	110000 DEM	273900 DEM
Transmission:	65000 DEM	
Starting equipment:	110000 DEM	
Infeed for chipper (7.5 kW):	43000 DEM	2475 DEM
Chipper for overs (30 kW):	87000 DEM	9900 DEM
Metal detector:	43000 DEM	
Outfeed for transporter (10 kW):	65000 DEM	3300 DEM
Conveyor for dust (4 kW):	22000 DEM	1320 DEM
Screw, screener (15 kW):	43000 DEM	4950 DEM
Conveyor for rubbish (8 kW):	43000 DEM	2640 DEM
Conveyor for bark (7.5 kW):	22000 DEM	2475 DEM
Knuckle boom + control cabin (60 kW):	260000 DEM	19800 DEM
Work shop+sharpening machine (5 kW):	174000 DEM	1650 DEM
Loading pocket+feeding pocket (10 kW):	163000 DEM	3300 DEM
Total cost, investment and electricity:	1250000 DEM	325710 DEM/year

Maintenance cost/year (10% of investment):	125000 DEM
Maintenance cost/day (10% of investment):	417 DEM
Maintenance cost/hour (10% of investment):	42 DEM
Operating cost/year:	450710 DEM
Operating cost/m3sub/year:	3.00 DEM
Building, groundwork + construction:	543000 DEM
Restvalue on building + construction:	81450 DEM
Investment cost/year for the building:	156 583 DEM
Investment cost/year (excl. building):	360 459 DEM
Investment cost/day (excl. building):	1 202 DEM
Investment cost/hour (excl. building):	120 DEM
Total investment cost/year:	967752 DEM
Total investment cost/day:	300 DEM
Total investment cost/hour:	30 DEM
Total cost/m3sub/input volume:	**6.45 DEM**
Total cost/m3sub/remaining volume:	**8.06 DEM**

Results

New system, Cost/m3sub

Morbark, cost/m3sub:	88.72 DEM
Peterson Pacific, cost/m3sub:	88.83 DEM
Bruks, cost/m3sub:	88.46 DEM
Existing system, cost/m3sub today:	80 DEM

Difference in cost

Morbark, difference in cost/m3sub:	8.72 DEM
Peterson Pacific, difference in cost/m3sub:	8.83 DEM
Bruks, difference in cost/m3sub:	8.46 DEM
Morbark, difference in cost/m3sub:	11%
Peterson Pacific, difference in cost/m3sub:	11%
Bruks, difference in cost/m3sub:	11%

Revenues new system

Income from chips:	12000000 DEM
Income from leftovers:	1200000 DEM
Income from bark:	189000 DEM
Total revenue:	13389000 DEM

Total cost for transport

Total cost for transport (Morbark):	11275875 DEM
Total cost for transport (Peterson pacific):	11289024 DEM
Total cost for transport (Bruks):	11244946 DEM

Revenues/year today:	15000000 DEM

Costs today

Cost/m3sub today:	80 DEM
Truck transportation cost:	3150000 DEM
Railway transportation cost (59 DEM/m3sub):	8850000 DEM
Total cost/year:	12000000 DEM

The new system vs. the old system, profit or loss in DEM/year.

Today:	3000000 DEM profit
Morbark:	2113125 DEM profit
Peterson Pacific:	2099976 DEM profit
Bruks:	2144054 DEM profit

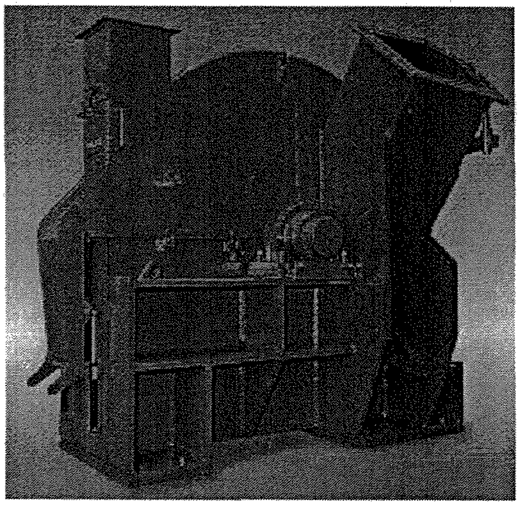
Comparing the systems

Morbark:	-30%	886875 DEM less/year!
Peterson Pacific:	-30%	900024 DEM less/year!
Bruks:	-29%	855946 DEM less/year!

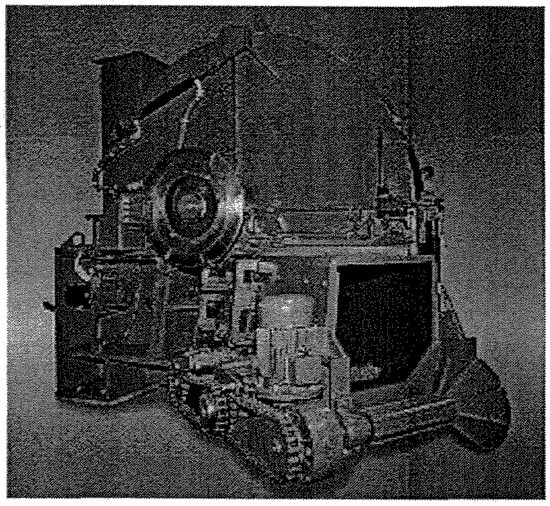
Appendix II:

- Bruks whole log chippers.
- Bruks free-swinging chip screens.
- Bruks tubulator conveyor.

Bruks Round Log Chippers R/RS



Bruks self-feeding, gravity-fed chippers with a chipping angle for optimum infeed force and highest chip quality.



Bruks self-feeding, horizontal fed chippers with a chipping angle for optimum infeed force and highest chip quality.

Chipper disc and disc shaft

Vertical chipper disc, on larger chipper with a star-shaped, bolted hub mounted on the disc shaft with a tight fit and clamping devices. This combined with efficient axial roller bearings minimizes axial disc movement. Clearence between knife and anvil can be optimized for best chip quality.

Knife holding system / Knife change

To facilitate knife handling, the knives for large chippers come in two sections. The knives are as standard mounted in cassettes so that light-weight knives can be used. On 1500 RS and 2003 RS the knives are in one piece.

Chipper housing

The chipper house has got a welded structure of mild steel plate. For top discharge the chips can be blown out by means of fan blades mounted on the chipper disc. All chippers are also available with bottom discharge.

Feed chute

The feed chute is welded on the chipper housing and has exchangeable wear plates. The chute is so designed that it guides the wood to one corner for optimum chipping geometry. The anvils are easily accessible throught a hatch on the feed chute.

Wear parts

All exposed surfaces have exchangeable wear plates.

Technical Data

Machine type	***1500 R/RS***	***2003 R/RS***	***2502 R/RS***
Chipper disc dia., mm	1500	2000	2470
Max roundwood dia., mm	330(13")	485(19")	650(25")
Chip length, mm	20-50	20-50	20-50
Capacity m³ chips/hr	40-175	110-300	250-400
Power requirement, kW	55-250	160-450	375-800
Normal speed of chipper disc, rpm	620	400	325
Chipper disc fly-wheel mass GD², kpm²	1650	6320	25000
Number of knives, standard	5	7	(2x)8
Knife dimensions, mm	450x175x20	550x175x20	375x125x16
Blowing distance, approx. M	20	20	20
Machine weight, kg	4500	9500	18000

Bruks Free-Swinging Chip Screens

The efficient screens come in several sizes and separate up to four fractions. Exchangeable screen decks with decreasing openings ensure optimum economic yield from the chipped wood material.

Design

The screen box is suspensed by steel cables and contains two or three screens for decreasing fractions sizes and maximum screen effect. The upper deck has perforated screen plates, while the other deck usually have clamped and tightened woven nets. Wire nets give superior results for fines and pinchips.
All screen decks are exchangeable and can have many different perforations. The perforations will be adapted to the individual screening requirements to ensure the very best economic yield from the by-product. The screens have a high net weight so they are less sensitive to high loads.

Optimum screening effect

The intensive screen motion with large amplitude and high rpm is generated by a motor-driven, rotating counterweight. The horizontal dynamic forces are fully balanced by the weight of the screen box. This eliminates the need for a special, heavy foundation.

Technical Data

Screen type	***BS-2***	***BS-32/3***	***BS-32/4***	***BS-4***	***BS-7B/3***	***BS-7B/4***
Average Capacity, m^3 /hr	30	60	60	120	250	250
Momentary peak capacity, m^3 /hr	60	100	100	200	300	300
Chips screening area, top deck, m^2	3.8	5	5	7.6	11	11
Pinchips screening area, interm. Deck, m^2	-	-	3.1	-	-	11
Fines screening area, bottom. Deck, m^2	1.7	3.1	2.4	6.4	11	11 (+2)
Power rating, kW	2.2	4.0	4	5.5	7.5	7.5
Net weight, kg	1000	1600	1800	3200	4000	4500

Bruks TT Tubulator® Conveyor

Pictures of Tubulator installations

Bruks TT Tubulator® conveyors represent a new way of transporting bulk goods such as chips, fines, bark, grain, stones, fodder or food stuffs, at high speeds, in an energy-saving, tight system. Dustfree and spill-free.

Design

The conveyor is built as a closed tubular system with standardized steel tubes. Inside the conveyor tube, a rubber belt runs at high speed on an air cushion. The tube is equipped with a fan that provides the air under the belt. The driving unit consists of a drum with driving components as well as a cleaning brush for the returning belt.
The turning unit is fitted with a turning drum and a belt tightening device.
So this is a conveyor with very few moving parts, which makes it easy to service and extremly reliable.

Range of application

The tubulator conveyor is intended for

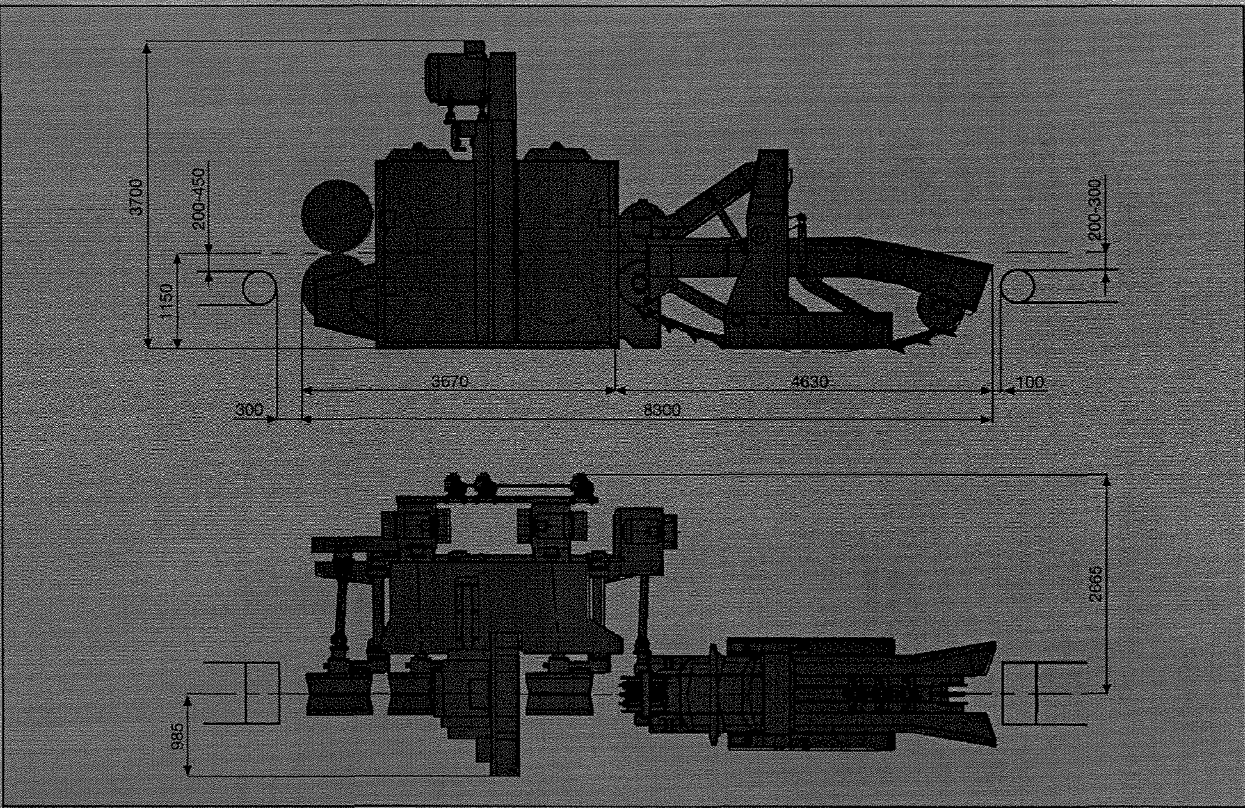
- tight and spill-free transports;
- indoor and outdoor use;
- long transport distances, up to 300 meters;
- great self-supporting conveyor lengths; up to 25 meters.
- Capacities of up to 500 cu.m. loose goods per hour.

Technical Data		
Machine type	***TT500***	***TT800***
Conveyor belt width, mm	500	800
Capacity, cu.m. loose goods/hour	300	500

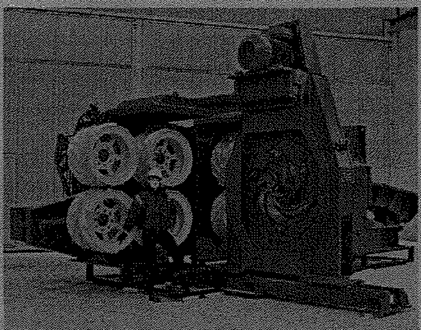
Appendix III:

- Valon Kone, 820/5 debarking machine.

HÖGEFFEKTIV BARKNINGSMASKIN VK820 / VK620



Huvuddimensioner (mm)



En utskjutbar pull-out-rotor

Tekniska data		VK820	VK620
Barkningsdiameter	mm	100 - 820	100 - 620
Min stocklängd	m	2,4 (2,2)	2,4 (2,2)
Matningshastighet	m/min	60 - 85 (100)	60 - 90 (105)
Effektbehov			
- rotor	kW	90	75
- matning	kW	3 x 15	3 x 15
- hydraulik	kW	4 + 7,5	4 + 7,5
Vikt	kg	23 900	23 700

Rätt till tekniska ändringar förbehålles.

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VALON KONE AB
Bollnäs
SVERIGE

VALON KONE PTE
SINGAPORE

2.97.1000 Printed in Finland

2001-05-17

VK 820/5
STORAENSO

VK VALON KONE

Leveransvillkor 820/5 Barkningsmaskin

Ritn Nr:0-82-1088

Maskin	1 st VK 820/5 enligt offert	1 960 000,- SEK
Pull-Out (option)		55 000,-SEK
Leveransvillkor		Fritt Lohja Finland
Betalningsvillkor		30% vid beställning
		70% vid leverans
Leveranstid		Enl senare överenskommelse
Offerten giltig till		För leverans 2001

Bästa Hälsningar
Valon Kone AB

Jukka Nilsson

2. TEKNISK SPECIFIKATION / VK820/5 BARKMASKIN

2.1. ALLMÄNT

Maskintyp

- Denna tekniska specifikation specificerar de tekniska detaljerna av en komplett barkmaskin

VK820/5

inkl:- grundmaskin
- matarvalsar
- VK-inmatningstransportör

Högerutförande (R) / vänsterutförande (L)

- VK820/5 tillverkas i såväl höger-(R) som vänsterutförande (L).
- Det faktum, om maskinen är i höger- eller vänsterutförande, påverkar inte priset
- Huvudmått från måttritningar nr:

VK820/5-R högerutförande	O-82-1088
VK820/5-L vänsterutförande	O-82-1040

Typmärke

- Ett exempel på detaljerat typmärke:

VK820/5-RAP

VK820/5	grundmaskinens typ
R/L	höger-/vänsterutförande
A	hydraulikackumulatorsystem
P	pull-out-system (extra)

2.2. ROTOR

- VK820/5 barkmaskinen har en rotor med 5 verktyg; rotorns typmärke 820/5.

Verktyg

- Självöppnande verktyg på rotorns utmatningssida
- Smidda knivarmar
- Utbytbara hårdmetallknivspetsar
- Renskniv som hindrar rotorns tilltäppning
- Olika specialknivspetsar tillgängliga (vinter, eucalyptus osv)

2.2.2. Knivtryck

- Hydraulcylinder och gummifjäder för varje verktyg
- Steglös tryckreglering för verktygen hydrauliskt
- Regleringspumpenhet: 0,75 kW

2.2.3. Rotorlager

- 4-punkt axial-radial kullager
- Trycksmörjning och temperaturmätning
- Vid tryckfall eller värmestegring stannar rotorn automatiskt

2.2.4. Rotordrift

- Elmotor: 75 kW
- Kraftöverföring med powerband remmar

2.3. MATARVALSAR

- VK820/5-maskinen har tre (3) par matarvalsar (= 6 st), varav tre är drivna.

2.3.1. Vals

- Centrerande dubbelkonisk - typ VK
- V-formad ribb av specialstål
- Hydrauliskt tryck - se punkt 2.5.

2.3.2. Valsarnas drift

- Elmotor: 15 kW
- Två snäckväxlar; låda av specialgjutning

2.4. INMATNINGSTRANSPORTÖR

Med maskinen levereras alltid en centrerande VK-inmatningstransportör av typ 600-SK.

2.4.1. Transportör

- Centrerande V-medbringarkedja - typ VK
- Hydrauliskt tryck, steglös reglering

2.4.2. Transportörens drift

- Elmotor: 15 kW
- Snäckväxel; låda av specialgjutning

2.5. HYDRAULIK

Med VK820/5-maskinen levereras alltid ett komplett tryckackumulatorhydraulsystem:

- Tryck för varje matarvalspar
- Tryck för VK-inmatningstransportör
- Drift för rotorns pull-out system (extra)

2.5.1. Presstryck

- Steglöst reglerbart tryckackumulatorsystem
- Valsarnas presstryck är hela tiden oförändrat, inställt tryck

2.5.2. Centralsmörjning

- Kolvpump och tank i hydraulaggregat
- Motor: 0,25 kW

Smörjpunkterna:
-rotorlager
-inmatningstransportörens kedja
-inmatningstransportörens slitskena

2.6. MASKINENS VIKT

–	Maskin:	17.800 kg
–	Inmatningstransportör:	4.800 kg
	Totalt:	22.600 kg
-	Rotor (ingår i maskinens vikt:	5.400 kg

2.7. MATNINGSHASTIGHET/VIRKESMÅTT

2.7.1. Matningshastighet

- Hastighetsområde: 40-64 m/min
- Med VK:s godkännande: max. 75 m/min (6 knivar)
- Ett (1) hastighetsalternativ ingår i maskinpriset

2.7.2 Virkesmått

- Min. stocklängd: 2,4 m
- Max. stocklängd: obegränsad
- Min. stockdiameter: 10 cm

– Max. stockdiameter: 82 cm

2.8. MOTORLISTA

– Rotor:	75 kW	1500 1/min
– Matarverk:	2 x 15 kW	1500 1/min
– Smörjpump:	0,25 kW	1500 1/min
– Handpump:	0,75 kW	1500 1/min

2.9. KORROSIONSSKYDD OCH YTBEHANDLING

Alla VK:s stålkonstruktioner är sandblästrade och målade tre gånger enligt följande:

- Blästring: SFS 4962 A 120/3 SA 2.5
- Grundfärg: alkyd 40 µm
- Mellanfärg: alkyd 40 µm
- Ytfärg: alkyd 40 µm
- Färgkulör: VK-blå (RAL 5015)

2.10. LEVERANSOMFÅNG

2.10.1. VK:s leveransomfång:

Elutrustningar

- Maskinens elmotorer

Drivanordningar

- Växlar, kardanaxlar, drivremmar och remskydd

Hydraulik

- För maskinens hydraulik behövliga cylindrar, ventiler, rör och ackumulatorer

Säkerhetsanordningar

- Skyddsdörrar av stål som garanterer maskinens driftstrygghet

Specialverktyg

- Alla behövliga specialverktyg

- Handpump för kniv- och valstrycksreglering

Tekniska dokument
- Sammansättnings- och fundamentritningar
- El- och hydraulikscheman
- Drifts- och serviceanvisningar
- Reservdelsbok

2.10.2. Kundens leveransomfång
- Styr- och pådragsutrustning
- Elcentral
- Maskinens kabling och därtill behövliga elinstallationskomponenter
- Fundamentkonstruktioner
- Stålbalklag under maskinen
- Hydraulik- och smörjoljepåfyllningar
- Separata säkerhetsanordningar som möjligen erfordras av lokala myndigheter

FUNKTIONSBESKRIVNING AV VALON KONE VK820/5 BARKNINGSMASKIN

Denna punkt beskriver VK820/5 barkningsmaskinens allmänna konstruktion, funktion och drag.

1. VK 820/5 automatisk barkningsmaskin

1.1. Maskinens funktion

Valon Kones 820/5 rotorbarkningsmaskin har utvecklats för en automatisk och störningsfri funktion.

Barkningsdiameter från 100 (100) mm till 820 mm. Min. virkeslängd 2,4 m. Matningshastigheten kan regleras mellan 40-65 m/min (Enligt matningslista).

1.2. Matarverk

Sett från inmatningssidan finns på vänster sida eller den "aktiva" sidan matarverket och rotorn. Högra sidan består av driften med växlar, transmission osv.

Det med länkarmar sammankopplade matarverket gör att matarvalsarnas rörelser är symmetriska för en exakt centrering av stocken under barkningen. Matarvalsarna med snedställda ribbegg i kombination med separat steglöst justerbart matarvalstryck är till stor fördel när det gäller att hålla stocken i rätt läge vid barkningen.

1.3. Rotor

Rotoröppningen är 835 mm och tillåter barkning av stockar upp till 820 mm. Rotorn är lagrad med ett kullager som är speciellt tillverkat för VK barkningsmaskiner. I rotorn är inbyggt en automatsmörjning som ger en säker och effektiv smörjning av rotorlagret. Rotormotorn går ej att starta förrän smörjsystemet uppnått rätt smörjtryck. Om smörjsystemet av någon orsak ej fungerar under drift, stannar rotorn automatiskt. Rotorerna drives av 75 kW elmotorer via poly-V-remmar. Rotorvarvtal 180 r/min.

Rotorn är försedd med 5 st självöppnande barkningsverktyg med lätt utbytbara hårdmetallknivspetsar. Varje verktyg är anslutet till ett knivhus och fäst med två bultar. Verktygen behöver inte demonteras för slipning - endast knivspetsen bytes. Snabbslipning av knivspetsarna kan också göras utan att de tas bort.

Stocken öppnar knivarna automatiskt när den matas genom rotorn. Genom rotorns rotationsrörelse och den framåtgående stocken vrids verktygen upp på stocken på ett smidigt sätt. Barkverktygens tryck regleras via extra kraftiga gummifjädrar och hydraulcylindrar. Verktygstrycket är hydrauliskt steglöst justerbart.

Rotorn är utrustad med en rotorrenskniv.

Alla komponenter i rotorn med undantag av rotorlagret kan bytas ut utan att rotorn demonteras. Tack vare rotorns lättåtkomlighet arbetar servicepersonalen lätt och säkert.

Byte av knivspetsar på barkverktygen görs med ett minimum av tidsförlust.

1.4 Fullservice av rotorn

Att demontera rotorn går snabbt och enkelt genom dess lättåtkomlighet och modulkonstruktion med förutsättning att en 2 t lyftanordning står till förfogande.

1.5. Kraftöverföring

Modulutförandet gör att alla transmissionsdelar är lätt åtkomliga från utsidan av maskinen, vilket underlättar service.

Matarvalsarna, 3 par, drives över kraftiga drivaxlar och växellådor.

Driften är ordnad så, att 1 st 15 kW elmotorer driver 2 st växellådor, en växellåda för en matarvals, förutom det sista matarvalsparet, där den nedre matarvalsen får driften per rullkedja från föregående nedre matarvals och den övre matarvalsarna är utan drift. M.a.o. 6 st matarvalsar av 3 st är drivna.

2. VK600 självcentrerande inmatningsbord

2.1 Funktion

Inmatningsbordets uppgift är att automatiskt centrera stocken och att mata den fram till barkningsmaskinens inmatningsvalsar samt också stöda stocken då den matas in i barkingsrotorn.

Inmatningsbordets vagga är upphängd i länkarmar som är sammanbundna med en styrklaff. Styrklaffen är försedd med en frigående rulle.

För varje centimeter klaffen höjs av stocken, sänks inmatningsbordet i motsvarande grad. Härigenom centreras varje stock automatiskt enligt diametern genom hela barkningsprocessen.

V-formade medbringare underlättar stockens centrering och matning. Transportörkedjorna och slitskenorna har automatsmörjning för maximal livslängd.

2.2. Kraftöverföring

En 15 kW fotmonterad elmotor driver transportör-kedjan via en snäckväxel och drivaxel.

3. Hydraulikt

3.1. Funktion

Hydraulikaggregat (bärbar) drivs av en 0,75 kW elmotor. Aggregatet används för att tjustera trycket på inmatningstransportör, matarvalssystemet.

Alla fyra paren matarvalsar samt inmatningstransportören har hydrauliskt tryck för att hålla stocken. Trycket regleras separat för varje enhet från hydraulikaggregatet.

Inmatningstransportören och matarvalsarna kan hydrauliskt öppnas efter behov, bl.a. vid fast-körning av övergrov stock.

Appendix IV:

- Söderhamn Eriksson, Cambio 90-80 debarking machine.
- Drawings and measurements of the machine.

Söderhamn Eriksson

STORAENSO Forest Central Europé
Anderas Oscarsson
Box 32

230 53 ALNARP

Söderhamn Eriksson Cambio AB
Kjell Wiksten
Box 113

826 23 SÖDERHAMN

Söderhamn 2001-05-29

Hej Andreas,

Refererande till vårt samtal beträffande barkningsutrustning för barkning av bok timmer har vi härmed nöjet att inkomma med offert. Vi reserverar oss för de krokiga och kvistiga stockar Ni barkar, och ber att få diskutera detta vidare. På grund av tidspressen väljer vi att offerera maskinutrustningen innan vi vet exakt vad Ni tänker barka.

En möjlighet är att vi provbarkar ett lass timmer av den typ det gäller. Det finna Cambio maskiner på många håll även i Tyskland om Ni skulle vilja testa där. Det är möjligt att vi kan ordna med vår tyska agent med ett prov i Tyskland, eller i Sverige om det är möjligt att transportera hit ett lass bokträ.

Det är inte bok i sig som är problemet , utan möjligen trädens form. Som Du ser är min stocklängd som standard 3,0 m. Detta innebär att om stockarna är +- 3 m kan bli ned till 2,7 m. Detta kan vi klara med tilläggsutrustning. Vi kan väl återkomma med detta senare.

Med vänlig hälsning

SÖDERHAMNS ERIKSSON CAMBIO AB

Kjell Wiksten
Area manager

Söderhamn Eriksson

STORAENSO Forest Central Europe

Söderhamn 2001-05-15

Your ref.: Mr. Anderas Oscarsson / Cambio Debarking Machine
Our ref.: Mr. Kjell Wiksten (Phone/Fax +46 270-17000/18797)

Dear Sir,

Project: CAMBIO 90-80 DEBARKER FOR LOGS

We refer to your inquiry and have the pleasure of submitting our offer no. 010515.STORA for debarking equipment from Söderhamn Eriksson Cambio AB.

PRICES:	Quoted prices are in SEK (Swedish Crowns) and are included your commission of 10%., FOB Gothenburg Sweden, packed in container (Incoterms 1990)
DELIVERY TIME:	About 4 months after order, with reservation for intermediate sales.
CONDITIONS OF DELIVERY:	ECE 188 with Addendum
GUARANTEE:	12 months material guarantee after delivery in one-shift operation, or 2000 hours, what comes first. Excluding distance costs.
CONDITIONS OF PAYMENT:	30 % with order, 70 % at delivery against irrevocable Letter of Credit accepted by and made payable to the Swedish bank of Söderhamns Verkstäder AB, or as per later agreement.
VALIDITY OF THIS OFFER:	Until 2001-07-29 for delivery not later than December, 2001.

With kindest regards

SÖDERHAMN ERIKSSON CAMBIO AB
Marketing Dept.

Kjell Wiksten

OPERATIONAL CONDITIONS:

Log length	3,0 - 6,3 m
Log diameter	80 - 700 mm (794 mm rotor opening)
Species	Beech
Feed speed	50 m/min. - other speeds on request, max. 83 m/min.
Arc height	The arc hight of the logs may not be more than 100 mm of a log length of 6 m.

SHORTFIBREDED DECIDUOUS TREE

Beech, shortfibred

Beech wood is in general curved and hard to debark. The problems are that the beech wood is very curved, and that make big demands on in- and outfeed arrangement.

Debarking of fresh Beech is normally free of problems because the bark is shortfibred. Here may 5 ea. 53 mm wide debarking tools with 0.5 mm debarking edge radii be used, feed speed approx. 50 m/min.

Dry beech wood should be water sprinkled. Frozen beech wood should pass the thawing pool.

SCOPE OF DELIVERY

Cambio debarking equipment

Item	**Qty**	**Product**
10	1	Infeed conveyor WIM 750
20	1	CAMBIO 90-80 Air-Ten
30	1	Outfeed guidework type RS

PRICE, Item 10 - 30 **SEK 2.492.000;-**

TECHNICAL SPECIFICATION

Item 10
1 only INFEED CONVEYOR TYPE WIM 750

For vertical and horizontal centring of logs before debarker. Improves infeed control and prevents the log from wobbling or rotating, thus increasing machine life and productivity.

Base frame of welded square tubing with heavy conveyor trough and upper press roller consisting of a steel wheel. Trough raised and lowered pneumatically. A link system ensures parallel movement. Press roller placed close to the debarker and connected with the trough and base frame via a parallel rod, to obtain accurate centring. The log is held firmly when entering the debarker.

The initial position of the conveyor is trough up – roller down. When a log enters, the roller open and the trough are lowering at the same time. The roller press the log against the conveyor chain in centred position, Logs are fed by a chain with flat dogs, running on steel wear rails in the conveyor trough. Electric motor drive via speed reducer.

TECHNICAL DATA

Min / max. log diameter:	110 – 750 mm
Main motor:	11 kW
Upper roller:	4 kW
Net weight:	3.300 kg
Conveying lift:	Air pressure min. 6 bar
Dynamic load:	50.000 N

Delivered complete with drive motor and pneumatics.

Starting equipment and electrical control equipment not included.

Item 20
CAMBIO 90-80 AIR-TEN DEBARKER

Debarker for logs. For clean and gentle debarking at high feed rates.

Frame:
Welded steel plate design with integrated mounts for rotor and feed arms.

Rotor:
Ring type, journalled in adjustable, automatically lubricated ball bearing. Carries six pivoting, self-opening debarking tools in bearings. Tool pressure controlled by AIRBAG tensioners for faster tool response behind knots and wrinkles, giving superior debarking result. Pressure can be varied air pressure adjustment.

Feedworks:
Triangular feedworks with three turnable, welded spiked rollers each on infeed and outfeed sides, mounted on pivoting feed arms in bearings. Feed arms linked together to ensure uniform movement around the rotor axis. Feedworks open automatically. Feed pressure controlled by tensioners with variable tension. Feed rollers powered via automatically oiled roller chain and gear in oil bath. Sight glass for oil level.

Feedwork tensioners:
Hydraulic tensioners with variable tension. Feed rollers on infeed and outfeed side remain pressure-relieved while climbing onto the log. For sorted log diameters larger than 250 mm, there is a fixed opening position which facilitates infeed of larger logs. Both feedworks can be fully opened for good service accessibility. Hydraulic unit (1.5 kW) included.

TECHNICAL DATA

Rotor opening:	794 mm
Min. log diameter:	110 mm
Rotor speed:	220 rpm (adapted to feed speed)
Feedwork motor:	15 kW at 1465 rpm
Rotor motor:	75 kW at 1470 rpm
Hydraulic unit:	1.5 kW at 950 rpm
Weight net:	10,500 kg
Dynamic load:	147,000 N

Delivered with mounted electric motors, hydraulic unit, one set of hand tools and air line with gauge for tool tensioning.

One set of debarking tools mounted in the machine:
6 x CamTools with replaceable Carbide tips.

Starting equipment and electrical control equipment not included.

Item 30

1 only OUTFEED GUIDEWORK TYPE RS

For CAMBIO debarkers.

For centred and smooth outfeed of logs from the debarking machine. Improves outfeed control and prevents the log from wobbling or rotating, especially when crooked logs are debarked, thus increasing machine life and productivity.

Design with two pairs of rubber wheels mounted on a linkage system with a spiked ring in the middle. By means of a tensioner, the logs are efficiently fixed and the wheels return smoothly towards the centre. The drive is fitted with an idler hub so that the wheels run idle and engage only to assist in feeding out the log completely.

For debarking short logs, the guidework can be installed in the opposite feed direction so that the wheel pairs catch the log closer to the debarker outfeed rollers.

TECHNICAL DATA

Drive:	2,2 kW geared motor with idler hub and roller chain
Feed speed:	According to agreement
Tire air pressure:	2 kg/cm^2
Net weight:	1.400 kg
Dynamic load:	21.000 N

Delivered complete with drive and motor.

++++++++

Technical specification
Debarker
Cambio 90-75/6 A AIR-TEN

Ever since the mid 1950's, Cambio debarkers are well known and appreciated all over the world for their high capacity, efficiency and reliability. The Cambio has been a forerunner that has contributed economically as well as technically to the development of the sawmills. And not just sawmills:
Throughout the world, Cambio debarkers are operating in pulp mills, paper mills, chip board mills and other wood industries.

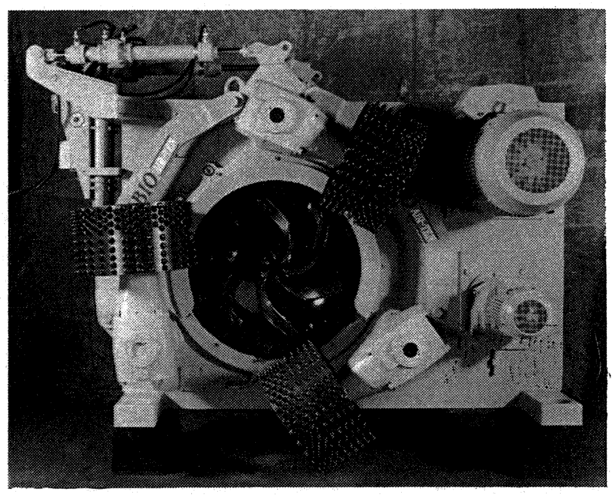
The new generation of machines was named Cambio 90. This debarker has been developed in close cooperation between our designers, service engineers and customers. The Cambio 90-75/6 A is a ring rotor debarker for saw logs.

Design
Machine base
Welded construction of steel plate, with brackets for rotor, feedworks, feedwork dampers and motors. Equipped with inspection hatches for drives and oil level sight glass. Foundation attachment with rubber dampers. Oil sump drain plug in the lowest part of the frame.

Feed work
Rotating, cylindrical spiked rollers, three on each side of the rotor, mounted on pivoting arms. The arms are interconnected by links to obtain uniform centering in relation to the rotor centre.
The feedworks are self-opening for all log dimensions. Hydraulic dampers are applying a variable pressure against the log.
For pre-sorted logs bigger than ø 250 mm, there is a fixed opening position in order to ease the infeed of bigger logs. Further the feedworks on the in- and outfeed sides can be fully opened for full service accessibility.
The design of the hydraulic feed dampers allow the feed rollers on the infeed side to remain depressurised while climbing onto the log.
Feedwork transmission: The rollers are driven by an automatically lubricated roller chain and gears in oil bath.

AIR-TEN Rotor
Ring rotor journalled in adjustable, automatically lubricated ball bearing. Fitted with six journalled, pivoting debarking tools in self-opening design. Pressure against the log is controlled pneumatically. Thanks to the even pressure of the air bags, the debarking tools react faster and can therefore move more smoothly over uneven parts of the log. This means that the log is debarked much more uniformly all around.
The tool pressure against the log can easily be adjusted with a foot pump or an air line. Resetting is not a problem with Cambio 90-75/6 A.

Debarking tools
The machine is delivered with type CamTool debarking tools. These tools were specifically designed for the 90-75/6 A. Significant features are low weight,



long service life, smooth debarking and exellent bark evacuation. These qualitities have been made possible by an elaborated use of the forged and hardened steel in the tool holder. The tool tips have been designed to its optimum in one position only. This has been made possible thanks to that the tip is not turnable, which no longer is required with the superior carbide material quality.

Standard equipment
The machine is delivered with mounted motors for rotor and feedworks as well as hydraulic unit, panel for control of the feedworks, hoses between machine and hydraulic unit (max. 4 m), one set of service tools and one set of debarking tools with tips, mounted in the rotor.
Start and control equipment for electric motors are not included.

Optional extras
Baby Rolls guidework for short logs.
Heater for hydraulic unit.
Heater in oil sump.
Special tools, such as different tools tips and combined cutting and debarking tools tips for different debarking conditions.

Technical data

Rotor opening	80 cm
Min. log diameter	11 cm
Min. log length	3 m (1,5 m with Baby-Rolls)
Feed speed	71/47 m/min (84/56 m/min) or max 100 m/min with infinitely variable speed
Rotor speed	222 rpm (245 rpm)

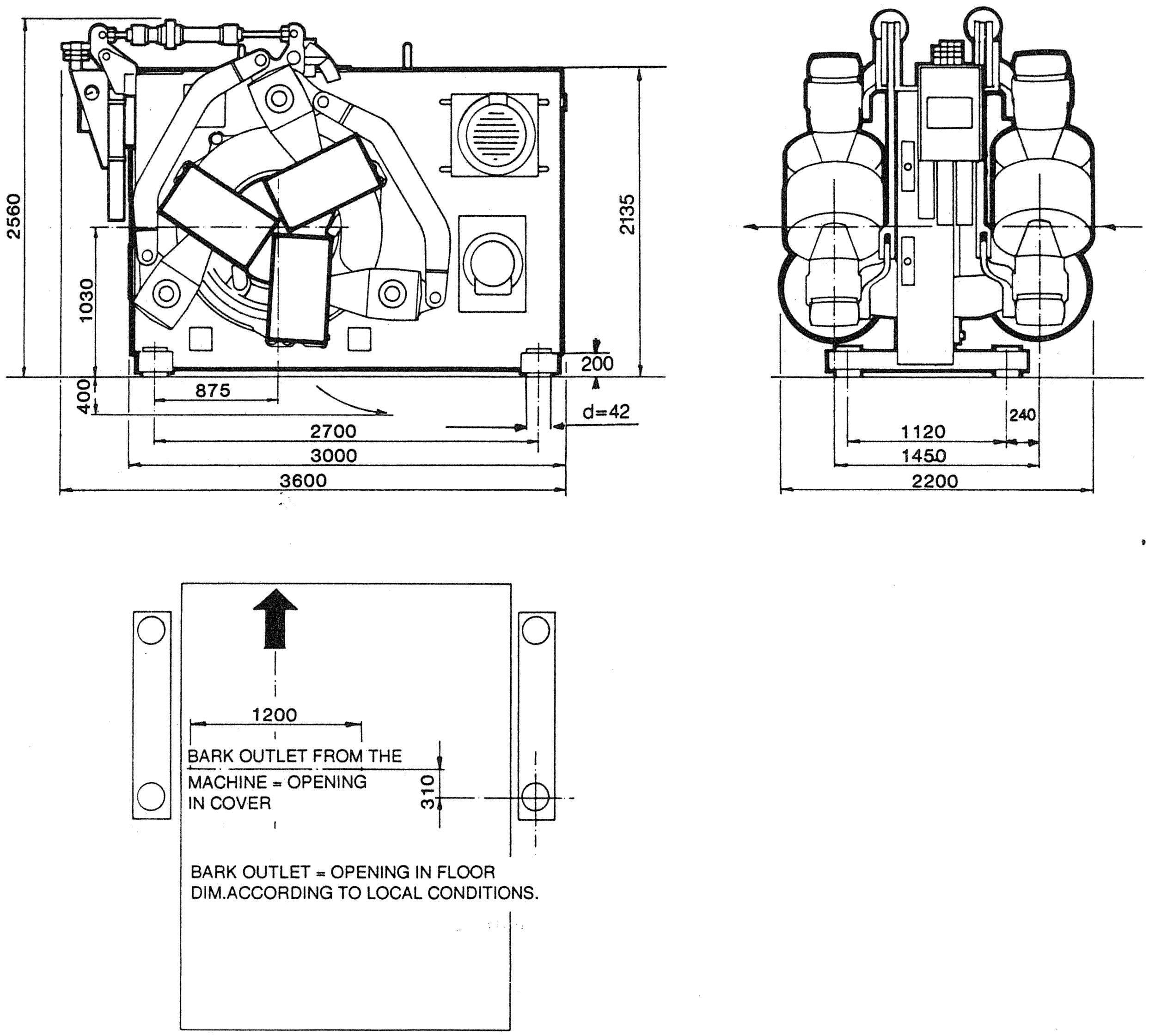
Power ratings

Feedwork motor	11/8 kW (frequence controlled 15 kW)
Rotor motor	75 kW
Hydraulic unit	1,5 kW

Weight

Net weight	10500 kg
Dynamic load	147000 N

Dimensions Cambio 90-75/6 A AIR-TEN



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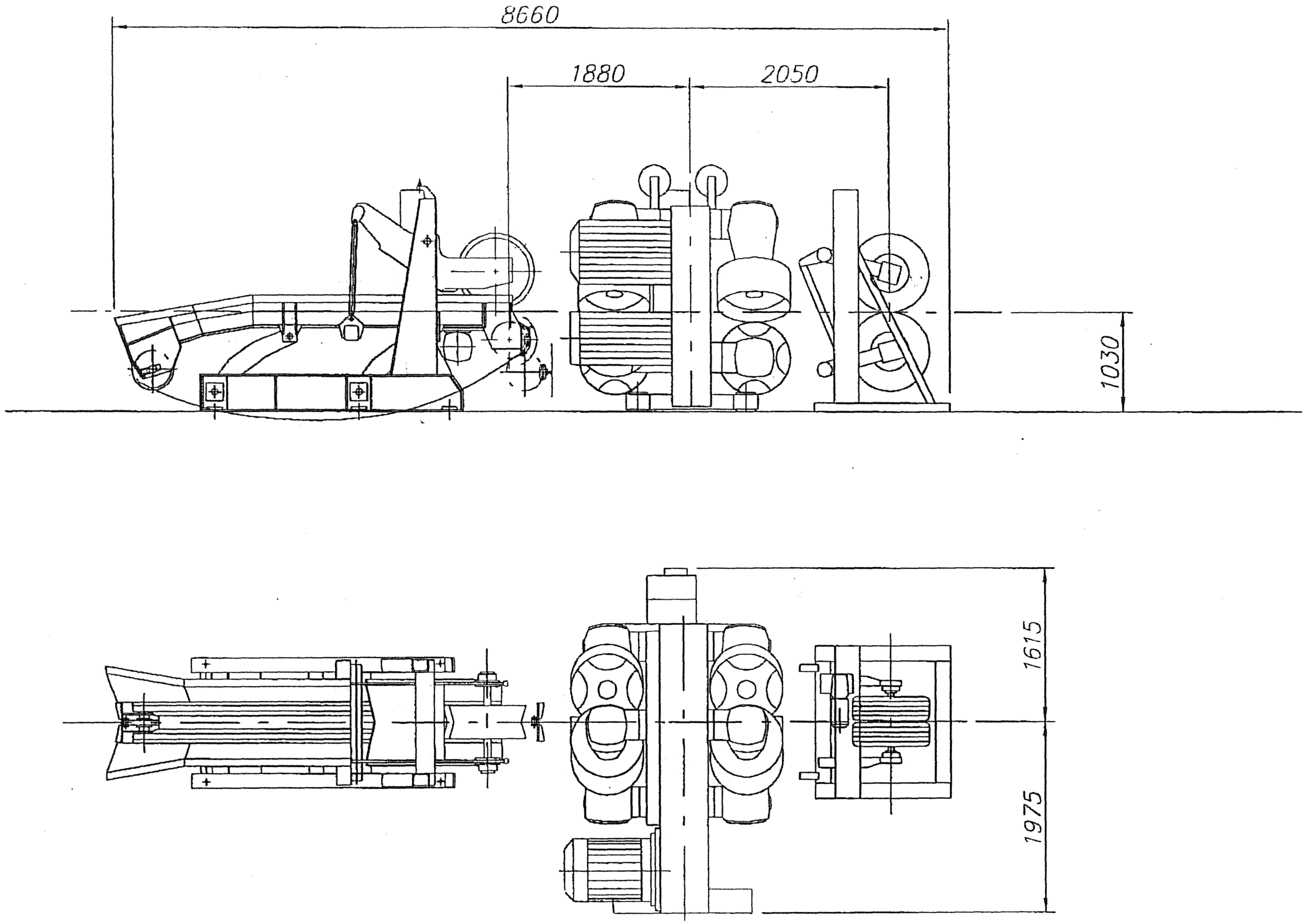
Reg.nr. 3096-9620

SÖDERHAMNS VERKSTÄDER
Box 506, S-826 27 Söderhamn, Sweden Phone +46 270 170 00 Fax +46 270 187 30

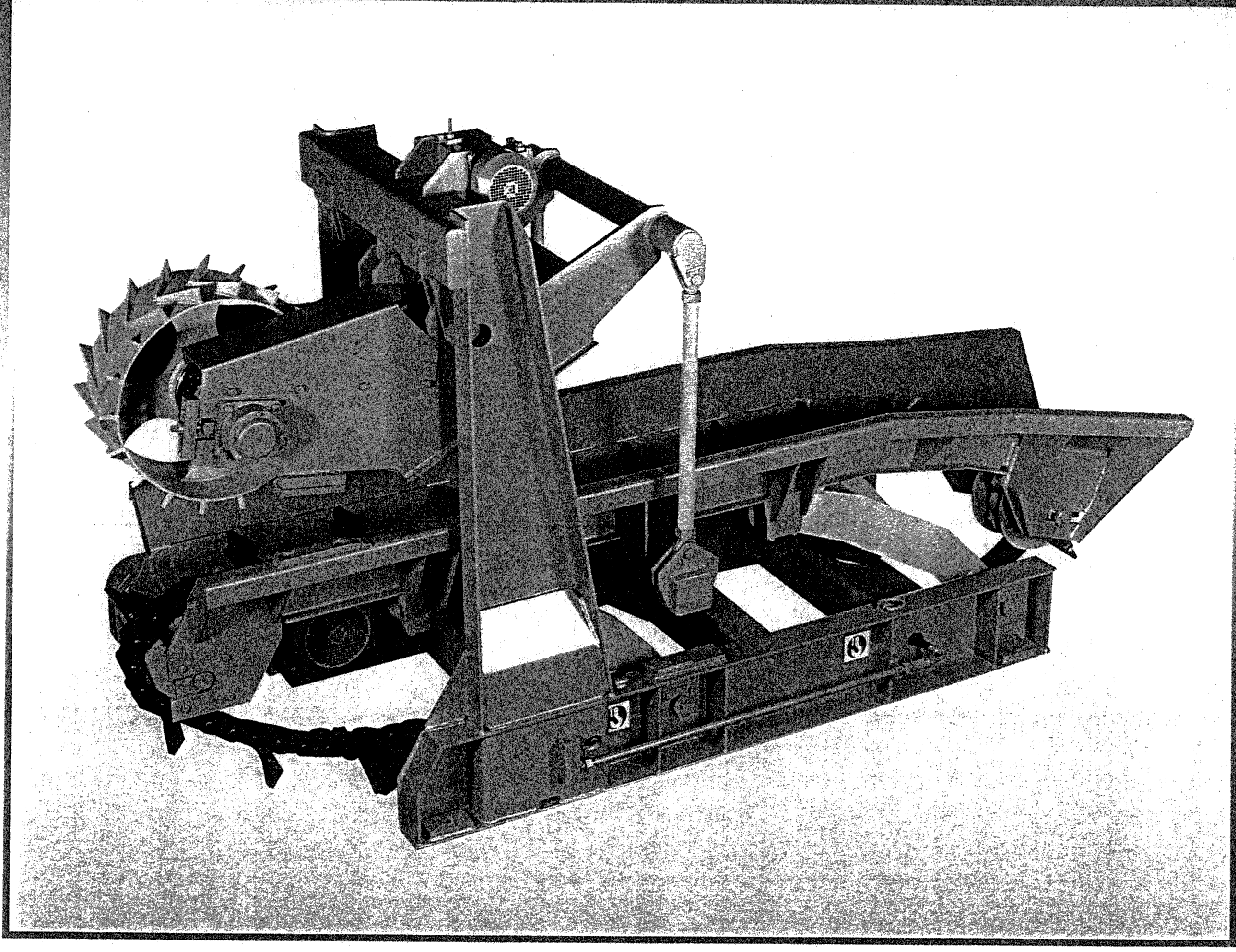
AKE
AB AK ERIKSSON
Box 1002, S-570 30 Mariannelund, Sweden
Phone +46 496 107 40 Fax +46 496 212 22

NO	ÄNDRING/CHANGE	DAT/DATE	SIGN



Generell Barkanläggning				SÖDERHAMNS VERKSTÄDER BOX 506 82601 Söderhamn TELEFON 0270/17000 TELEX 47025 TELEFAX 0270/18790
WIM 750–C75–Remill				DISKETT / TAPE/ETIKETT
Layout				
GODK.	KONTR.	JÄMFÖR	REV.	RITSYSTEM AutoCAD
DATUM 000125	RITAD IW	SKALA 1:50	PROJ.	83 127 613 /

WIM 500/750



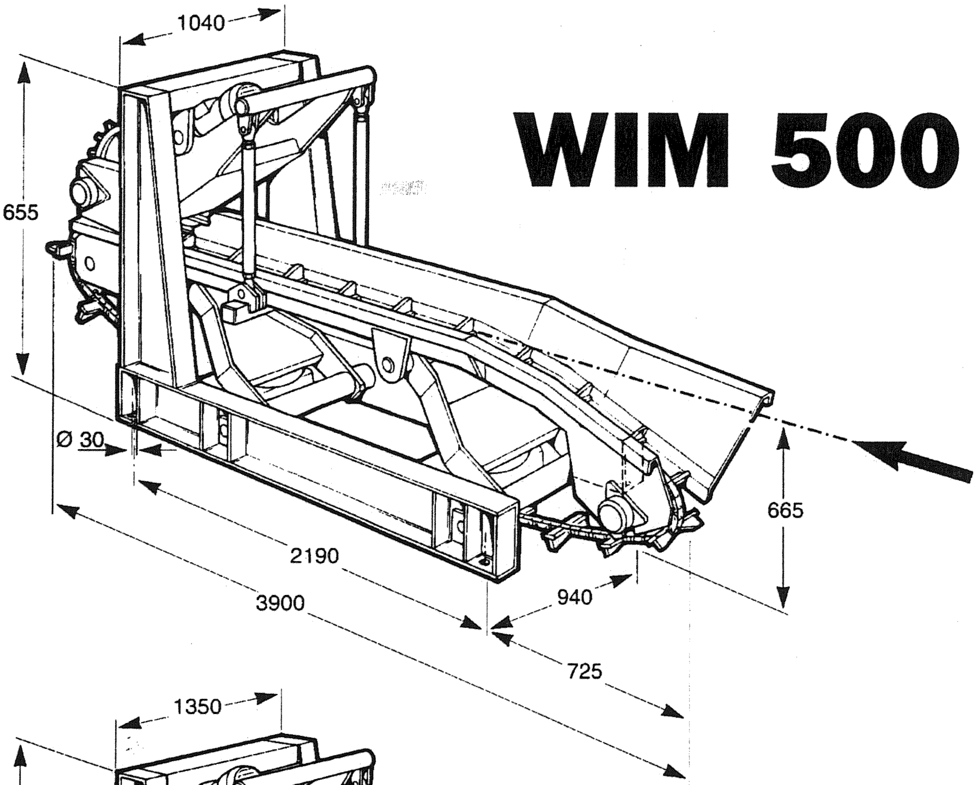
A lift of the debarking line

WIM is a strong and reliable feeding conveyor worth its price. By a selfcentering function, operated by compressed air, the debarking can be performed without any log gaps. Productivity will be raised to an absolute top level. Simultaneously wood damage will decrease and quality improve.

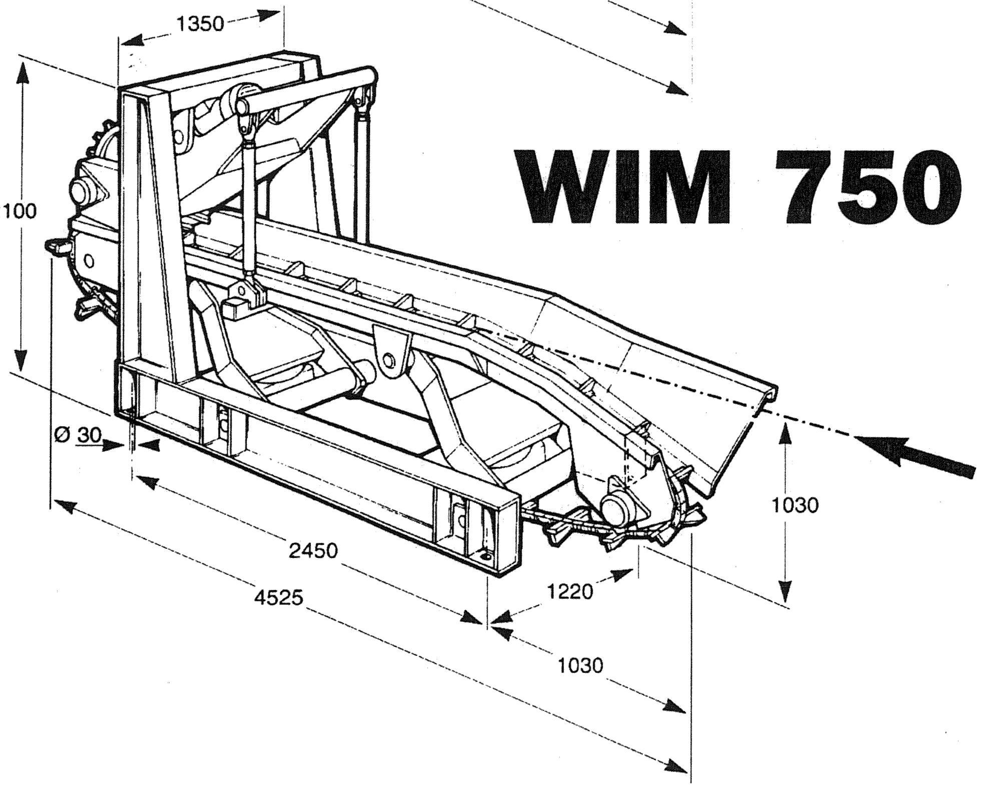
WIM is an appreciated conveyor in the sawmills debarking lines, especially by maintenance technicians for its simple and robust design, faciliating service, maintenance and repair.

Söderhamn Eriksson
CAMBIO AB

WIM 500



WIM 750



	WIM 500	WIM 750
Log dimension	6 - 50 cm	12 - 75 cm
Feed speed, max	115 m/min	115 m/min
Weight	2300 kg	3300 kg
Main motor	7,5 kW	11 kW
Upper driving roller	4,0 kW	4,0 kW
Conveyor lift	air bellows	air bellows

These data are approximate and given without obligation.

Söderhamn Eriksson
CAMBIO AB

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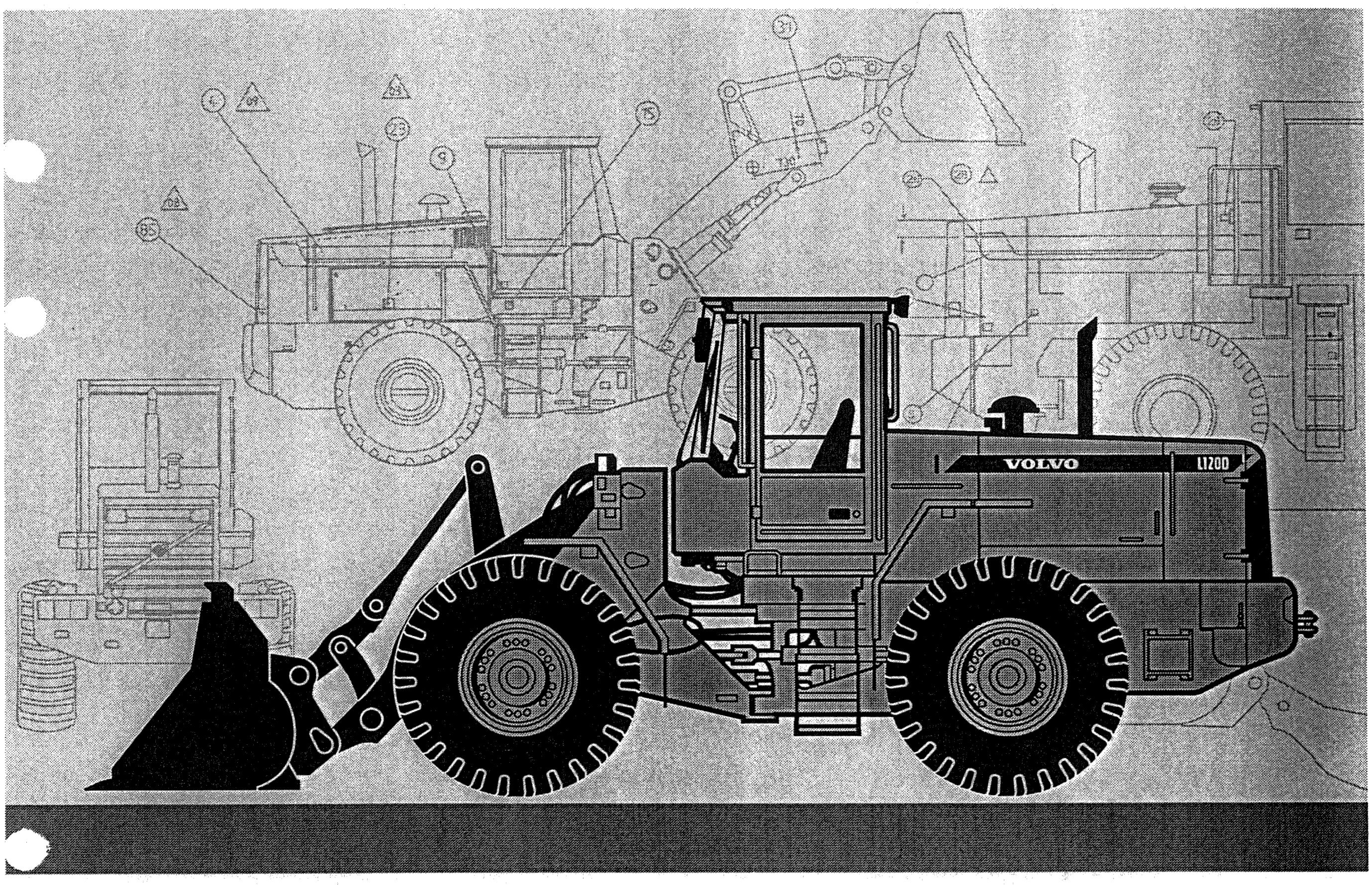
www.se-saws.com

Appendix V:

- Volvo wheel loader L120 D. Unloader of the pulpwood and loader of the chips.

VOLVO WHEEL LOADER

L120D



- **Engine output SAE J1995:** gross 153 kW (208 hp) **ISO 9249, SAE J1349** net 148 kW (201 hp)
- **Operating weight:** 18,4–20,6 t
- **Buckets:** 3,0–9,5 m^3
- **Volvo high performance-low emission engine**
  - with excellent low rpm performance
  - meets all exhaust emission regulations for off-road vehicles
- **Volvo transmission with APS II**
  - 2nd generation Automatic Power Shift with mode selector
  - optimizes performance
- **Wet disc brakes**
  - fully sealed, oil-circulation cooled
  - outboard mounted
- **Torque Parallel Linkage**
  - high breakout torque throughout the working range
  - excellent parallel lift-arm action
- **Care Cab II**
  - pressurized cab with high comfort and safety
- **Contronic II monitoring system**
- **Load-sensing steering system**
- **Pilot-operated working hydraulics**

Optional Equipment

- Hydraulic attachment bracket
- Long Boom
- Boom Suspension System
- Comfort Drive Control

VOLVO

SERVICE REFILL CAPACITIES

The Contronic II monitoring system provides information on scheduled service intervals and machine condition. Minimizes time required for troubleshooting.

Service accessibility: Large, easy-to-open engine access doors with gas struts. Hinged radiator grille and radiator.

Fuel tank	255 l	Transmission	35 l
Engine coolant	65 l	Engine oil	24 l
Hydraulic tank	145 l	Axle front / rear	36/41 l

ENGINE

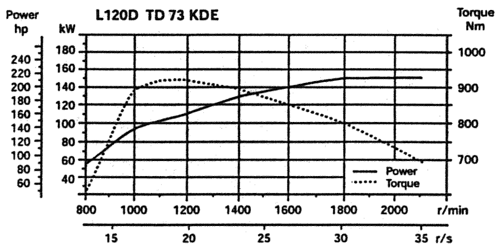
The Volvo engine offers high torque and quick response at low rpm. The machine operates efficiently at low engine speeds which contributes to good fuel economy, less noise, reduced wear and longer life.

Engine: 6-cylinder, in-line, direct-injected, turbocharged, intercooled 4-stroke diesel engine with wet replaceable cylinder liners.

Air cleaning: three-stage.

Engine	Volvo TD 73 KDE	
Max. power at	35 r/s	(2 100 r/min)
SAE J1995 gross	153 kW	(208 hp)
ISO 9249, SAE J1349 net.	148 kW	(201 hp)
ISO 9249, SAE J1349 net.	151 kW	(205 hp)*
Max. torque at	18,3 r/s	(1 100 r/min)
SAE J1995 gross	925 Nm	
ISO 9249, SAE J1349 net.	920 Nm	
Displacement	6,7 l	

* *With optional EU noise reduction kit*



ELECTRICAL SYSTEM

Contronic II monitoring system with increased function control. Electrical system with circuit boards, well protected by fuses. The system is pre-wired for installation of optional equipment.

Central warning system: Central warning light for the following functions, (buzzer with gear engaged): Engine oil pressure, transmission oil pressure, brake pressure, parking brake, axle oil temperature, steering system pressure, coolant temperature, transmission oil temperature, hydraulic oil temperature, overspeeding in engaged gear, brake charging, computer malfunction.

Voltage	24 V
Batteries	2x12 V
Battery capacity	2x140 Ah
Cold cranking capacity, ea	1050 A
Reserve capacity, ea	290 min
Alternator rating	1 680 W / 60 A
Starter-motor output	5,4 kW (7,3 hp)

DRIVETRAIN

The drivetrain and working hydraulics are well-matched and of reliable design. Quick acceleration increases productivity. Extensive Volvo component coordination facilitates service work.

Torque converter: Single-stage

Transmission: Volvo Power Shift transmission of countershaft type with single lever control. Fast and smooth forward / reverse shifting.

Shifting system: Volvo Automatic Power Shift (APS II) with mode selector.

Axles: Volvo, fully floating axle shafts with planetary-type hub reductions. Cast-steel axle housing. Fixed front axle and oscillating rear axle. 100 % differential lock on front axle.

Transmission	Volvo HT 205
Torque multiplication	2,85:1
Speeds, max forward/reverse	
1	7,3 km/h
2	13,3 km/h
3	25,2 km/h
4	35,5 km/h
Measured with tires	23.5 R25* L2
Front axle	Volvo / AWB 31
Rear axle	Volvo / AWB 30
Oscillation, rear axle	±13°
Ground clearance at 13° oscillation	460 mm

BRAKE SYSTEM

A simple and reliable brake system with few moving parts. Self-adjusting oil circulation cooled wet disc brakes give long service intervals. Brake wear indicator and brake test in Contronic II are included in the brake system.

Service brakes: Volvo, dual-circuit system with nitrogen-charged accumulators for dead engine braking. Fully hydraulically operated, enclosed internal oil circulation-cooled, outboard mounted disc brakes. Transmission declutch during braking can be preselected with a switch on the instrument panel. Brake performance test in the Contronic II system.

Parking brake: Enclosed wet multi-disc brake built into the transmission. Spring-loaded application. Electro-hydraulic release via a switch on the instrument panel. Automatically applied when the key is turned off.

Secondary brake: Either of the service brake circuits or the parking brake fullfills ISO/SAE safety requirements.

Standards: The brake system complies with the requirements of ISO 3450, SAE J1473

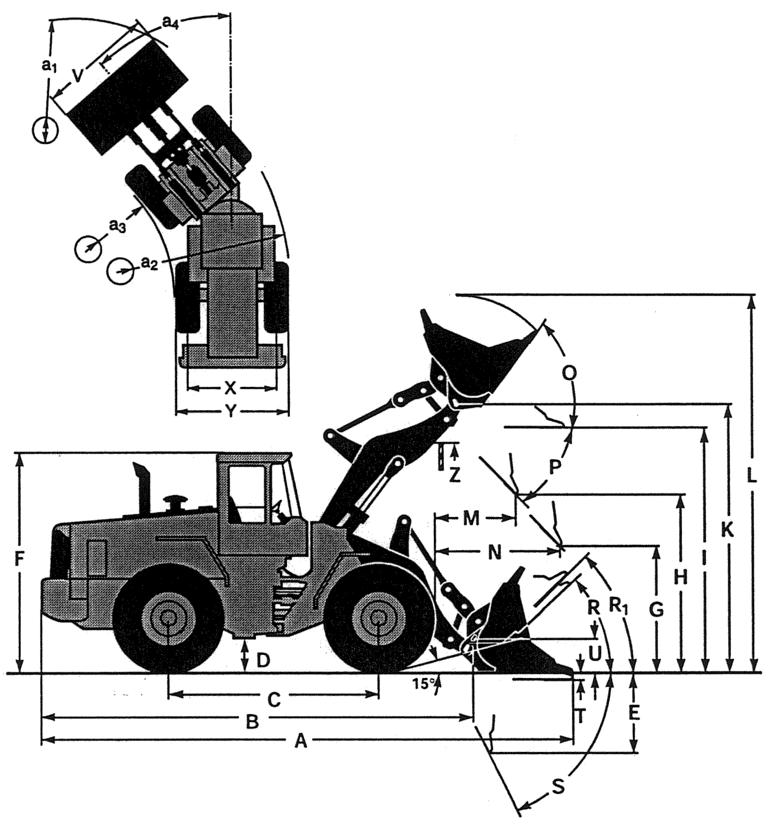
Number of discs/wheel	1
Number of accumulators	3
Volume, each	1,0 l

OPERATIONAL DATA & DIMENSIONS

Tires: 23.5 R25* L2		
	STANDARD BOOM	LONG BOOM
B	6 680 mm	7 170 mm
C	3 200 mm	3 200 mm
D	420 mm	420 mm
F	3 350 mm	3 350 mm
G	2 135 mm	2 135 mm
J	3 790 mm	4 310 mm
K	4 110 mm	4 620 mm
O	55°	55°
P	45° (P max. 49°)	45°(P max. 49°)
R	42°	43°
R_1*	47°	50°
S	67°	64°
T	90 mm	130 mm
U	510 mm	630 mm
X	2 060 mm	2 060 mm
Y	2 680 mm	2 680 mm
Z	3 350 mm	3 720 mm
a_2	5 730 mm	5 730 mm
a_3	3 060 mm	3 060 mm
a_4	±40°	±40°

* Carry position SAE

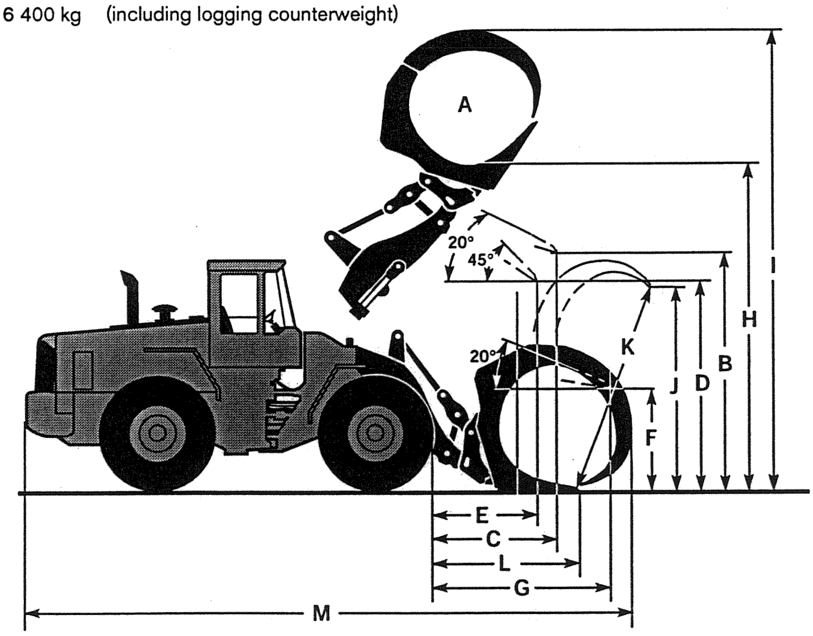
Where applicable, specifications and dimensions are in accordance with ISO 7131, SAE J732, ISO 7546, SAE J742, ISO 5998, SAE J818, ISO 8313.



SORTING GRAPPLE *(Hook-on)*

Tires: 23.5 R25* L3	
A	2,4 m²
B	3 570 mm
C	1 850 mm
D	2 950 mm
E	1 470 mm
F	1 540 mm
G	2 780 mm
H	4 690 mm
I	6 710 mm
J	2 750 mm
K	2 960 mm
L	2 130 mm
M	8 950 mm

Order No:	92746	
Operating weight:	19 860 kg	(including logging counterweight)
Operating load:	6 400 kg	(including logging counterweight)



STEERING SYSTEM

Easily operated steering results in fast work cycles. The power-efficient system results in good fuel economy, good directional stability and a smooth ride.

Steering system: Load-sensing hydrostatic articulated steering with power amplification.

System supply: The steering system is supplied by a separate steering pump.

Pump: Double variable-flow axial piston pump.

Cylinders: Two double-acting cylinders.

Steering cylinders	2
Bore	80 mm
Piston rod diameter	50 mm
Stroke	476 mm
Relief pressure	21 MPa
Max. flow	91 l / min
Articulation	± 40 °

CAB

Care Cab II with wide door opening and easy entry. Inside of cab lined with noise-absorbent materials. Noise and vibration suppressing suspension. Good all-round visibility through large glass areas. Curved front windshield of greentinted glass. Ergonomically positioned controls and instruments permit a comfortable operating position.

Instrumentation: All important information is centrally located in the operator's field of vision. Display for Contronic II monitoring system in center console on dashboard.

Heater and defroster: Heater coil with filtered fresh air and fan with four speeds. Defroster vents for all windows.

Operator's seat: Operator's seat with adjustable suspension and retractable seatbelt. The seat is mounted on a bracket on the rear cab wall. The forces from the retractable seatbelt are absorbed by the seat rails.

Standards: The cab is tested and approved according to ROPS (ISO/CD 3471, SAE J1040), FOPS (ISO 3449, SAE J231). The cab meets with requirements according to ISO 6055 ("protective roof for high-lift vehicles") and SAE J386 ("Operator Restraint System").

Emergency exits	2
Sound level in cab	
According to ISO 6396	LpA 77 dB(A)
External sound level	
According to ISO 6395	LwA 109 dB(A)
External sound level	
Optional EU noise red. kit	LwA 106 dB(A)
According to EU 2002/2006 requirements	
Ventilation	9 m³/min
Heating capacity	11 kW
Air conditioning (optional equipment)	8 kW

HYDRAULIC SYSTEM

Open center hydraulic system with efficient, high capacity vane pumps allows precision control and quick movements at low rpm.

Pump: Vane pump fitted to a power take-off on the transmission. The pilot system is supplied from a combined pilot/brake pump which is mounted in series with the steering pump.

Valve: Double-acting 3-spool valve. The control valve is actuated by a 3-spool pilot valve.

Lift function: The valve has four functions: raise, hold, lower and float. Inductive/magnetic automatic boom kickout can be switched on and off and is adjustable to any position between maximum reach and full lift height.

Tilt function: The valve has three functions: rollback, hold and dump. Inductive/magnetic automatic bucket positioner that can be switched on and off.

Cylinders: Double-acting

Filter: Full-flow filtration through 20 μm (absolute) filter cartridge.

Vane pump	
Relief pressure	22,5 MPa
Flow	275 l/min
at	10 MPa
and engine speed	35 r/s (2 100 r/min)
Pilot system	
Relief pressure	3,0 MPa
Cycle times	
Raise*	5,8 s
Dump*	1,7 s
Lower, empty	2,8 s
Total cycle time	10,3 s

* with load as per ISO 5998 and SAE J818

LIFT-ARM SYSTEM

TP Linkage combines high breakout torque throughout the working range with nearly exact parallel lift-arm action. These features, together with high lift height and long reach, make the lift-arm system equally good for bucket loading and work with attachments.

Lift cylinder	2
Bore	160 mm
Piston rod diameter	80 mm
Stroke	676 mm
Tilt cylinder	1
Bore	230 mm
Piston rod diameter	110 mm
Stroke	412 mm

STANDARD EQUIPMENT

Engine
Air cleaner, dry type, dual element, exhaust aspirated pre-cleaner
Water separator
Dual fuel filters
Crankcase ventilation oil trap
Coolant level, sight gauge
Engine intake manifold preheater
Muffler, spark arresting
Fan guard

Electrical system
Alternator, 24 V/60 A
Battery disconnect switch
Fuel gauge
Engine coolant temp. gauge
Transmission oil temp. gauge
Hour meter
Electric horn
Instrument panel with symbols
Lighting:
- Twin halogen front headlights with high and low beams
- Parking lights
- Double brake and tail lights
- Turn signals with flashing hazard light function
- Halogen working lights (2 front and 2 rear)
  Instrument lighting

Contronic II monitoring system
Contronic II ECU
Contronic II display
Engine shutdown to idle function:
- High engine coolant temperature
- Low engine oil pressure
- High transmission oil temperature

Neutral start interlock
Brake performance test
Test function for warning and indicator lights
Warning and indicator lights:
- Charging
- Oil pressure, engine
- Oil pressure, transmission
- Brake pressure
- Parking brake applied
- Axle oil temperature
- Primary steering
- Secondary steering
- High beams
- Turn signals
- Rotating beacon
- Preheating coil
- Differential lock
- Coolant temperature
- Transmission oil temperature
- Low fuel level
- Brake charging

Drivetrain
Transmission: modulated with single lever control, Automatic Power Shift II, and operator controlled declutch
Forward/reverse switch on hydraulic lever console
Differentials:
- front 100 % hydraulic differential lock
- rear, conventional

Tires 23.5 R-25* L2

Brake system
Wet, internal oil circulation cooled, disc brakes, 4-wheel, dual circuit
Brake system, secondary
Parking brake alarm - brake applied and machine in gear (buzzer)

Cab
ROPS (SAE J10400C) (ISO 3471), FOPS (SAE J 231) (ISO 3449).
Acoustical lining
Ashtray
Cigarette lighter
Door lockable (left side access)
Heater/defroster/pressurizer with four speed blower fan
Filtered air
Floor mat
Interior light
Interior rearview mirrors(2)
Exterior rearview mirrors(2)
Openable window, right-hand side
Safety glass, tinted
Adjustable hydraulic lever console
Seat, ergonomically designed, adjustable suspension
Retractable seat belt (SAE J386)
Storage compartment
Sun visor
Beverage holder
Windshield wiper, front & rear
Windshield washer, front & rear
Intermittent wiper, front
Cab access steps and handrails
Speedometer (in Contronic II display)

Hydraulic system
Main valve, 3-Spool, pilot operated
Pilot valve, 3-spool
Vane pump
Bucket lever detent
Bucket leveler, automatic with position indicator, adjustable
Boom lever detent
Boom kickout, automatic, adjustable
Hydraulic control lever lock
Boom lowering system
Hydraulic pressure test ports, Quick connect
Hydraulic fluid level, sight gauge
Hydraulic oil cooler

External equipment
Isolation mounts: cab, engine, transmission
Lifting lugs
Side panels, engine hood
Steering frame lock
Vandalism lock, provison for: batteries, engine oil, transmission oil, hydraulic oil, fuel tank
Fenders, front & rear with anti-skid-tape
Towing hitch with pin

OPTIONAL EQUIPMENT *(May be standard in certain markets)*

Service and maintenance equipment
Tool box
Tool kit
Wheel nut wrench kit
Refill pump for automatic lubrication system
Automatic lubrication system
Automatic lubrication system for attachment bracket

Engine
Coolant filter
Extra fuel filter
Cold starting aid, engine
coolant preheater (220V/1500 W)
Pre-cleaner, oil bath type
Pre-cleaner, turbo type
Radiator, corrosion protected

Electrical system
Reverse alarm (SAE J994)
Attachment light
Working lights front, extra
Working lights rear, extra
Rotating beacon, amber with collapsible mount
Alternator, brushless, 50A
Alternator 100A
Head lights assym. left
Light, license plate
Side marker lights
Parking brake alarm, audible buzzer if brake not applied when operator leaves seat

Drivetrain
Speed limiter, 3-speed version
Limited-slip differential, rear
Limited-slip differential, front/rear

Cab
Installation kit for radio
Hand throttle
Sliding window, door
Sliding window, right side
Air suspended operator's seat
Heated operator's seat
Seat belt, 3 inch
Air conditioner 8 kW, 27 300 Btu/h
Air conditioner with corrosion protected condensor
Spinner knob on steering wheel
Sun blinds, front and rear windows
Sun blinds, side windows
AM/FM radio with cassette deck
Lunch box holder
Dual service brake pedals
Armrest (left)
Cab filter for asbestos contaminated environment
Instructor seat
Noise reduction kit, cab
Steering wheel, adjustable tilt, telescopic

Hydraulic system
Hydraulic control, 3rd function
3rd function detent
Hydraulic control, 4th function
Hydraulic single acting lifting function
Boom Suspension System
Biodegradable hydraulic fluid
Pilot hoses, 3rd function and separate attachment locking
Attachment bracket
Separate attachment locking system
Single lever hydraulic control
Single lever hydraulic control plus 3rd function

External equipment
Fenders, full coverage, swingout
Logging counterweight
Fenders, axle mounted

Other equipment
Comfort Drive Control (CDC)
Slow moving vehicle emblem
Secondary steering
50 km/h sign
Fuel fill strainer
Long boom
Noise reduction kit, acc. EU stagell 2006

Tires
23.5–25
23.5 R25*

Protective equipment
Protective grids for front running lights
Radiator guard
Protective grids for rear working lights
Window guards for side and rear windows
Windshield guard
Protective grids for tail lights
Bellyguard, front
Bellyguard, rear
Heavy-duty main valve cover

Attachments
Buckets
Fork equipment
Material handling arms
Log grapples
Snow blades
Brooms
Cutting edge, 3 pc reversible, bolt-on
Bucket teeth, bolt-on
Bucket teeth, weld-on
Wear segments, bolt on
Bale clamp
Drum rotator

Under our policy of continuous product improvement, we reserve the right to change specifications and design without prior notice. The illustrations do not necessarily show the standard version of the machine.

VOLVO

Volvo Construction Equipment Group

Ref. No. 21 3 669 2321 English
Printed in Sweden 2000.04 – 5,0 WLO
Volvo, Eskilstuna

OPERATIONAL DATA VOLVO L120D

Tires 23.5 R25 L2		GENERAL PURPOSE						ROCK**	LIGHT MATERIAL	LONG BOOM	
		Teeth	Bolt-on edge	Teeth	Bolt-on edge	Bolt-on edge	Bolt-on edge	Teeth Segments	Bolt-on edge	Bolt-on edge	Bolt-on edge
Volume, heaped ISO/SAE	m^3	3,0	3,1	3,3	3,4	3,4	3,6	3,1	5,5	2,6	2,6
Actual volume, 110%	m^3	3,3	3,4	3,6	3,7	3,7	4,0	–	6,1	2,9	2,9
Static tipping load, straight	kg	14 440	14 200	14 280	13 340	14 050	13 250	14 490	12 660	11 180	11 780
at 35° turn	kg	12 790	12 570	12 640	11 760	12 430	11 680	12 790	11 120	9 810	10 380
at full turn	kg	12 310	12 100	12 160	11 300	11 950	11 220	12 290	10 660	9 410	9 960
Breakout force	kN	159,1	150,7	151,1	132,7	143,5	129,0	150,3	104,8	156,7	171,2
A	mm	8 300	8 130	8 370	8 320	8 210	8 370	8 280	8 710	8 610	8 510
E	mm	1 350	1 200	1 420	1 370	1 260	1 410	1 280	1 730	1 220	1 120
H *)	mm	2 810	2 920	2 760	2 790	2 870	2 760	2 870	2 480	3 440	3 520
L	mm	5 630	5 630	5 700	5 750	5 700	5 800	5 750	5 910	6 080	6 020
M *)	mm	1 300	1 160	1 350	1 290	1 210	1 330	1 210	1 540	1 130	1 050
N *)	mm	1 870	1 780	1 890	1 850	1 810	1 860	1 830	1 880	2 220	2 170
V	mm	2 880	2 880	2 880	2 880	2 880	2 880	2 880	3 000	2 880	2 880
a_1 clearance circle	mm	12 770	12 680	12 810	12 770	12 710	12 800	12 760	13 120	13 090	13 020
Operating weight	kg	18 790	18 880	18 870	19 210	18 960	19 260	20 020	19 540	19 380	19 110

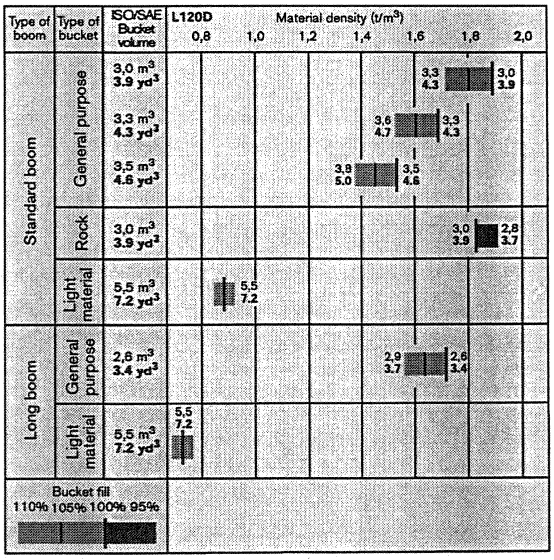
*) at dump angle 45°
**) with L5 tires

BUCKET SELECTION CHART

The choice of bucket is determined by the density of the material and the bucket fill factor. The TP-linkage uses a very open bucket design, has very good roll back in all positions and fills the bucket very well. This means that the actual volume carried is often larger than the rated capacity of the bucket. Bucket fill factors for different materials and how they affect the actual bucket volume are shown in the table. Example: Sand and gravel. Fill factor ~105%. Density 1,65 ton/m³. Result: The 3,3 m³ bucket carries 3,5 m³.
For optimum stability always consult the bucket selection chart.

Material	Bucket fill %	Material density ton/m³	ISO/SAE bucket volume, m³	Actual volume, m³
Earth/Clay	~ 110	~ 1,7	3,0	~ 3,3
		~ 1,5	3,3	~ 3,6
		~ 1,4	3,5	~ 3,8
Sand/Gravel	~ 105	~ 1,75	3,0	~ 3,2
		~ 1,65	3,3	~ 3,5
		~ 1,5	3,5	~ 3,7
Aggregate	~ 100	~ 1,9	3,0	~ 3,0
		~ 1,7	3,3	~ 3,3
		~ 1,6	3,5	~ 3,5
Rock	≤ 100	~ 1,8	3,0	~ 3,0

The volume handled varies with the bucket fill and is often greater than indicated by the bucket's ISO/SAE volume. The table shows optimum bucket choice with regard to the material density.



SUPPLEMENTAL OPERATING DATA

		Standard Boom	Long Boom
		23.5R25 L5	23.5R25 L5
Width over tires	mm	+10	+10
Ground clearance	mm	+10	+10
Tipping load, full turn	kg	+570	+460
Operating weight	kg	+820	+820

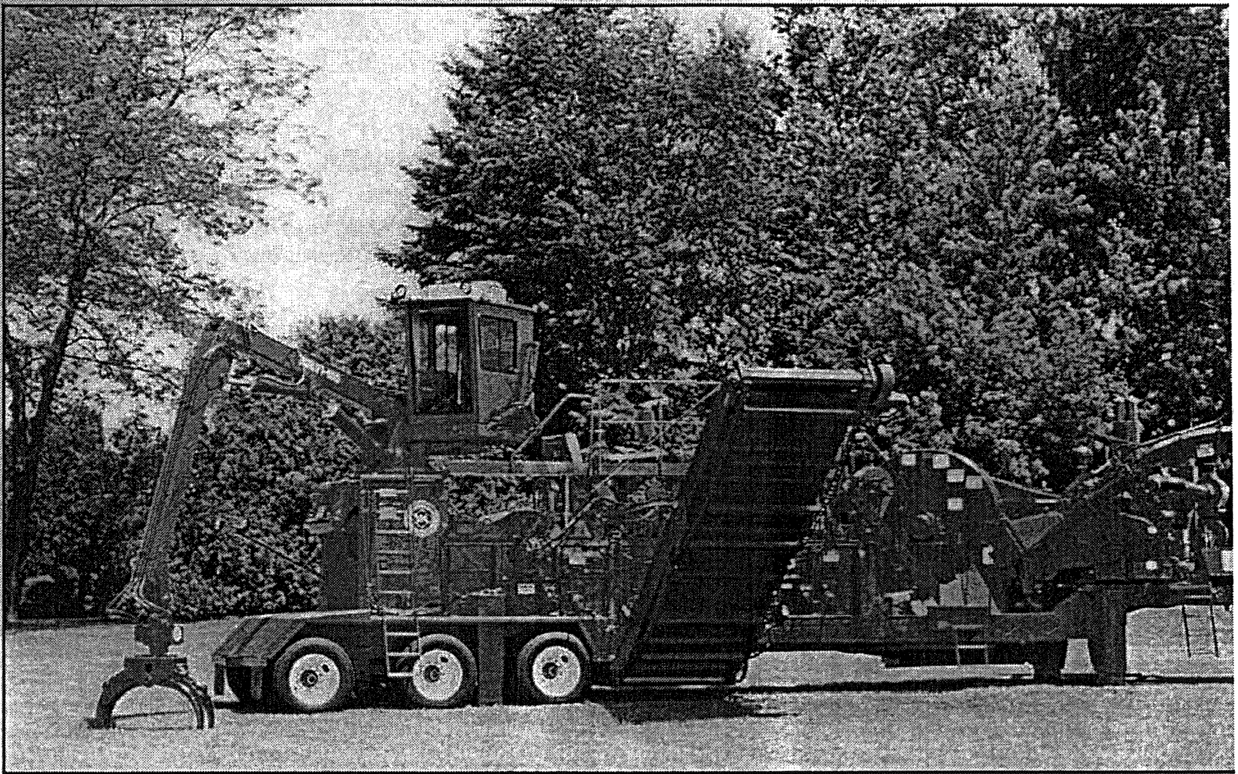
Appendix VI:

- Morbark flail chiparvestor, model 2755.
- Information about the costs that are related to the machine.

Morbark Flail Chiparvestor

Product Information

Model 2755



The new Model 2755 Flail Chiparvestor blends time-tested field chipping capabilities with the latest in flail debarking technology.

This portable, in-woods system produces clean, pulp & paper quality chips at rates in excess of 100 tons per hour while processing whole trees ranging from 2 to 27 inches in diameter.

Hydraulic flail drive is standard equipment on the 2755. A closed loop system equipped with a cab-mounted tachometer and speed control for each flail drum lets the operator set individual flail speeds in a range from 0 to 600 RPM, depending on conditions. This system, in conjunction with Morbark's trademark twin-engine design, provides great latitude in controlling overall efficiency as well as flail speed, chipper RPM, feed rate and other adjustments.

For the first time, Morbark offers the option of adding a third flail drum on the Model 2755. Hydraulically driven and set in a pivoting yoke, the third flail greatly increases debarking efficiency.

Standard features on the Model2755 include an air curtain, rear hydraulic stabilizers, five live bottom feed rolls, a deluxe operator's seat and extended debris conveyor. This extended conveyor makes it convenient to add a Morbark Model 1000 Forestry Tub Grinder for total fiber utilization.

From the company that pioneered whole tree chipping, the Model 2755 sets a new standard for excellence.

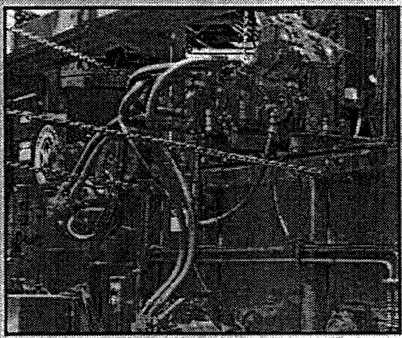
Morbark, Inc.

8507 S. Winn Road
P.O. Box 1000
Winn, MI 48896

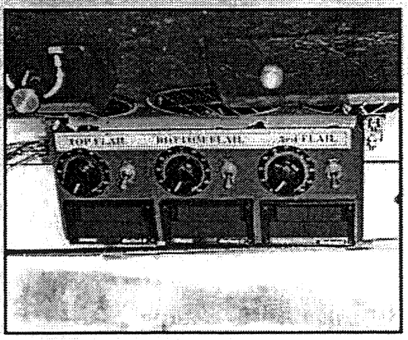
(800) 233-6065
(517) 866-2381
Fax (517) 866-2280

E-mail: morbark@worldnet.att.net
Web site: http://www.morbark.com

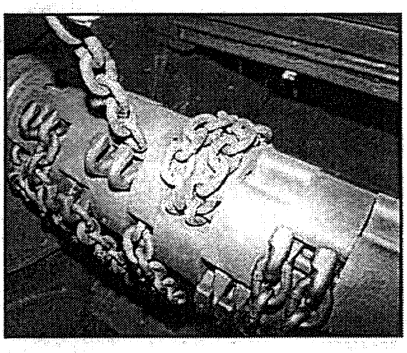
Morbark Flail Chiparvestor **Model 2755**



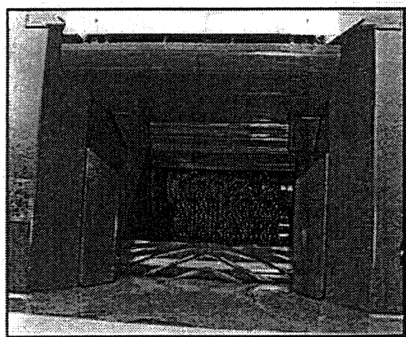
Standard hydraulic flail drive system cuts weight, improves efficiency and provides more precise debarking control.



Closed loop hydraulic drive system allows the operator to individually control flail RPMs from the cab.



Morbark's patent pending Kwik Hook system saves producers time and money, representing a major improvement over conventional methods of fastening chain links to the flail drum.



55" wide patented flail infeed spreads and holds multiple stems from 2-27" in diameter for maximum debarking.

GENERAL

Overall length	48'
Transport height	13'6"
Transport width	12'
Gross weight	105,000 lbs.
Tri-axle trailer	67,500 lbs. suspension
Tires (12)	22.5 x 75R x 14 ply radials
Brakes	air
Stabilizer legs (4)	hydraulic
Towing arrangement	fifth wheel
Engine(s)	Caterpillar or Cummins
Horsepower (flail)	325
Horsepower (chipper)	600-800
Drive (flail)	hydraulic
Drive (chipper)	belt
Fuel capacity (tank)	310 gallon
Hydraulic oil capacity (flail)	130 gallon
Hydraulic oil capacity	200 gallon

CAB & LOADER

Enclosed weatherized operator's cab mounted on rubber shock absorbers, tilts hydraulically for transport
6-way adjustable seat and joy stick controls
Morlift Model 500 knuckleboom loader, 270° swing, 23' reach, 360° continuous rotation grapple
Lift capacity 17,200 lbs. at 10'

FLAIL

Infeed opening 27" x 55"
Three (3) top feed rollers mounted on yoke assemblies
Five (5) stationary bottom feed rollers
Two horizontal chain flails with segmented drums are equipped with eight (8) flail chain rods each. Each rod holds eleven (11) chains. (or) Tube type drums equipped with six (6) flail chain rods each. Each rod holds thirteen (13) chains
Top flail drum set in pivoting yoke assembly
Bark discharge conveyor, 60" wide x 23' long, drag chain, hydraulically driven, telescoping for transport, discharge height of 11'
Air curtain

CHIPPER

27" diameter chipping capacity
83" diameter chipper disc, 3-knife configuration
Chip sizes: 5/8", 3/4", 7/8", or 1"
Dirt separator bottom discharges onto the bark and debris conveyor
Hydraulic swivel/telescoping discharge spout

OPTIONS

4-knife chipper disc
Third flail drum
Mechanical drive on two main flail drums
Top loading discharge system
Combination air conditioner/heater
Halogen light package
Single Power Unit (950-1050) (2 drum only)

5M 10-99R Specifications subject to change without notice.

MORBARK, INC.
8507 S. WINN RD P.O. BOX 1000
WINN, MICHIGAN 48896 (517) 866-2381 FAX (517) 866-2280 www.morbark.com

April 27, 2001

Andreas Osarsson & Johan Norman
Box 32 Hotel Villa Sundet
230 53 Alnarp Stanvagen 104, rum 22
Sweden 234 31 Lomma
Sweden

Dear Mr. Oscarsson & Mr. Norman

We offer a machine that can debark, separate debris and dirt, and chip all in one application. This machine is our 2755 Flail Total Chiparvestor. This portable machine, produces clean pulp and paper quality chips, at rates of 100 tons per hour. While processing whole trees ranging from 2 to 27 inches in diameter.

With the optional spout extension for the end discharge, you are able to load open top rail cars. This way you can set up your site right next to the railway.

This 2755 Flail comes standard with a 500 knuckleboom loader. This loader has a 270-degree swing, 23-ft reach, 360-degree rotation grapple, and a lifting capacity of 17,200 lbs. at 10-ft. An enclosed weatherized operator's cab mounted on rubber shock absorbers, tilts for transport. It also has a 6-way adjustable seat and joy stick controls.

This machine can produce 4 different chip sizes: 5/8", ¾", 7/8", 1". It has an 83" diameter chipper disc, and a 3-knife configuration. With a built in dirt separator, debris are bottom discharge onto a 48" wide conveyor, which discharges directly to the 23' refuse drag chain conveyor.

One person can operate this machine. You will need an area of about 60-ft by 60-ft. The 2755 will produce up to 1% or less bark and dirt content. The cost of the machine with all the is about $640,000.00 US. With this one machine, you can eliminate 3 machines.

I hope this will help you guys. If you want it done with a debarker, chipper, and screening machines, I can do that for you. The 2755 Flail is by far the way to go. If you have any questions, feel free to call me at: (517) 866-2381.

Thank You,

Kevin M. Kowallic

Kevin Kowallic
International Sales

"With Pride in Performance"

MORBARK, INC.

Estimated Owning and Operating Cost of

The Model 2755 (3) Flail Chiparvestor

GENERAL STATEMENT:

The following owning and operating cost analysis is based on reported contractor information and test runs conducted by Morbark Inc. Obviously, there will be cost variations depending upon the type and conditions of the material being processed.
This analysis is based on 5 year/s or 8,750 hours.
We have fully depreciated the equipment over the 5 year period.

** It should be noted that we have not allowed for any residual value for the machine at the end of the depreciated period. We estimate the forementioned equipment will have a value of approximately $107,016.00 after 5 years.*

OWNING COSTS

Purchase Price - Based on a $ 640,000.00 purchase price amortized over 5 year/s or 8750 Hrs	$ 73.14
Interest - Figuring 9.50% per year on a declining balance of $ 640,000.00 total interest cost will be approximately $ 166,471.47 divided 8750 hrs:	$ 19.03
Insurance Cost - Based on a replacement value of $ 640,000.00 at an average rate of $ 1.10 per every $ 100.00 per year over 5 year/s = $ 35,200.00 divided by 8750 Hrs =	$ 4.02
TOTAL OWNING COST:	**$ 96.19**

OPERATING COST

Machine Maintenance - Includes labor and material for daily lubrication, filters and replacement of miscellaneous wear parts. Based on these factors we estimate the average yearly maintenance to be $ 136,675.00 per year multiplied by 5 yrs = $ 683,375.00 divided by 8750 hours =	$ 78.10
Fuel Cost - Fuel consumption estimated at 26 gallons per hour. Estimated cost at $ 2.00 per gallon.	$ 52.00
Labor - Operator cost includes Benefits $ 25.00 per hr (Costs may vary depending on area)	$ 25.00
TOTAL OPERATING COST	**$ 155.10**
TOTAL OWNING AND OPERATING COSTS	**$ 251.29**

SUMMARY OF HOURLY OWNING AND OPERATING COSTS:

Owning Costs		
1)	Depreciation	$ 73.14
2)	Interest	$ 19.03
3)	Insurance	$ 4.02
TOTAL OWNING COSTS PER HOUR		$ 96.19
Operating Costs		
1)	Machine Maintenance	$ 78.10
2)	Fuel Cost	$ 52.00
3)	Labor	$ 25.00
TOTAL OPERATING COSTS PER HOUR		$ 155.10
TOTAL OWNING & OPERATING COSTS PER HOUR		$ 251.29

DISCLAIMER: The previous owning and operating costs are estimates only, based on reported contractor information and factory test runs. These costs do not imply any [illegible] guarantees by Morbark Inc.

Machine Maintenance - Includes labor and materials for daily lubrication, inspection, chipper knives and counter knives.

Page 2 *Revised 3:34 PM 4/27/2001*

1) Grease - $ 1.90 per hour x 8750 hours = $ 16,625.00 per 5 yr/s
Divided by 8750 Hrs. $ 1.90

2) Chipper Knives - 20 per yr @ $ 213.00 per set = $ 2.13
per hour x 8750 Hrs. = $ 18,637.50 over 5 yr/s Divided by 8750 Hrs. $ 2.13

3) Counter Knives - 20 per yr @ $ 189.00 per set = $ 1.89 per hour x
8750 Hrs. = $ 16,537.50 over 5 yr/s Divided by 8750 Hrs. $ 1.89

4) Two sets of knife clamps 6 @ $ 280.17 each = $ 0.84 per hour
an 3 knife holders at $ 240.33 each = $ 0.36 per hour x
8750 Hrs. Totals $ 1.20 per hour or $ 10,500.00 Divided by 8750 Hrs. $ 1.20

5) Labor involved in changing knives, Babbiting and grinding knives: $ 0.75 per hour x
8750 Hrs. = $ 6,562.50 over 5 yr/s Divided by 8750 Hrs. $ 0.75

6) Fuel, oil, air, and hydraulic filters for engine (per manufacturer's service recommendations)
$ 6.50 per hour x 8750 Hrs. = $ 56,875.00 ove 5 yr/s 8750 Hrs. $ 6.50

7) Flail Chain replacements @ $ 42.80 per hour x 8750 Hrs. = $ 374,500.00
over 5yr/s divided by 8750 Hrs. = (52.5 tons per hr = .52 cents per ton) $ 42.80

8) (2) Flail drum and rod replacements per year @ $ 8.75 per hour x 8750 Hrs. =
$ 70,562.50 over 5 yr/s divided by 8750 Hrs. = $ 8.75

9) Labor for changing chain 35 min. per day x 200 days = $ 0.75 per hour x 8750 Hrs. =
$ 6,562.50 ove 5 yr/ 8750 Hrs. = $ 0.75

10) Misc. including knife sharpening and babbiting $ 11.43 per hour x 8750 Hrs. = $ 11.43
$ 100,012.50 ove 5 yr/ divided by 8750 Hrs. =

TOTAL MAINTENANCE COSTS = $ 683,375.00 $ 78.10

ESTIMATED COST PER TON IN A 7 HOUR WORK DAY

** Based on 250 days per year*

9 Loads per day @ 25 Tons per load = 225 Tons per day
divided by 7 hours = 32.14 Tons per hour $ 251.29 divided by 32.1 Tons = $ 7.82

12 Loads per day @ 25 Tons per load = 300 Tons per day
divided by 7 hours = 43 Tons per hour $ 251.29 divided by 43 Tons = $ 5.86

15 Loads per day @ 25 Tons per load = 375 Tons per day
divided by 7 hours = 53.6 Tons per hour $ 251.29 divided by 53.6 Tons = $ 4.69

17 Loads per day @ 25 Tons per load = 425 Tons per day
divided by 7 hours = 60.7 Tons per hour $ 251.29 divided by 60.7 Tons = $ 4.14

20 Loads per day @ 25 Tons per load = 500 Tons per day
divided by 7 hours = 71 Tons per hour $ 251.29 divided by 71 Tons = $ 3.52

25 Loads per day @ 25 Tons per load = 625 Tons per day
divided by 7 hours = 89.3 Tons per hour $ 251.29 divided by 89.3 Tons = $ 2.81

30 Loads per day @ 25 Tons per load = 750 Tons per day
divided by 7 hours = 107 Tons per hour $ 251.29 divided by 107 Tons = $ 2.35

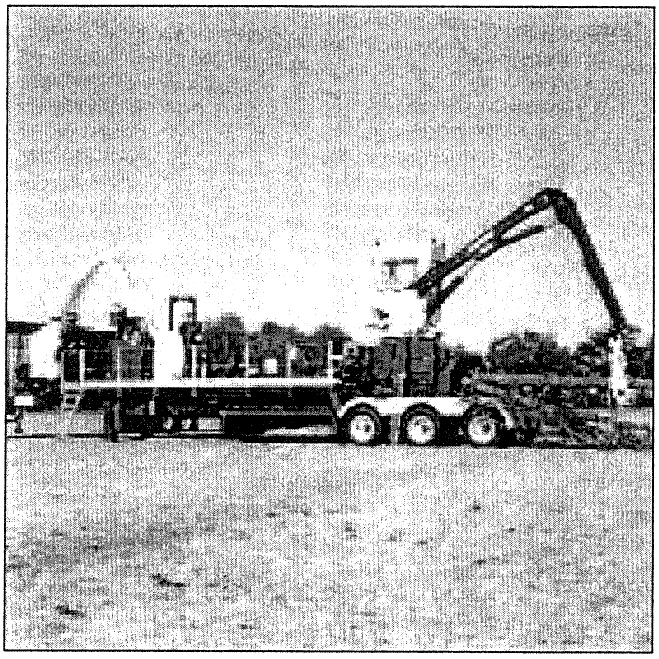
DISCLAIMER: The ... based upon ... information and factory test runs. These ... do not ...

Appendix VII:

- Peterson Pacific, DDC 5000-G. (Delimber, Debarker, Chipper).

DDC 5000-G

Delimber
Debarker
Chipper



The DDC 5000 demonstrates reliability and productivity in processing tree length wood; delimbing, debarking and chipping in one continuous operation.

The Peterson Pacific model DDC 5000-G portable chip plant;

- ✓ excellent for in-the-woods or yard chipping productions,
- ✓ processes multiple whole trees from 2"–23" (5.1–58.4 cm) diameter simultaneously,
- ✓ production rates of up to 100 U.S. tons/hour, with excellent chip quality,
- ✓ achieves bark content under 0.3%, optional third flail drum for tough jobs,
- ✓ provides improved reliability and mobility.

The *one machine, one operator* concept reduces capital expenditures. Using our patented pressure compensation system allows the use of a single engine, which reduces fuel consumption and maintenance, and increases up time. All of this makes the DDC 5000-G the ideal machine for whole tree chipping. *You must see the model DDC 5000-G!*

GENERAL SPECIFICATIONS

Weight	approximately 90,000 lbs. (40,853 kg)
Length	51 ft., 9 in. (15.8 m) overall
Width	10 ft., 8 in. (3.25 m)
Height	13 ft., 5 in. (4.09 m)

Peterson Pacific Corp.

Leading the way...with total tree harvesting

29408 Airport Road, (97402) • P.O. Box 40490 • Eugene, OR 97404 USA • 541/689-6520 • FAX 541/689-0804

DDC 5000-G Delimber Debarker Chipper

Trailer

Double 4 x 12 box section frame with strapping
Tridem oil bath axles – 10 ft. (3.05 m) spread
Dual steel belted tires – 275/80R-22.5
10 hole Budd style wheels
Tridem spring walking beam suspension
Four hydraulic outriggers
Heavy duty fenders with redesigned in-feed system

Delimber/Debarker

Dual horizontal debarker flail drums - six chain rods
Optional third debarker drum floats on a parallelogram
and dual air cylinders or optional hydraulic cylinders
Dual feed rollers – debarker and chipper
Top floating, powered feed rollers – debarker and chipper
Six powered lower feed rolls
Side discharge bark mover – 10 ft. (3.05 m) wide
Variable flail speeds, adjustable from the cab

Log Loader

Hydraulic two-section knuckle boom – 25 ft. (7.62 m)
42" (106.7 cm) continuous rotation grapple with heel rack
Two lever joystick controls (pilot pressure type)
Enclosed weatherized operator's cab
Pressurized cab with heater and air conditioner (optional)
Lift capacity: 11,600 lbs. at 15 ft.

Chipper

Heavy duty three pocket chipper disk, 66" (167.6 cm) dia.
Standard three knife configuration
Top or side loading chip chutes with hydraulic fold cylinder
Hydraulic swivel telescoping discharge spout
Dirt separator removes contaminants, overs, fines and slivers

Power Unit

Caterpillar Model 3412, 800 hp
277 U.S. gallon (1048.6 liter) fuel tank
Heavy duty clutch
30 CFM air compressor
Pressurizing air compressor

Hydraulic Pumps

Nine hydraulic pumps;
2 – Hydrostatic (3 on three-flail models)
1 – Pressure compensated
6 – Fixed GPM pumps

Specifications subject to change without notice

Find out more about the entire Peterson Pacific Corp. product line at:

Peterson Pacific Corp.
Leading the way...with total tree harvesting

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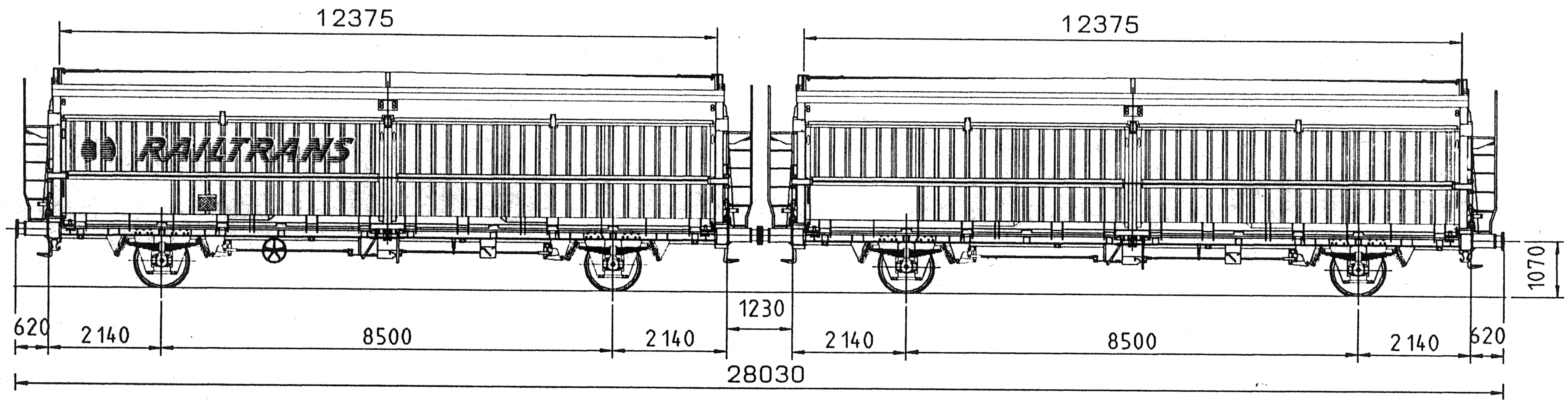
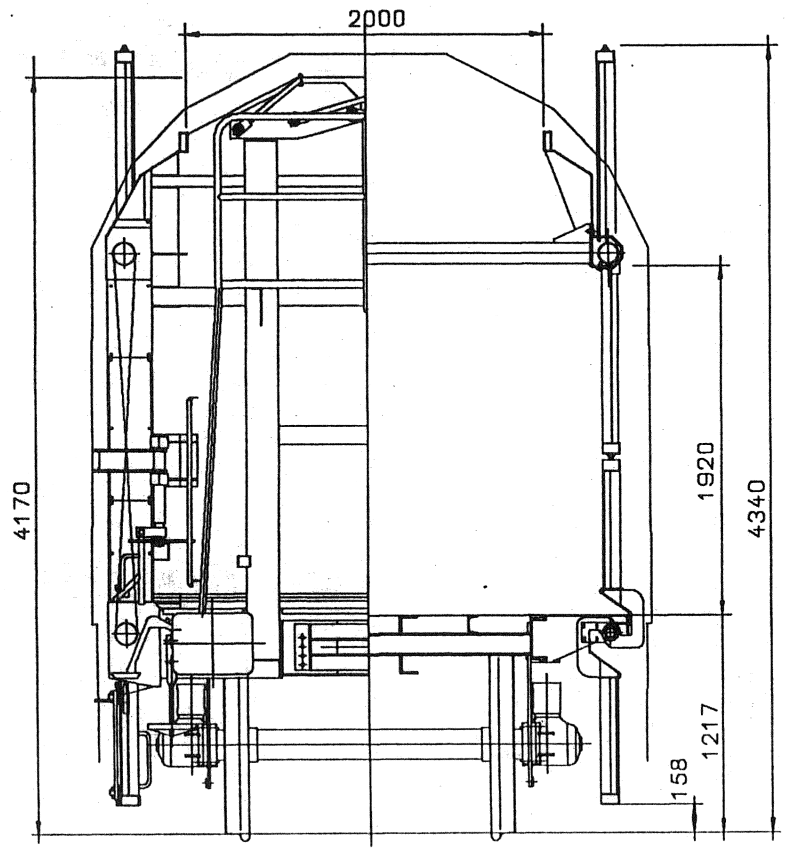
Appendix VIII:

- Fehring railway wagons, specifications.
- Questions to Mr Dieter Fehring.
- Answers from Mr Dieter Fehring.





Volume utile : 182 m³	Usual volume : 182 m³	Laderaum : 182 m³
Longueur utile : 24,75 m	Usual lenght : 24,75 m	Ladelänge : 24,75 m
Largeur utile : 2,64 m	Usual widht : 2,64 m	Ladebreite : 2,64 m
Tare : 29 t	Tare weight : 29 t	Eingengewicht : 29 t
Charge utile : 51 t	Cargo weight : 51 t	Ladegewicht : 51 t

RAILTRANS

Mr Fehring,

We are two forestry students who are doing our final thesis about transportation systems. This thesis mainly handles the transport of beech pulpwood from Thüringen in Germany to Nymölla pulpmill in Sweden. We received this commission from StoraEnso Forest Central Europe, vice president Weine Genfors and our contact person at the company is Ralf Löbbermann. Our supervisor at the university is assistant professor Bo Dahlin.
One of the things we are investigating is the possibility to have chipping terminals along the railway. Then the pulpwood would be barked, chipped and screened by the railway. The chips are then transported to Sweden by rail. To increase the capacity of the system and the amount of returning transports we are looking at different kind of railway wagons. For example if it is possible to use some kind of covered railway wagon. We talked to Weine Genfors and he told us that your company was skilled in logistics and transportation of chips. Therefore we have a few questions for you. It would be really nice of you if you could take the time to answer them and return the answers by email to Andreas or me. If you don't have the time it would be good if you could forward these questions to someone who has. If you forward them we would be thankful to know who has answered the questions.

Here are the questions:

1. What different types of wagons do you have in you company?
2. We have found out that you have a special kind of wagon to transport chips, how does it work in practical?
3. Is it possible to have a returning transport of "ordinary goods" in your special wagons made for chips?
4. Does the transport of chips require some kind of packaging of the chips, in big bags for example?
5. How are the chips stored by the railway, and how much is the cost for it?
6. Will the quality be decreased if the pulpwood chips are transported all the way to Sweden from Germany?
7. What kind of machines are involved in the loading and unloading of the wagons?
8. How is the loading and unloading done?
9. Do have any experiences in constructing chipping systems at railway terminals containing barkers, chippers and screeners?
10. How much would it approximately cost to establish a chipping terminal by the railway?

11. Do you have any idea of where, for example in Thüringen these terminals could be situated?

12. Suppose that this terminal system works and is producing chips of different fractions and qualities. Will it then be an alternative to sell chips to OSB and MDF mills? It would also be interesting if the bark could be sold to a heating mill for example?

13. How much would the OSB and MDF mills pay for the chips?

14. How much would the heating plants pay for the chips?

15. How much would it cost to transport 1 m^3 of chips with your wagon/system?

Thank you very much for your cooperation!

Here are our addresses and phone numbers:

Telephone number daytime: +46 (0) 40-41 51 84

Andreas Oscarsson
Box 32
230 53 Alnarp

+46(0)40-463588
+46(0)708-646582

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Johan Norman
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FEHRING HOLZSPÄNE

Postfach 17 04 51, 33704 Bielefeld / Brönninghauser Str. 32, 33729 Bielefeld,
Tel.: 0521/ 39 81-0 (Zentrale), Fax.: 0521/ 39 19 93

TELEFAX MESSAGE

to:	**Mr. Andreas Oscarsson, Sweden**
from:	Mr. D. Fehring
Date:	2001-05-11
Ref.:	***Your Email of May 3, 2001*** ***Transportation system***

Dear Mr. Oscarsson,
Dear Mr. Norman,

With regards to your Email concerning transport of beech roundwood and chips here are our answers to your questions:

At 1.: We operate private and Deutsche Bahn AG railcars. The Deutsche Bahn AG railcars are regular railcars for roundwood. The chip-railcars belong to a French subsidiary of Fehring, who is specialised for the transport of woodchips and sawdust.

At 2.: With separate mail we send you a photograph and drawings of the chip-railcars with all measures necessary.

The railcars have doors on both sides which can be opened up, both downside and upside. The chips are being filled from the top (conveyor belt or caterpillar front-loader) and will be unloaded from the side by a caterpillar with a special pushing gear. The chips will be pushed from one side to the other. For each railcar to unload it will take about 20 minutes time.

At 3.: Yes, respecting the openings of the door any goods can be transported. You have to make sure, that the top will be covered by a hood to prevent the goods from getting wet.

At 4.: No.

At 5.: Usually the Deutsche Bahn AG does not do the storage or the loading of the chips for us. This has to be done and organised by the user of the railcars. Therefore the costs are not clear and have to be calculated individually. Fehring will be at Stora's disposition to do this research.

At 6.: No.

At 7.: As said above the loading will be either by conveyor belt or by a front-loader caterpillar type of vehicle. The unloading of the chips will be effected from the side where the caterpillar has to use a special device to push the chips from one side to the other. This device is not very expensive and can be changed very quickly.

At 8.: See 7.

At 9.: No, we have not constructed or built any debarking and chipping devices, but we are familiar with those machines from our customers.

At 10.: We believe that Deutsche Bahn AG will not be interested in putting up a chipping terminal. On the other side Fehring will be interested in doing this on the basis of a long term contract with Stora.

At 11.: No idea at this time. This has to be researched. We believe though, that the chipping terminals should be very close to the main beech areas from where the logs will be transported and forwarded to the terminals.

At 12.: It will be difficult to sell beech chips to OSB- and MDF-mills as they are mostly based on softwood. Nevertheless we believe that a fraction of those chips can be sold to those factories unless the quality- and size-specifications are correct.

The bark and the fines can certainly be sold to a combustion unit. As Fehring will be supplying several combustion units in Germany this is an interesting point of cooperation with Fehring.

At 13.: At today's prices the OSB- and MDF-mills will not pay any more than DM 16,-- to DM 20,-- per loose cubic metre supplied to the mill.

At 14.: A combustion unit may be paying between DM 40,-- and 60,-- per green ton delivered.

At 15.: As of today this is difficult to tell, because each individual relation and distance of transport has to be calculated individually. We suggest that we have talks with the Deutsche Bahn AG (DB Cargo) as soon as preliminary terminal sites are identified.

As to the cost of the private railcar we suggest to use between DM 80,-- and 90,-- per day of railcar rent. Each railcar will carry about 50 tons. Of course, the transport and forwarding of those railcars will come on top.

We hope, that we could sufficiently answer to your above mentioned questions. For any further details please contact us any time.

Kindest regards

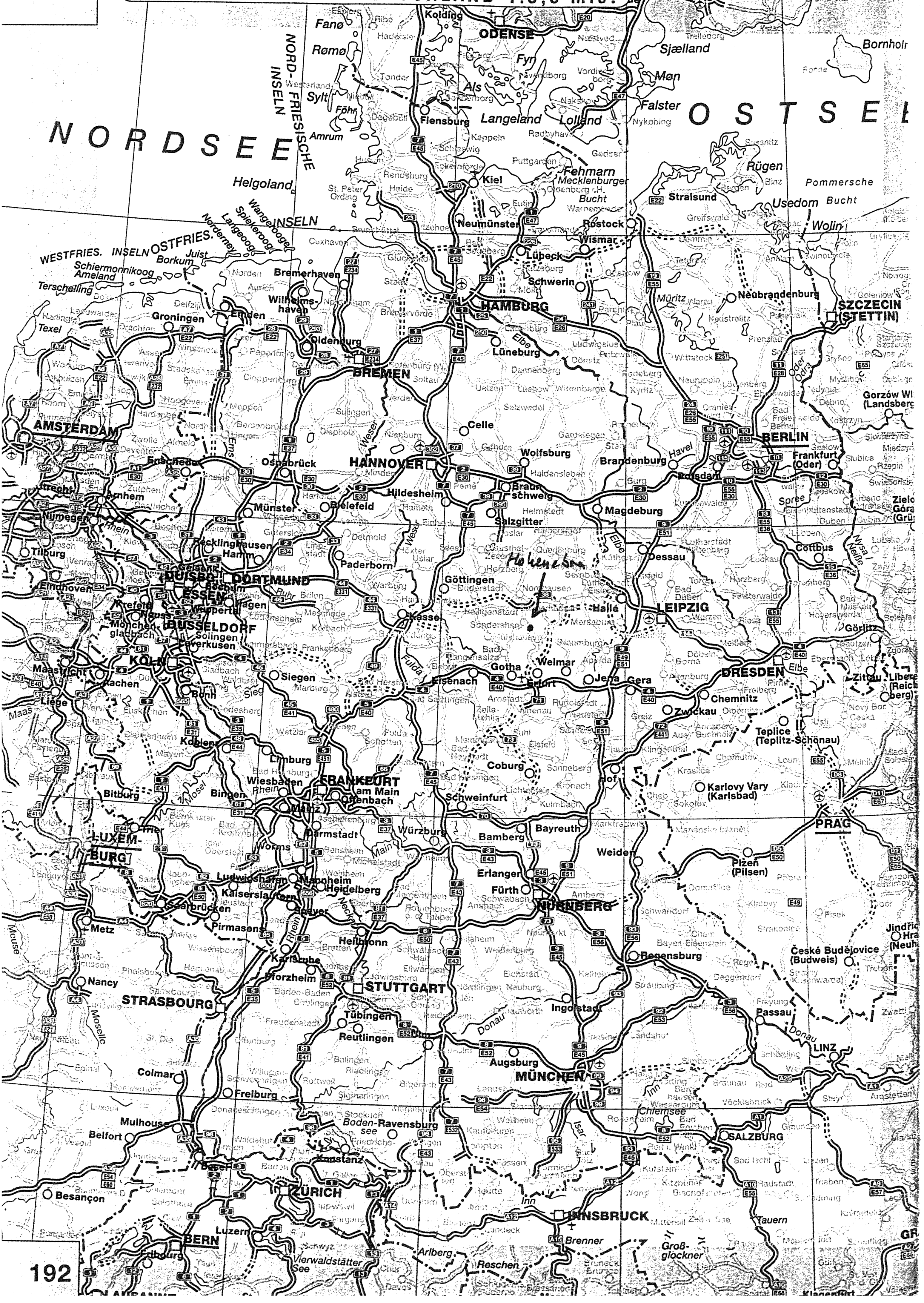
Fehring Holzspäne GmbH & Co.

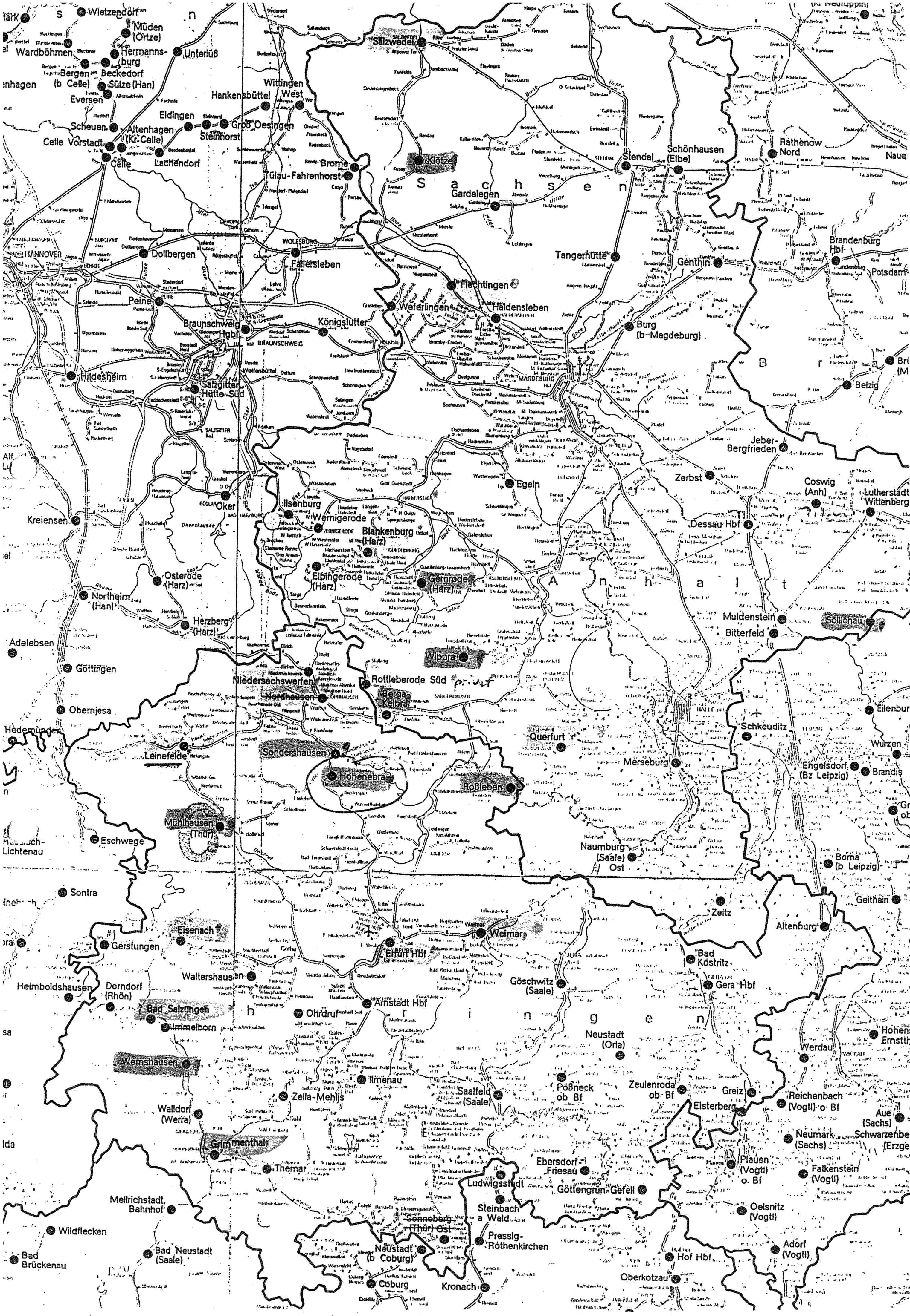
D. Fehring

Appendix IX:

- Information about the terminal in Hohenebra, Thüringen, Germany.
- Plan drawings.
- Maps and pictures.

Einzugsgebiet Bahnhof Leinefelde


NORDSEE
OSTSEE
NORDFRIESISCHE INSELN
OSTFRIES. INSELN
WESTFRIES. INSELN
MALMÖ
ODENSE
Kolding
Fanø
Rømø
Sylt
Föhr
Amrum
Helgoland
Fyn
Als
Sjælland
Møn
Falster
Langeland
Lolland
Bornholm
Flensburg
Kiel
Fehmarn
Mecklenburger Bucht
Rügen
Pommersche Bucht
Stralsund
Usedom
Wolin
Rostock
Wismar
Lübeck
Neumünster
Schwerin
Neubrandenburg
SZCZECIN (STETTIN)
Bremerhaven
Wilhelmshaven
Emden
Groningen
Oldenburg
HAMBURG
Lüneburg
BREMEN
AMSTERDAM
Celle
Wolfsburg
HANNOVER
Osnabrück
Enschede
Arnhem
Nijmegen
Münster
Bielefeld
Hildesheim
Braunschweig
Magdeburg
Brandenburg
BERLIN
Frankfurt (Oder)
Potsdam
Salzgitter
Dessau
Cottbus
Tilburg
Eindhoven
Recklinghausen
Hamm
DUISBURG
DORTMUND
ESSEN
Bochum
Krefeld
Wuppertal
Hagen
Mönchengladbach
DÜSSELDORF
Paderborn
Göttingen
Kassel
Halle
LEIPZIG
Leverkusen
Solingen
KÖLN
Maastricht
Aachen
Liège
Bonn
Siegen
Eisenach
Gotha
Weimar
Erfurt
Jena
Gera
DRESDEN
Chemnitz
Zwickau
Görlitz
Koblenz
Limburg
Wiesbaden
FRANKFURT am Main
Offenbach
Mainz
Bingen
Bitburg
Trier
LUXEMBURG
Coburg
Schweinfurt
Würzburg
Bamberg
Bayreuth
Hof
Karlovy Vary (Karlsbad)
Teplice (Teplitz-Schönau)
PRAG
Darmstadt
Worms
Ludwigshafen
Mannheim
Heidelberg
Kaiserslautern
Saarbrücken
Pirmasens
Metz
Speyer
Erlangen
Fürth
NÜRNBERG
Weiden
Plzeň (Pilsen)
Heilbronn
Karlsruhe
Pforzheim
STUTTGART
Nancy
STRASBOURG
Regensburg
České Budějovice (Budweis)
Tübingen
Reutlingen
Ulm
Ingolstadt
Passau
LINZ
Augsburg
MÜNCHEN
Colmar
Freiburg
Mulhouse
Belfort
Bodensee
Ravensburg
Konstanz
Basel
ZÜRICH
Chiemsee
SALZBURG
Besançon
Luzern
BERN
INNSBRUCK
Brenner
Arlberg
Reschen
Großglockner
Tauern
Vierwaldstätter See
Rhein
Main
Donau
Elbe
Weser
Mosel
Neckar
Inn
Isar


Wietzendorf
Müden (Örtze)
Wardböhmen
Hermannsburg
Unterlüß
Bergen (b Celle)
Beckedorf
Sülze (Han)
Eversen
Scheuen
Celle Vorstadt
Celle
Altenhagen (Kr. Celle)
Lachendorf
Eldingen
Steinhorst
Groß Oesingen
Hankensbüttel
Wittingen West
Brome
Tülau-Fahrenhorst
Salzwedel
Klötze
S a c h s e n
Gardelegen
Stendal
Schönhausen (Elbe)
Rathenow Nord
Naue
Dollbergen
Fallersleben
Flechtingen
Tangerhütte
Genthin
Brandenburg Hbf
Potsdam
Peine
Braunschweig Hgbf
Königslutter
Weferlingen
Haldensleben
Burg (b Magdeburg)
Hildesheim
Salzgitter Hütte Süd
Egeln
Zerbst
Jeber-Bergfrieden
B r a
Belzig
Kreiensen
Oker
Ilsenburg
Wernigerode
Blankenburg (Harz)
Elbingerode (Harz)
Gernrode (Harz)
Osterode (Harz)
Northeim (Han)
Herzberg (Harz)
Dessau Hbf
Coswig (Anh)
Lutherstadt Wittenberg
A n h a l t
Muldenstein
Söllichau
Bitterfeld
Adelebsen
Göttingen
Obernjesa
Hedemünden
Wippra
Niedersachswerfen
Nordhausen
Rottleberode Süd
Berga-Kelbra
Leinefelde
Sondershausen
Hohenebra
Querfurt
Roßleben
Schkeuditz
Merseburg
Eilenburg
Wurzen
Engelsdorf (Bz Leipzig)
Brandis
Mühlhausen (Thür)
Eschwege
Hessisch-Lichtenau
Naumburg (Saale) Ost
Borna (b Leipzig)
Sontra
Zeitz
Geithain
Altenburg
Eisenach
Gerstungen
Weimar
Erfurt Hbf
Bad Köstritz
Waltershausen
Heimboldshausen
Dorndorf (Rhön)
Göschwitz (Saale)
Gera Hbf
Bad Salzungen
Immelborn
Ohrdruf
Arnstadt Hbf
Neustadt (Orla)
Werdau
Wernshausen
Ilmenau
Zella-Mehlis
Saalfeld (Saale)
Pößneck ob Bf
Zeulenroda ob Bf
Greiz
Elsterberg
Reichenbach (Vogtl) o. Bf
Aue (Sachs)
Walldorf (Werra)
Grimmenthal
Themar
Schwarzenberg (Erzgeb)
Neumark (Sachs)
Plauen (Vogtl) o. Bf
Falkenstein (Vogtl)
Ebersdorf-Friesau
Göttengrün-Gefell
Ludwigsstadt
Steinbach a Wald
Mellrichstadt, Bahnhof
Oelsnitz (Vogtl)
Wildflecken
Pressig-Rothenkirchen
Sonneberg (Thür) Ost
Neustadt (b Coburg)
Adorf (Vogtl)
Bad Neustadt (Saale)
Bad Brückenau
Hof Hbf
Coburg
Kronach
Oberkotzau

THÜRINGEN

Bahnhof (mittelfristig bestandsgesicherter Holzverladebahnhof)	Nutzbare Gleislänge für Holzverladung in m*	verfügbare Flächen für Zwischenlagerung in m²	Abstellgleise Nutzlänge in m	Streckenklasse*	Bedienungsfrequenz Verkehrstage*
■ Dorndorf (Rhön)	150	210	1575	CM 4	Bedarf Mi
■ Eisenach	650	9300		D	W (Sa)
■ Göttengrün-Gefell	195			CM 4	W (Sa)
■ Grimmenthal	120	2400		CM 4	W (Sa)
■ Hohenebra	255	1380		C	W (Sa)
■ Ilmenau	120			CM 4	Di + Do
■ Leinefelde	200	5000		D	W (Sa)
■ Mühlhausen (Thür)	620	3300		C	W (Sa)
■ Neustadt (Orla)	500	1700		CM 4	W (Sa)
■ Niedersachswerfen	178	2260		D	W (Sa)
■ Ohrdruf	622	6000		C	W (Sa)
■ Sondershausen	250	1430		C	Bedarf Di, Mi, Do
■ Sonneberg (Thür) Ost	120			C	W (Sa)
■ Themar	300	1820		C	W (Sa)
■ Walldorf (Werra)	400	600		CM 4	Di, Do
■ [illegible]altershausen	230	3600		CM 4	Di, Do
■ Weimar	154	2400		CM 4	W (Sa)
■ Wernshausen	242	600		CM 4	W (Sa)
■ Zella-Mehlis	390	910		CM 4	W (Sa)

Bahnhof (Bestand abhängig von wirtschaftl. Entwicklung)	Nutzbare Gleislänge für Holzverladung in m*	verfügbare Flächen für Zwischenlagerung in m²	Abstellgleise Nutzlänge in m	Streckenklasse*	Bedienungsfrequenz Verkehrstage*
■ Altenburg				CM 4	W
■ Arnstadt Hbf				CM 4	W (Sa)
■ Bad Köstritz				CM 4	W (Sa)
■ Bad Salzungen				CM 4	W (Sa)
■ Ebersdorf-Friesau				C	W (Sa)
■ Elsterberg				CM 4	W (Sa)
■ Erfurt Gbf	500	5030	6534	D	W (Sa)
■ Gera Hbf				CM 4	W (Sa)
■ Gerstungen				D	Mo–Sa
■ Göschitz (Saale)				D	Mo + Mi + Fr
■ Greiz				CM 4	W (Sa)
■ Immelborn				CM 4	W (Sa)
■ Nordhausen				D	W (Sa)
■ Pößneck Ob Bf	262			CM 4	W (Sa)
■ [illegible]oßleben				CM 4	Di, Do
■ Saalfeld (Saale)				D	W (Sa)
■ Zeulenroda Ob Bf				CM 4	Di, Do (S)