Best Practice Guidelines on Logistics and Quality Assurance for Pellet Production

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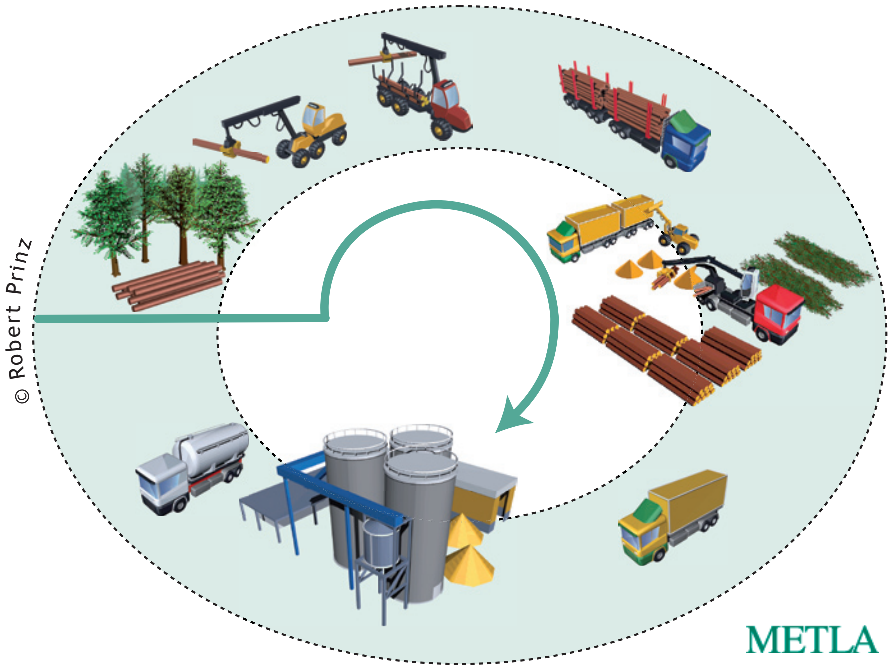

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The PELLETime project encourages the sustainable expansion of the raw material resource through increasing the awareness and information to facilitate market development. PELLETime is aiming to provide new tools for designing sustainable pellet supply chain and examining the new potential raw materials for pelletizing. Various solutions for raw material fuel supply for pellet production are available and greatly depend on each specific situation. Supply of raw materials to pellet units can ensure an efficient use of existing available materials. Different logistic systems and solutions have been developed for raw material supply of pellet- and other end-using facilities across the Northern Periphery area. The Best Practice Guideline provides information about such logistical solutions and highlights the importance of quality measures within the fuel supply for pellet production.

An availability analysis conducted in a certain area shows the potential in that area and the supply- and procurement options for an existing or potential new end-using facility. This studies have to be conducted case specific, general conclusions are difficult to make from a broader view. Based on the availability of material in a certain area, cost calculations can then predict costs and deliver productivity information as a useful analytical planning tool for the support of decisions.

A very important factor of raw material supply for pellet production is quality. This is of great interest in the small and medium scale of pellet production where the use of high quality raw materials is essential for a successful pellet production. Quality factors are the contents of bark, needles and other particles or elements that affect the pelletizing process and the combustion of such pellets. Ash forming elements that create slag within the combustion unit and cause higher emissions should be avoided and are an effect of raw material quality. Moisture content as a quality factor mainly effects the costs of transportation and artificial drying. Therefore, measure for increased natural drying are considered as very important and improve the raw material supply conditions for pellet production.

Contents

1 Introduction

1.1 Pellet plants in the Northern Periphery Region

In Sweden, the first pellet plant started wood pellet production in 1982, since then the number of pellet plants has increased to 94. Today Sweden is the world leader with regards to pellet production in addition to being the largest wood pellet consumer (Peksa-Blanchard et al. 2007, Sikanen et al. 2008). Out of the 94 pellet producers, the production capacity of six of the plants is 100 000 t or over while 15 plants have a capacity of between 50 000–100 000 t. Additionally there are around 50 small scale pellet producers whose production capacity is from a few hundred tons to several thousand tons a year (Figure 1). The total capacity of the small scale producers is under 100 000 tons/year, which is around 5% of the total capacity of the pellet industry in Sweden (Bioenergi 2008). A pellet plant with a capacity of 160 000 t is currently being built, which would increase the country's total pellet production capacity to over 2 million tons.

In Finland, the first pellet plant was built in 1998, since then the number of producers increased to 24; with the total production capacity being around 750 000 t. There are six plants with a capacity of over 50 000 t, of which one is 100 000 t, and four small scale producers (capacity under 5000 t annually) (Figure 1). Additionally five new plants are planned; when operational the total production capacity could reach up to 1.1 million tons.

In December 2007, the first commercial pellet plant, was established in Scotland with a capacity of 15 000 t, besides that there are two other plants operating and one large scale plant (capacity 100 000 t) is under construction which should be in operation by summer 2009 (Figure 1). In the near future the total production capacity is going to be around 148 000 t.

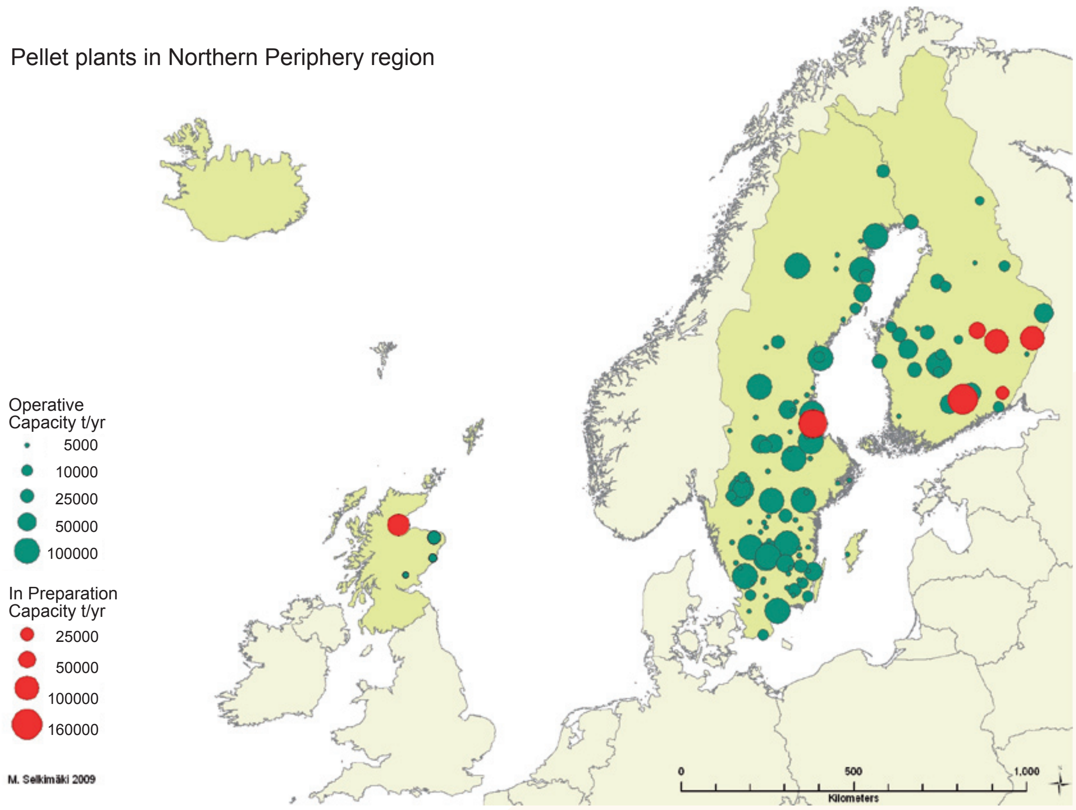

Figure 1. Location of existing and forthcoming pellet plants in Northern Periphery region.

1.2 Different heating systems: Why pellets?

Wood became more attractive for the production of heat and electricity during recent years in many private households and also in larger scale. One reason is the steadily rising costs for oil and gas. Wood fuel in the form of firewood, wood chips and pellets are often cheaper compared to oil, gas or electric heating systems and the price increase over the last few years has not been that rapidly than for oil or gas.

The higher investment costs for wood-based heating systems are usually compensated after a few years depending on the market developments. In the calculation (figure 2), which is based on an average domestic one-single-family home in Scandinavia, the total costs for different heating systems can be seen over a period of 20 years.

After about 6 years the total costs of a wood based heating system will be cheaper than a heating system based on oil. After about 9 years it will be even cheaper than an electric heating system which is still very common under Scandinavian conditions with low electricy fees.

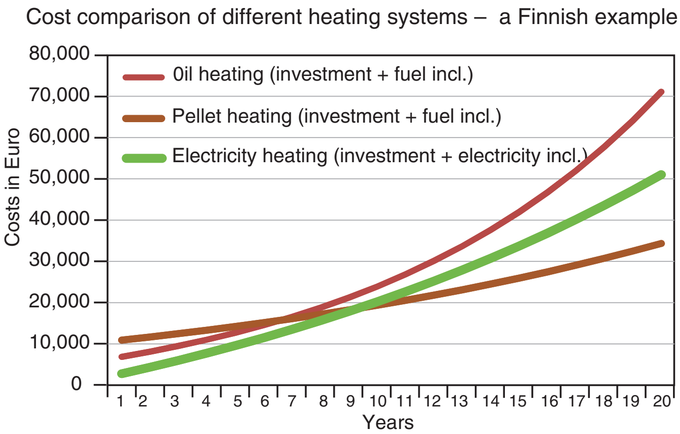

Figure 2. Costs comparison of different heating systems based on an average Scandinavian one single family home (114 m², heat demand 100 kWh/m²). The total costs of oil, pellet and electric heating systems are compared over a period of 20 years; the systems are including the investment costs and annual fuel costs (Status 2010).

1.3 Raw material

Existing raw materials are the by-products of the wood industry; sawdust, cutter chips and wood chips, mainly from spruce and pine. In Sweden, around 97% of the pellets are made from these raw materials, the rest are from bark and peat (New ways 2008). Thin stem wood has started to be used as a raw material in two pellet production sites in Sweden (Kallio & Kallio 2004, Näslund 2007).

There are many potential raw materials for pellets, and some are already in use, however, the whole potential is not being utilized. In Sweden several plants are aiming to use round wood for pellet production in the near future (New Ways 2008) and short rotation coppice, which is currently used only in district heating, could be used also for pelletizing. Currently only 50 000 t of bark is used for pellet production, however, the potential production is estimated to be around 3 000 000 t. The limiting factor is that most of the bark is combusted in places where it is produced, mainly in saw mills and pulp mills. Bark pellets are mainly combusted in large heat and district heating plants as its ash content (3.5%) is too high for small scale boilers (Näslund 2007). Other possible raw materials for pelletizing could be rejected wood, pulp wood, hydride aspen and salix as well as forest residues (tree tops and branches). In Sweden, there are large volumes of forest residues not being utilized, mainly because of the long distances from the origin to places with demand (Hismark 2002, Peksa-Blachard et al. 2007, Höglund 2008).

There are many other materials than wood which can be processed into fuel pellets as well. This includes grasses such as Miscanthus (*Miscanthus spp.*), Reed Canary Grass (*Phalaris arundinacea L.*), Switchgrass (*Panicum virgatum*) and Hemp (*Cannabis spp.*). Also agricultural residues like wheat and barley straw are viable biomass resources for fuel pellet production. Residues from food crop production such as corn cobs can also be processed into pellets.

Many biomass feedstocks have a higher ash content than the current European Standards allow. In addition, some grasses and other materials generate ash that tends to form clumps and can cause slugging. Therefore, many wood pellet stoves are not suitable for the combustion of fuel pellets made from non-wood. Instead, "biomass pellet" stoves or boilers, which are designed especially for various fuels, should be used.

1.4 Trends in handling of raw materials for pellets

In recent years several manufacturers expanded their range of models and new brands with tailored equipment for pellet production are starting to enter the markets. For example, numerous manufacturers offer new chippers or grinders producing micro-chips which are suitable for pellet production. Also debarking machines for round wood are sold with increasing numbers in the pellet sector.

Figure 3. Example of a good storage facility for various chipped materials for pellet production at a pellet plant in Germany. © Robert Prinz, Metla

Figure 4. Raw material transported in trucks. © (SCA) BioNorr Ab

2 Raw materials for pellet production

2.1 Raw material handling and transportation

Raw materials are mainly domestic, by-products of the wood processing industry (cutter chips and sawdust). Most of the pellet plants are next to their raw material supply (sawmill, wood industry, furniture industry etc.) which is lowering the raw material transportation costs. In addition, a small amount of sawdust is imported to Finland from Russia and to Sweden from Finland by trucks (Alakangas et al. 2007, Höglund 2008). Many small and medium scale pellet plants are working together with other activities, such as planing mills or carpentry factories, which are the source of raw materials, often meaning that short distance transportation of the material is done by conveyors or pneumatically in a tube to the pelletizing lines. Larger producers are mainly collecting the raw materials from several wood processing places in the locality of the pellet plant; transportation is done mainly by trucks. Raw materials arriving to the pellet plant are stored inside if the plant does not have dryers and outside if there is a dryer. Typically only the largest pellet plants have dryers, while the small and medium scale producers are mainly using dry raw materials. At least one Swedish small scale producer uses fresh sawdust and therefore has a dryer. Raw materials are emptied from the trucks to open air field storages which are asphalted or to warehouses, from where they are moved to the production line with loading shovels or by conveyors. If the raw material is coming from several places by trucks, it is usually sieved and a magnetic separator is used to remove the foreign particles, such as stones and metallic pieces.

2.2 From the forest to the pellet plant

Due to an increasing demand and competition for raw materials for the production of pellets, particularly for side products from the forest industries, solutions providing pellet plants with wood material directly from the forests have become more important in recent years. Wood in the form of round wood, whole trees, residues or short rotation coppice has to be delivered to the plants where the processing into pellets takes place. The delivery of raw materials either chipped or crushed is already a first processing step and helps to decrease transportation costs.

Depending on the used raw material, the various process steps are harvesting, forwarding, chipping and transportation and end with the raw material at the storage facility of the pellet plant.

2.2.1 Roundwood for pellets

When using roundwood for pellets the harvesting is either carried out motor manual or by a harvester. There are also two opportunities to carry out the skidding. Under normal conditions when using roundwood with a typical length of 2 to 4 meters a forwarder is used. However, if the roundwood is still in full length, it is more efficient to use a skidder. After skidding/forwarding, the roundwood will get reloaded on to trucks to transport them to a place near the pellet plant. The reason why the chipping is not done directly in the forest is that the transportation of roundwood is generally more efficient than transportation of woodchips. When using a terminal, a truck mounted chipper is utilized for the chipping. Transportation of chips to the pellet plants is done cost effective with trucks.

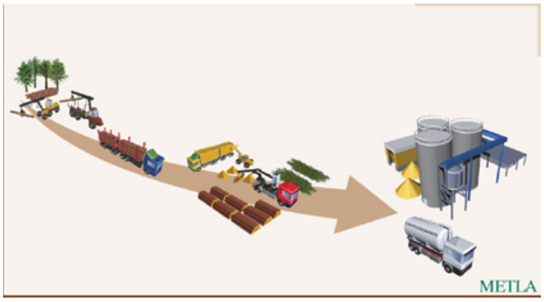

Figure 5. Mechanized harvesting of whole trees, roadside chipping and delivery of chips from the roadside to the pellet plant.

2.2.2 Logging residues

Logging residues can serve as an alternative source of raw material for pellet production. The residues can be collected after a clear-felling operations and brought to the roadside storage with a forwarder. In most cases the logging residues are then chipped at the roadside storage using a truck mounted chipper. The material is usually chipped directly into the truck and then transported to the heating plant (figure 6). In case of short road transportation distances the loose residues can also be brought directly to the plant where they are either chipped with a truck mounted chipper or crushed using in many cases stationary large scale electric or diesel powered crushers or grinders.

Figure 6. Collection of logging residues after clear-felling, roadside chipping and delivery of chips from the roadside to the pellet plant.

Another supply method for the utilization of logging residues is the bundling method (figure 7). A bundler collects the material in the clear-felling area and makes residue bundles that are then brought to the roadside by a forwarder. The produced bundles are log shaped which enables the use of typical cut-to-length technology and allows for the integration of the bundling operation into the normal roundwood harvesting. Using a bundler is also of particularly interest whenever road transportation distances are relatively long since the material is highly compressed. The bundles are usually crushed at the end-use facility using stationary large scale electric or diesel powered crushers or grinders. However, at present this method is only used in large scale operations.

Figure 7. Bundling of logging residues after clear-felling with chipping at a terminal.

2.2.3 Whole trees from thinning

Motor manual harvesting

Motor manual harvesting of trees is still very common in many countries across Europe. Especially in young forest stands this method can be profitable and cost efficient when compared to mechanized harvesting methods. In particular private forest owners have the possibility to carry out thinning operations by themselves. The hauling of whole trees from thinning operations to the roadside storage can be done efficiently using a forwarder. The whole trees should then be stored at the roadside for at least one drying season usually ranging, depending on the location, from April to early September in order to decrease the moisture content. The chipping operation is commonly done at the roadside with truck-mounted chippers. The chips are directly blown into a truck that brings the chips to the pellet facility.

Figure 8. Manual harvesting of whole trees, roadside chipping and delivery of chips from the roadside to the pellet plant.

Small scale ATV forwarding

In combination with motormanual harvesting methods, or in other special circumstances small scale forwarding methods can also be an interesting and a cost efficient solution. The investment costs of small scale equipment is lower compared to bigger and purposely built machinery and the main cost factor is the labour cost.

The overall hauling productivity is a function of the trailer capacity, the handling time (loading and unloading of logs) and the ATV´s driving speed. Resent trials (see figure 9) have revealed considerable differences in productivity in natural grown birch (*Betula pubescens*) stands, for pine (*Pinus contorta*) and larch (*Larix sibirica*). In pine log forwarding the productivity was higher compared to conditions with birch stems. Larch stems had the highest average productivity and the variation has been very small.

Figure 9. Small scale forwarding with ATV after motor manual fellings in Iceland. © Robert Prinz

Figure 10. Whole trees from forests to pellet production with farm-based equipment.

Figure 11. Mechanized harvesting of whole trees, roadside chipping and delivery of chips from the roadside to the pellet plant.

Transportation and chipping with farm tractors

The transportation and chipping based on smaller scale farm based equipment is a suitable method for private forest owners and farmers with own machinery. In many cases the harvesting operation is done motor-manually followed by a tractor-based skidding. Forest trailers for tractors are commonly used for hauling of thinning material such as whole trees. The chipping will be done directly to farm trailers at the roadside with a wood chipper based on a farm tractor. The tractor will bring the wood chips directly to the pellet plant. In order to guarantee an efficient supply, the transportation distance to the pellet plant should be comparatively short.

Mechanized harvesting

The thinning operations are either carried out with purpose built machines such as harvesters, forwarders or a farm tractors equipped with a felling head. In recent years multitree felling heads have become increasingly popular in particular for thinning operations. A forwarder/farm tractor will then haul the whole trees to the roadside landing where they are properly stored for at leas one drying season usually ranging from, depending on climate conditions, April to early September. The chipping operation is commonly done with either truck-mounted chippers or farm tractor based chippers where the chips are directly blown into a separate truck or container for chip transportation. The chips are then directly transported to the pellet facility.

Roadside chipping

The most common and in many cases most cost efficient chipping operation is chipping at the roadside. This method is very common in most of the European countries and enables, in most circumstances, an efficient operations.

Terminal chipping

Chipping operations at a terminal are suitable when larger amounts of material is handled and in case the chipping operation can be done more effectively at such a terminal. The material is then brought to the terminal as whole trees where the comminution is done efficiently with either truck-mounted machines or electric or diesel powered crushers or grinders. The raw material transportation distance to the terminal as well as chip transportation to the plant are crucial factors that have to be taken into account. Terminals are also used in case the material is reloaded to other transportation options such as railways or ships.

There are three possibilities for terminal chipping:

1. *The chipping terminal is at a harbor with loading possibilities to ships*
2. *The chipping terminal is at a loading point for trains*
3. *The chipping terminal with loading point for trucks.*

Chipping at plant

Chipping or crushing operations at the plant are an option particularly for large scale operations where the comminution of the raw material can be done efficiently at the plant with effective electric or diesel powered crushers or grinders. After harvesting, a forwarder will bring the raw material to the roadside where the material is stored or directly transported as whole trees to the plant by truck. The transportation distance plays an important role for this option and should be comparatively short.

2.2.4 Harvesting of Short Rotation Coppice

In order to avoid damages to the crop and soil the harvesting of Short Rotation Coppice (SRC) should be done outside the growing season. The harvesting intervalls have a large effect on the yield of energy crops. In the case of poplar rotations periods of 5 to 15 years, and for willow 3 to 6 years are considered to be suitable. Advantages of shorter harvesting intervalls are cheaper harvesting methods and the earlier reflux of capital.

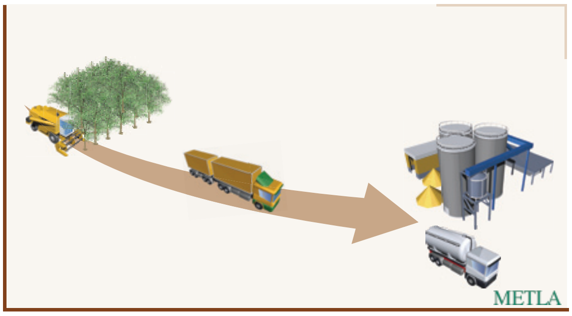

Figure 12. Harvesting of Short Rotation Coppice (SRC).

Stemwood method (5 to 20 year intervall)

When stemwood is the target, conventional forest harvesting methods are mainly used. Whether the harvesting is done manually or mechanized depends on the area and on the amount of merchandable timber.

Bundling and multi-stem method (1 to 10 year intervall)

When choosing shorter harvesting intervals, usually willow below 60 mm diameter, bundlers can be used. However, multi-stem felling heads are used in the case of longer intervals. These harvesting heads are commonly used in energy wood harvesting in forests and they can bunch several stems and pre-pile the material. Both of these methods have advantages in the storage of the material, however the methods are rather complex and costly.

Chipping method (1 to 5 year intervall)

This method is resulting in the cheapest harvesting costs as all work phases are combined in one operation. For the cutting of double rows, up to a diameter of 70 mm, cutting tools (e.g. HS-2) attached to conventional field chippens like the Claas Jaguar 880 are commonly used (see also "*High-tech machinery*").

Other options to the previous mentioned high-mechanized machines are attachments to conventional farm tractors. They are practicable for single row harvesting with diameters up to 12 cm. The quality of this material has to be checked carefully as the chips can be inhomogeneous and of comparatively low quality.

High-tech machinery

Purpose built machines are available for basically all harvesting methods. The Claas Jaguar with the HS-2 head is an example for a high-tech cutting-chipping machine (see figure 13). The HS-2 head is mechanically and hydraulically driven and the chip size can be modified at the knive drum.

Other purpose built machines continuously collect the harvested energy crop or produce bundles.

Figure 13. Claas Jaguar 850 field chipper with HS-2 cutting head. © Robert Prinz

Manual felling methods

Manual felling equipment is traditionally used in small tree energy wood harvesting, but the same tools can be used for manual SRC harvesting. Clearing saws or chainsaws with special handles are commonly used manual equipments.

Tractor based equipment

Several manufacturers produce equipment that can be attached to agricultural machines. These machines can be single row chippers or baling machines (see figure 14).

Figure 14. Bio Bales bundles for energy crops, the bales can be attached to a farm tractor. © Dominik Röser

Table 1. Technical data of different short rotation harvesting machine units. Source: KTBL 2006. Energiepflanzen. Daten für die Planung des Energiepflanzenanbaus. Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL). 372 pp.

Technical data	Unit	Field chipper units	Agricultural cutting attachments
Base machine		Conventional purpose-built field chipper 1)	Agricultural tractor with hydraulic system and power take-off
Engine power	kW	250–450	100–200
Own weight	kg	1300–2000	1000–1300
Number of rows		2	1
Distance between rows 2)	m	0.75 + >1.5	>0.9 or 0.75 + > 1.75
Cutting width	m	1.0–1.3	0.6
Cutting diameter	mm	< 70	< 120
Average chip length	mm	5–40	50–100
Mass productivity 3)	t DM/h	10–30	5–15
Acreage capacity 3) 4)	ha/h	0.25–0.75	0.12–0.38

1) Standard field chipper with forest tires, partly with stronger chipping drum
2) Single-row-distance <1.0 m and double-row-distance 0.75 require special tires for the agricultural cutting attachment
3) Based on productive machine hours; 10–40% productivity loss when including the overall productivity
4) Calculated with mentioned mass productivity for a 4-year crop with a yield of 40 t DM/ha

The proper method and machinery in the Northern Periphery will depend on whether SRC will have a commercially viable future. The growth of willow in peripheral areas is in the testing phase at the moment and mechanized harvesting methods are not considered to be feasible in all cases. However, on a larger commercial scale, when higher yield can be achieved, mechanized methods and machinery can be taken into consideration. Central European countries, as well as Sweden, have a considerable experience in that field and technology transfer from those countries should always be considered when starting a new endeavour.

3 Handling of pellets at the pellet plant & pellet delivery

Handling of the pellets at the plant site is similar in Finland and Sweden. The share of different delivery types is probably determined by the equipment used in the pellet packing process. Pellets are stored at the plant site in large silos or in warehouses for bulk deliveries and packed into small and large sacks. Pellets' packing in large (500–1000kg) and small (10–20kg) sacks is usually done straight from the pelletizing line or if the pellets are packed later, in the warehouse, in this case they are sieved again before packing.

Figure 15. Loading pellet to pneumatic truck from silo and warehouse. © (Metla).

Figure 16. Loading pellets to railroad carriage for export. © (Metla).

In Finland and Sweden bulk pellets are stored at the pellet plant in silo storages and/or in warehouses. Bulk deliveries are loaded from the silo storage to pneumatic trucks or with a loading shovel onto normal trucks (figure 15). Overseas transportation is done by train from the pellet plants which have a rail connection (figure 16); the train transports the pellets to the harbour where they are shipped. In Sweden, many plants are located on the coast and pellets are shipped straight from the plants for export as well as for domestic markets.

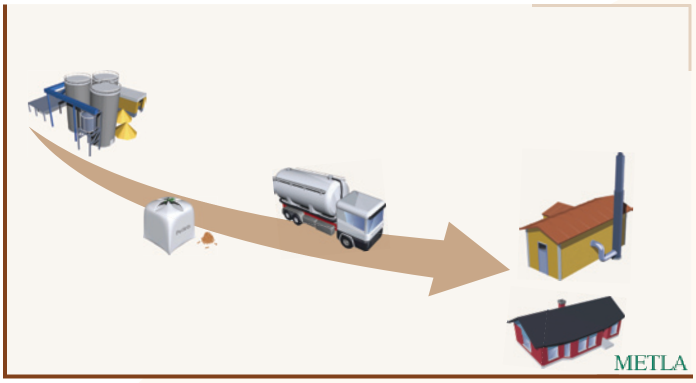

Figure 17. Pellet delivery.

Pellet transport to end users

Pellets are transported in sacks, loose on trucks and by pneumatic trucks. Private users can collect pellets straight from the plants loading them onto their own containers or trailers. Small sacks 15 to 40 kg are usually packed onto interchangeable pallets and delivered to retailers. Large sacks, 500 to 1000 kg, are sold straight from the plant or through retailers (see figure 18).

Pneumatic trucks are used when delivering pellets to households or medium size customers. For large scale users pellets are delivered by normal trucks. The equipment for bulk deliveries varies, from normal trucks and specially designed pellet tanker trucks, to existing machinery used for animal feed deliveries. New trucks have an integrated weighting scale which allows accurate delivery and billing. The minimum amount of bulk deliveries by truck is typically around 3 tons. Quality issues have to be considered since the length of the unloading pipe, pressure and power used during unloading and the model and conditions of the delivery trucks, as well as the experience of the driver, affect the quality of the pellets during transport and delivery (Tuomi 2007, Vapo 2008).

Figure 18. Mean transportation methods of pellets. © Robert Prinz, Metla.

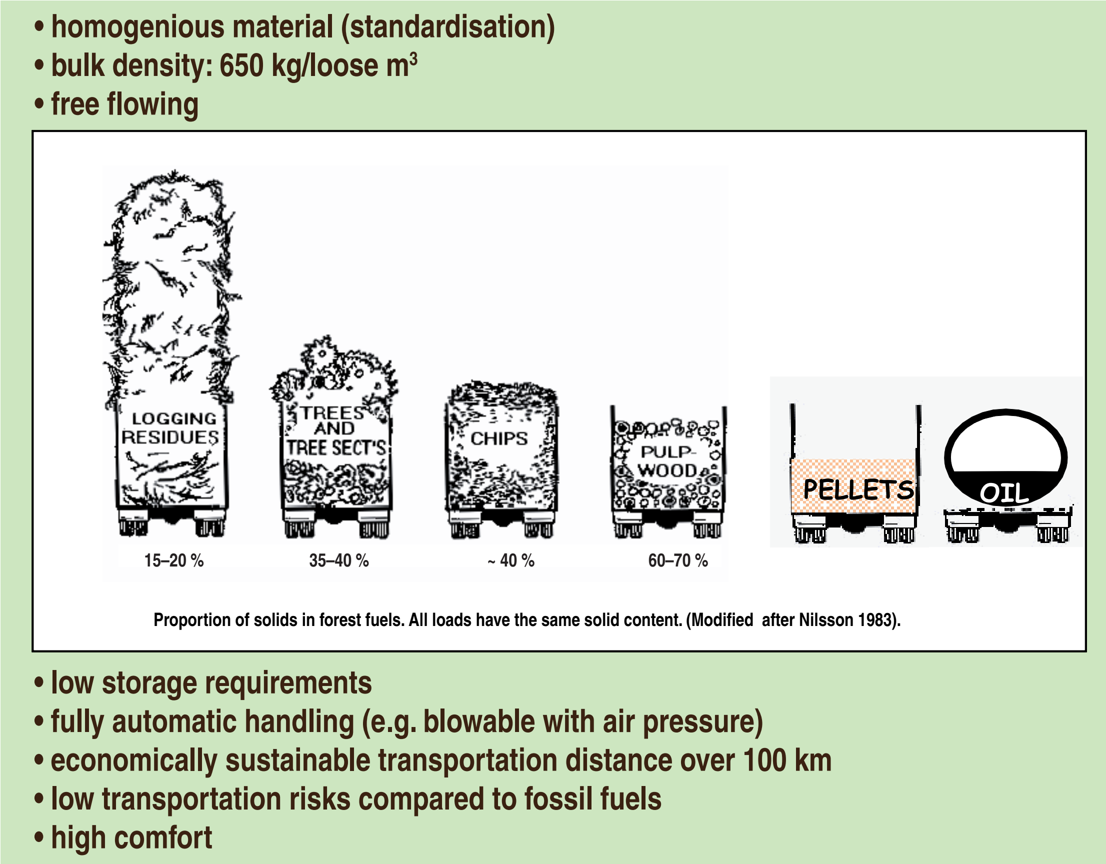

Figure 19. General pellet transportation information (Metla, R. Prinz).

Most of the pellet imports, for example to Sweden, are done by cargo ships. In the European market area ship loads are typically 4000–6000 tones, with the overseas shipments being done in large volumes of usually 20 000–30 000 tones.

Figure 20. Vapo's pneumatic truck for pellet deliveries. © Vapo.

Figure 21. Packing of small sacks in Arbuthnott pellet plant. © R. Prinz, Metla.

Arbuthnott Wood Pellets (AWP) offers pellets in 15 kg sacks bagged on pallets which carry 66 sacks (figure 22). Furthermore, Arbuthnott is also delivering large sacks of 1000kg as well as bulk pellets.

Figure 22. Small sacks on a pallet at AWP. © Robert Prinz, Metla.

Pellet storage systems

There are different storage possibilities for pellets, depending on several factors including; constructural aspects of buildings, storage capacity, preferred delivery method, supply structure as well as the personal preferences of the customers. Pellets can either be purchased in custom-made bags from hardware stores, enabling efficient storage, or they can be delivered in larger amounts by a silo-truck which deposits them into the storage room or container.

The storage room needs to be dust-tight and dry to ensure a optimal storage of the pellets to keep their moisture content below 10 %. This guarantees constant stability, regarding heating value. The storage room can be a dry room in the basement that can be converted into a pellet-storage. Alternatives are the storage in a silo made of metal or fabric to store the pellets. Another storage option is a subterranean tank which has advantages especially if there is insufficient space inside.

bulk density = 650 kg/m^3
1 kW heating load = 0.9 m^3 storage space (incl. empty space)
energy content = 4.9 kWh/kg
usable storage capacity = 2/3 of storage space
size of storage = 1.2–1.5 times of the anual demand

Figure 23. Facts about pellet storage systems. © Robert Prinz, Metla

4 Quality assurance

4.1 *Quality matters*

To be a reliable part of fuel supply, pellet plants have to have balancing raw materials available. An important issue with raw materials from forests is the moisture content of the different materials. Fresh timber can be assumed to have a moisture content of approximately 50% whereas pellets have a moisture content of approximately 10 to 12%. Consequently, when using fresh timber for pellets the moisture content has to be lowered. This can be done using natural drying methods and/or artificially during the processing of the material to pellets. Natural drying before the processing of the raw material can usually lower the moisture content to approximately 20–25%, the remaining 10–15% have to be reduced during the further processing of the material.

The lower the moisture value before the processing, the lower the costs of drying during the pelletizing process. Furthermore, the sensitivity towards mould infestation will decrease.

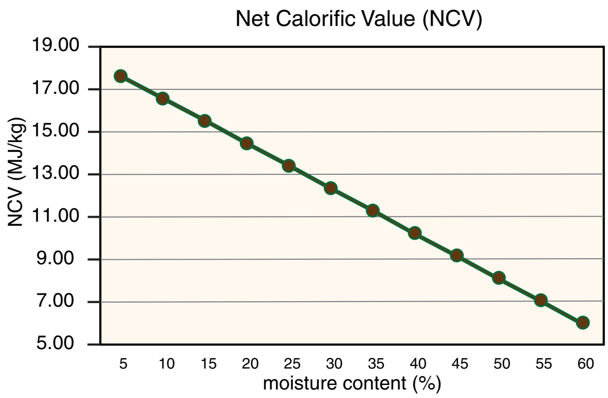

Figure 24. Net calorific value (NCV) depending on the moisture content of used raw material (Obernberger & Thek 2010).

4.2 *Storage and handling of raw material*

The aim of storage is to lower the moisture content in a certain time period. An ideal storage facility is highly aerated, aligned towards the sun and established on ground which is accessible throughout the year.

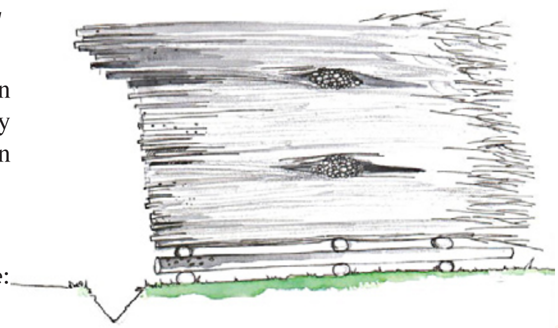

Figure 25. Optimal road-side storage of whole trees. (Source: Metsäkeskus 2010)

Optimal conditions for chipping and transportation:

1. *Road width min. 6 m.*
2. *Piles should be located on the right side of the road.*
3. *The feeding table of the chipper is ideally on the right side.*
4. *Tree ends should be facing towards the road.*
5. *Ideally, there should be 3m on the left side of the chipper, so that trucks can pass.*

Figure 26. Fresh whole trees from thinning operations as raw material source for pellets have high moisture contents. At the beginning of the trial (July 09) whole trees of pine had an average MC of 58.9%, birch whole trees had 43.4%.

Figure 27. Example of typical and good energy wood storage example. © Dominik Röser, Metla

Figure 28. Examples of NOT optimal energy wood storage. © Perttu Anttila, Metla

The chip storage facility should have a solid ground base which can be accessed under various weather conditions and enables air ventilation of the piles. Part of the storage should be covered by roof for optimal drying conditions (aerated construction with high roof). This way, decomposition is minimized and the moisture content can be kept at a certain level or even lowered until the material is used. The storage time for wood chips should be as short as possible.

Important quality factors for the storage of raw materials for pellet production:

1. *Eeasy accessible location of storage facilities with dry ground.*
2. *Storage 1 to 2 drying seasons (approximately April to early September).*
3. *Highly aerated location, south exposed piles.*
4. *Roof profile of piles to prevent remoistening from rain.*
5. *High piles for easier chipping operation and minimization of surface area.*
6. *Covering of piles with paper fabric is recommended.*
7. *Storage of chipped materials only when necessary.*
8. *Storage of chips in a well aerated pile.*

4.3 *Debarking of raw material*

The aim of debarking woody biomass is to lower the bark content in the mixture of material used for the production of pellets.

Debarking units (for example the Peterson 4800) can handle materials between 5 cm and 58 cm with minimum lengths of 4 to 5 meters. The debarking is done by a chain flail leaving a bark content of less than 1%. The production capacity reaches approximately 40–45 tons per hour.

In combination with a chipper unit (Peterson 5900) it is possible to produce micro-chips for pellet production with a capacity of 30 to 35 tons per hour.

The particle size of micro-chips is already sufficiently small that the material can be used optimally in pellet production and consequently the efforts at the plant are lowered. The use of two separate machines also allows a flexible design of supply chains as machines are working according to the needs at various locations.

Whole tree delimbing-debarking-chipping is a continuous operation producing high quality chips with a low bark content.

As an example, the Peterson 5000-H has a production capacity of approximately 35 tons of micro-chips per hour. Minimum diameters of 5 cm, maximum diameters of 58 cm (or multiple smaller stems) and a minimum length of about 4 to 5 meters can be handled. A flail drive provides delimbing and low bark contents before the wood is chipped with a disc. The whole operation has an intuitive control system monitored via a LCD display and provides the operator with information to more efficiently make chips. In order to handle various bark contents, e.g. eucalyptus bark, it is possible to add so called bark-pushers.

Figure 29. Whole tree chippers are delimbing, debarking and finally chipping the material. High qualities with low bark contents can be produces for high quality pulp and pellet production. © Dominik Röser, Metla.

Figure 30. Whole tree chipping including a debarking unit starts to become more popular especially for high quality pulp and pellet production. © Dominik Röser, Metla

Most probably it will still take some time until technology will offer better solutions to the meet the challenges of pellet production from forest materials. Several machine options are already available on the market. For example North American manufacturers provide different machinery handling round wood for high quality chip production, but also Scandinavian manufacturers are testing various raw materials with similar machinery in terms of productivity, quality outcome and energy consumption. This kind of technology is capable to be adapted to the optimal use in pellet production since quality issues are especially important for pellets. Pellet producers are constantly looking for alternative raw materials and new pellet plants are already supplying their plants with round wood. It will only be a matter of time before the increasing demand will need the large scale utilization of raw materials that are currently not yet economically or technically feasible.

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