Pelletime

Pellet logistics and transportation of raw materials in Finland
The pellet market and supply structures are currently undergoing rapid development. As the pellet markets develop, also the supply side is growing constantly. In some countries, the supply side is growing faster than the domestic use, while others need to import pellets to satisfy the demand. This report aims to present the state of the art of pellet raw materials and supply structures in participating countries (Finland, Sweden and Scotland). Furthermore, bottlenecks and major drawbacks are highlighted. Finally, opportunities and future developments of the pellet market are presented.

**FINLAND**

1. **Introduction to the pellet market**

The production of wood pellets started in Finland in 1998, when the first pellet plant was built in Vöyri. Since then the number of pellet plants, as well as the production, have been increasing steadily. Today Finland is producing more pellets than it is consuming; the pellet markets are export oriented, however, recently the number of pellet users has been growing in the country. In 2007 more than 58 % of produced pellets were exported; of which a large part is transported to Sweden and Denmark. Currently there is no importing of pellets to Finland.

In 2008 the pellet production was around 400 000 tons though the capacity would have been higher. At the moment there are 24 pellets plants/ producers operating and five new plants are planned or under construction. By the year 2010 pellet production is expected to grow to over 1 000 000 tons. The number of pellet users has been growing in recent years, especially the number of small scale users. Furthermore, the number of large scale users is also increasing, as well as the share of pellets and other bioenergy fuels used for heat and energy production, due to favourable EU regulations.

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1.1. **Existing pellet producers**

There are 24 pellet plants operating in Finland, of which four started operating during 2008. Five new pellet plants are planned. The location of the existing plants, as well as those planned, is presented in Figure 1 (numbers 1-29). Vapo Oy is the most important actor in the pellet sector in Finland. Vapo has 15 pellet plants of which 9 are located in Finland. Vapo’s pellet plants’ production is around 880 000 tons; which makes it the biggest producer in the Baltic Sea Region.
Pellet plants in Finland in 2008

Id | Name
---|---
1 | Parkanon Pellet Oy, Parkano
2 | Vapo Oy, Haapavesi
3 | Vapo Oy, Ilomantsi
4 | Vapo Oy, Turenki
5 | Vapo Oy, Ylistaro
6 | Vapo Oy, Haukivaara
7 | Vapo Oy, Vöyri
8 | Vapo Oy, Keskinen
9 | Paahkopuu Oy, Korkeakoski
10 | Vapo Oy, Kärämäki
11 | Lapin Ekolämpö Oy, Keminmaa
12 | Länsi-Suomen Biopower Oy, Soini
13 | Jannpellet Oy, Paltamo
14 | Formados Oy, Kuusamo
15 | Savon Bioenergia Oy, Rantasalmi
16 | Haminan Puunjaloostus Oy, Vehkalahti
17 | Keurak Oy, Keuruu
18 | Punkaharjun Pelletti Ky, Punkaharju
19 | Kurikka Timber Oy, Suolahti
20 | Järviseudun Pelletti Oy, Haukkala
21 | Versowood Oy, Heinola
22 | Vapo Oy, Vilppula
23 | M-Pelletti Oy, Kuhmo
24 | Lokapelletti Oy, Laitila
25 | Finn Pellets Oy, Hollola
26 | Stora Enso Oyj, Kitee
27 | Varwood Oy, Varkaus
28 | L & T Biowatti Oy, Suonenjoki
29 | L & T Biowatti Oy, Luumäki

Figure 1. Map of pellets plants in Finland in 2008.
1.1.1. Annual production

In 2007, pellet production was 329 000 tons, the estimation for production in 2008 is close to 400 000 tons. Since the domestic consumption is relatively small, most of the pellets are exported (see Figure 2). In 2006, around 75% of pellets produced were exported, however, due to the rise in domestic consumption, the share of the exports decreased to 58% in 2007. Pellets were mainly exported to Sweden, Denmark and to the Netherlands.

The annual production capacities of the existing and forthcoming plants are collated in Table 1. The actual production figures are lower since some of the plants are not working to their full capacity for various reasons. Four of the plants started operating during 2008 which means they are not yet using their full capacities. So far the biggest pellet plant is Vapo’s plant in Vilppula with an annual capacity of 100 000 tons, the plant started testing the production line in summer 2008 and it should be running at full capacity in 2009. The total pellet production in Finland is estimated to be around 700 000 tons in 2009. However, uncertainty regarding the raw material supply can delay the forthcoming plants as well as reduce the production of the existing pellet plants.

Figure 2. Pellets production and export in Finland.
<table>
<thead>
<tr>
<th>ID</th>
<th>Name, Location</th>
<th>Owner</th>
<th>Capacity (tn)</th>
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<td>Vapo Oy</td>
<td>70000</td>
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<tr>
<td>5</td>
<td>Vapo Oy, Ylistaro</td>
<td>Vapo Oy</td>
<td>40000</td>
</tr>
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<td>Vapo Oy</td>
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<td>M-Pelletti Oy, Kuhmo</td>
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**FORTHCOMING PLANTS**

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<td>German Pellets GmbH</td>
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<td>26</td>
<td>Stora Enso Oy, Kitee</td>
<td>Stora Enso Oyj</td>
</tr>
<tr>
<td>27</td>
<td>Varwood Oy, Varkaus</td>
<td>Varwood Oy</td>
</tr>
<tr>
<td>28</td>
<td>L &amp; T Biowatti Oy, Suonenjoki</td>
<td>L &amp; T Biowatti Oy</td>
</tr>
<tr>
<td>29</td>
<td>L &amp; T Biowatti, Luumäki</td>
<td>L &amp; T Biowatti Oy</td>
</tr>
<tr>
<td></td>
<td><strong>Total:</strong> 410000</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Pellet factories and their estimated production capacities in 2008 and estimated forthcoming production.
1.1.2. Equipment / technology

In Finland, much of the equipment and technology used by the pellet industry comes from Sweden, Germany and Austria. However, there are also some Finnish products available, mainly silos, storages, conveyors and other structures, while pressers, hammer mills, coolers and sieves are often imported. For small scale pellets production a few domestic options are available. Some pellet presses which are used for pelletizing animal feed can also be used for producing wood pellets. At the moment there are two Finnish pellet press machine producers which are presented below.

Pappinen Ltd. has developed a small pellet presser with a patented mechanism (Figure 3). The presser consists of a horizontal core die, inside there are two moving press rollers. The main engine is electric and has a power of 15 kW. The presser capacity is 180-250 kg pellets/hour depending on the raw material (for example with pine sawdust the capacity is 250 kg/h). The standard matrix size is 8mm. the machine also includes a frequency converter ready for a conveyor. The pellet presser is not yet on the market, however, there is one small scale pellet producer, Lokapelletti Oy (www.lokapelletti.fi), which is using the presser in pellet production and will also be the retailer of the press. The price for the presser is estimated to be around 30 000 € (plus taxes) and it is aimed to be on market during 2009. Some of the pellet trials of the PELLETime project have been done with this machine. The raw materials tested in the presser were sawdust and cutter chips, also first thinning pine as well as logging residuals chips from spruce have been tested.

Aimo Kortteen Konepaja in Ylivieska is producing the MurskaBioPellet presser which can be used for pelletizing wood or animal feed. The electrical engine power is 30 kW and the capacity with one presser is 350-450 kg pellets/hour. There are changeable matrices for ø6mm and ø8mm pellets. The company sells the whole pellet production chain machines from the hammer mill to the cooling conveyor. More information is available on the company’s home page (www.murskabiopacker.fi).

In Oulu one entrepreneur is developing a movable pellet presser integrated with a tractor carriage. At the moment the information about the unit is not available. The movable press is used in PELLETime pelletizing trials for straw pellets.
1.1.3. Raw materials used for pelletizing

The most common raw materials used for wood pellets are dry by-products from the wood industry, cutter chips and sawdust, mainly from spruce and pine. Also fresh sawdust and peat is used for pelletizing.

1.1.4. Quality of pellets produced (Standard)

Finland is waiting for a common European standard for solid biofuels (CEN335) to be developed as it currently does not have its own system of standards. This common pellet standard is being developed by the Technical Committee 335 of the European Committee for Standardization (CEN). So far the largest producers have followed the Swedish standards (SS 18 71 20) for pellet classification since most of the pellets are exported to Sweden. The Bioenergy Association of Finland was developing a national standard system but stopped the project in 2002 and instead concentrated on the development of standards at a European level. Some pellet plants, such as Vapo’s plants and the Versowood plant, are already following the draft of European CEN/TS 14961 standard in their pellet production.

1.1.5. Major customers

Many of the major customers are abroad since most of pellets produced in Finland are exported to large heating and CHP (combined heat and power) plants mainly in Sweden and Denmark. In Finland the largest number of users are private households, detached houses and cottages; in 2007 more than 52% of the pellets used in the domestic market were in small scale boilers. Larger scale users (boiler >25 kW) consumed around 48% of the pellets, these include, for example, public buildings, farms, greenhouses, monasteries (e.g. Valamo monastery in Heinävesi), schools and a few dozen heat and CHP plants. Currently there are six airports (Ivalo, Jyväskylä, Joensuu, Kemi-Tornio, Kajaani and Kruunupyy) which have been changed or are changing to using a pellet heating system and in the future possibly four more airports will follow suit.

1.1.6. Delivery methods

Pellets are mainly delivered straight to the customers or commercial retailers by trucks (sacks and bulk) or by pneumatic trucks (bulk). Private users can also collect the pellets straight from the plants in their own containers or trailers. Some of the pellet producers have their own delivery equipment while some are using contracted transporters. Vapo’s biggest retailer is the Agrimarket chain, while other pellet producers are selling directly from the plant, or via small retailers which are often selling pellet boilers and other pellet related equipment. Retailers are only selling the pellets in sacks (both small and large sacks).

In 2008, the main method of pellet delivery was bulk delivery; which accounted for 71% of all the deliveries including by both pneumatic truck and normal truck. Sack deliveries are much smaller, big sacks are 25.5% and small sacks 3.5% of all the deliveries. Collection of pellets from the plant is not common, mainly people living close to the plant collect bulk pellets with their own containers or buy a few sacks. Exports are mainly done by ships from the main harbours; both sea and lake harbours from Inkoo, Loviisa, Joensuu, Oulu, Kokkola and Kaskinen.
1.2. Existing pellets users

1.2.1 Number of pellets users

In Finland the number of pellet users has been growing slowly. In 2001, only about 300 households were using pellets. The number of small scale pellet users in 2003 was 1000-2000 users, with the number growing with 400-500 new users per year. Approximately 15 000 households were using pellets in 2008, additionally a few hundred public buildings, schools and industrial buildings are using pellets heating systems and a few dozens heat and CHP plants are combusting pellets for energy production.

1.2.2. Customer sectors

Small scale users are private houses and cottages where pellets are used as a primary heating system or burnt in fireplaces. Small scale users are mainly using pellet boilers under 25 kW or pellet stoves or a special basket designed to burn pellets in normal fireplaces. Medium scale users include public buildings, commercial and industrial premises such as schools, greenhouses, health centers, administrative buildings as well as monasteries and airports. Typical large scale users are district heat plants and power plants where pellets are usually combusted together with other fuels. Exported pellets are mainly going to large scale customers such as heating and CHP plants.

1.2.3 Annual consumption of pellets

In 2007, the total domestic consumption of pellets was 117 000 tons, of which 61 000 tons were used in small scale boilers (<25 kW) with the remainder being used in medium and large scale boilers (>25 kW). In the same year the total production was 326 000 tons. So far the domestic consumption of pellets has been small compared with other countries using pellets. The domestic consumption of pellets is likely to increase quickly in the near future. According to the Finnish Pellet Energy Association estimates for consumption in 2012 are: small scale users ~300 000 tons, medium scale users ~500 000 tons and the large scale users ~300 000 tons, which means that altogether consumption is estimated to be almost one million tons more than it is at present. The development of pellet consumption and production in 2001-2007 can be seen in Figure 4.

1.2.4. Storage types

Pellets are stored in silos or warehouses after production from where they are delivered to the customers. Customers can receive pellets in sacks or in bulk delivered by normal or pneumatic trucks. The storage type used by the customers depends on the method employed to deliver the pellets. Storages are bigger when pellets are delivered in bulk and if a pneumatic truck is used the storage needs to have some special features to minimise the disintegration during unloading.

The yearly demand for pellets, pellet delivery type and space available define the volume and structure of the storage. Pellets can be bought in a sack (16 kg-1000 kg) or they can be transported by truck in bulk. The moisture content of the pellets is approximately 8-10 %, the pellets must remain dry for the entire

Figure 4. Annual consumption of pellets in small (<25 kW), medium/large (>25 kW) boilers and the total consumption in Finland.
storage cycle otherwise they may lose their effectiveness and disintegrate. The sacks are stored on top of pallets to avoid the pellets absorbing moisture from the floor. Storages are placed close to the boiler room to minimise the disintegration of the pellets during the usage, however the pellets cannot be stored in the boiler room for safety reasons. Additionally, there should be no electrical devices in the storage room. The storage must follow the Finnish national building and fire safety regulations RakMK part E9.

For bulk pellets there are some manufactured storage bins or the storage can be built by the user. In Finland, it is very common that the consumers are building the pellet storage by themselves. There are many guidelines available of how it should be done and what material can be used. All building materials used should be non-static since fine wood dust that will be present is highly flammable. Customers buying the pellets in bulk should have a minimum storage space of 8m³; including the space for pellets as well as a run-off area in case of over filling. Storages which are filled by a pneumatic delivery system should be placed in areas whose carrying capacity is sufficient enough to bear the weight of a truck that could weigh several tons. The recommended distance between the trucks and the storage is 10 meters; the maximum is 30 meters. Pellet suppliers can give different distances for pneumatic deliveries for example, Vapo gives a guarantee for pellets content of fine material only till 15 meter when storage is filled with pneumatic system and Versowood up to 22 meters.

Pellet storage can be placed outside or inside. The storage needs to be efficient, dustproof and safe. When placing the storage outside special attention needs to be paid to protection from moisture. Storage of pellets for over a year can reduce their quality. Air moisture does not spoil the pellets but contact with water can break up their structure. Storage does not necessarily need to be isolated against the cold as cold temperatures do not affect them. Changes in temperature can form condensed water inside the storage what should be taken into account when choosing the building materials.

Pellet storage can be also placed underground; in this case the pellets need to be delivered by pneumatic truck. Pellets are moved from storage to boiler mainly by a pneumatic system. Nowadays in Finland it is possible to buy underground storage for pellets. One Finnish underground pellet storage producer is the Uhvola company from Joroinen (www.uhvola.fi). Underground storage (Figure 5) is a good solution for pellet storage since it does not reduce the permitted building right of the property unlike the normal, above ground, storages.

Figure 5. Underground pellet storage, filling the storage (Jouko Parviainen).
Small heating station

Container solution is a compact heating station, where the pellet storage and boiler are integrated into one unit which is delivered ready to use. For example JPK-tuote, Säätötuli have small heating units in their products. The power of a small heating station is usually 60-150 kW which can be used by a housing association, such as apartment houses or terraced houses. In many heating stations both wood or peat pellets can be used. Container solution is good for medium scale users, for example, for schools, greenhouses and farms. Larger units are used in public buildings or in industrial buildings. Vapo is offering a maintenance free container solution where the company is taking care of everything from filling the storages and the maintenance of the boiler, with the user just buying the heat.

1.2.5. Quality demands

Smaller pellet boilers, under 25 kW, which are mainly used in households, need good quality pellets. If pellets are disintegrating during the transportation and delivery they may contain fines (wood dust) which can cause problems in the small boilers as well as to the supply equipment, this can be sometimes be a problem when delivering pellets with pneumatic trucks. In Finland, many of the small scale users are ordering pellets in bulk. The main complaint from the users is the amount of the fines that pellets delivered in bulk sometimes contain. Low quality pellets can cause corrosion and more ash, resulting in the fact that the boiler needs to be checked and cleaned more often. In Finland the need for premium quality pellets is rising all the time as more households are choosing the pellet heating system. Since in Finland many producers do not follow a pellet standard, at present, the quality between the pellet producers can vary. Bigger boilers can burn lower quality pellets and many of them can use also peat and mixed pellets. The largest plant has the lowest quality demand, pellets are usually pulverized and combusted together with other fuels.

2. PELLET RAW MATERIALS

2.1. Existing raw materials

Wood pellets are produced mainly from spruce and pine cutter chips, wood chips and sawdust, also wet sawdust is used in the pellet plants which have dryers. Vapo produces also peat pellets and mixed wood/peat pellets.

2.2. Potential raw materials

There are many new potential raw materials. The PELLETtime project in Finland is currently researching the use of pellets made from first thinning pine, chips from spruce logging residuals and whole birch trees from first thinning. The same project is also investigating pelletizing of reed canary grass (Phalaris Arundinacea) and straw, this is being conducted at Oulu University of Applied Sciences. Reed canary grass is growing well in natural conditions in Finland; with an annual yield of around 5.5-6.5 dry tons per hectare. Vapo, and its contractor farmers, have 9000ha of reed canary grass fields, with the aim being to increase the field area to 40 000 ha by 2010 and to 100 000 ha by 2015, the production is estimated to be profitable by 2010. Vapo has been conducting pelletizing tests mixing the grass with peat or wood. Reed canary grass is a very promising new bioenergy source, at the moment it is used in mixed combustion in power and heat plants for example in the Vapo Ilomantsi plant. According to FINBIO (the Bioenergy Association of Finland) the current use of straw for energy production is 6000 tons and the potential could be 1.8 million tons, of which 10-20% could be used for energy production. In addition pelletizing and the durability of the pellets made from pine bark, aspen and birch has been tested.

Residuals from harvesting and bark are good potential raw material for pellets, for example in Sweden one plant is producing pellets from bark, while in Finland Vapo has been planning to start producing pellets from coniferous bark. Other potential raw materials are roundwood birch and short rotation species as hydride aspen and salix.
2.3. Drying of forest residuals chips

Forest residuals chips can be dried with “free” energy or secondary energy in association with a district heating plant. As an example Kokemäen Lämpö Oy (www.kokemaenlampo.fi) is using technology where waste energy of returning water from the district heating network and combustion gases from the CHP-plant are used to dry wood chip in order to increase the calorific value. Combustion gases are washed and cleaned before being used for drying; the temperature is lowered during the process to around 30°C. The temperature of water returning from the district heating network is around 30-50°C. The low-temperature energy is fed into fuel dryers outside, where the chips are dried. This method of drying can reduce the moisture content to 10%, though typically chips are dried to a level of 15-25% moisture content. This method could be used for wood chips drying for pelletizing in which case no extra energy would be needed for drying the raw material. Condens heat recovery Oy produces equipment for fuel drying (www.condens.fi).

3. EXISTING PELLET SUPPLY STRUCTURES

Three pellet plants are presented as examples of existing pellet supply structures in Finland: a large scale independent plant Versowood in Heinola, large scale pellet plant of Vapo in Ilomantsi and a medium scale plant M-Pelletti Oy in Kuhmo.

Versowood is the largest independent sawmill, as well as pellet producer, in Finland; their annual pellet production capacity is 60 000 tons. The pellet plant started operation in the end of 2007 in association with one of the company’s sawmills in Vierumäki, close to Heinola in South Finland. Raw material is dry cutter chip, dry sawdust and dry wood chips from the company’s own wood processing facilities. Pellets are produced following the EU standard CEN/TS 14961. The company aims to process the by-products of its production by themselves instead of transporting by trucks to other users.

The Vapo Ilomantsi pellet plant in East Finland, started operations in 2000 and was renovated and enlarged in 2006. The pellet plant is part of the combined heat and electricity plant which is self-sustained by producing the electricity and the heat needed for drying the raw material and energy for the pellet production, the rest of the heat and power goes to the local town. Fuels used for heat and energy production are wood chips, peat and reed canary grass. The plant is working round the clock, employing 15 people. The Vapo Ilomantsi plant produces around 70 000 tons pellets annually. Most of the pellet production is exported. Vapo is following the EU standard CEN/TS 14961, it produces premium quality pellets for households and secondary quality for industry use.

M-Pelletti Oy in North-East Finland, started operations in April 2008, though is not yet working to its full capacity. The plant has one pellet press with a capacity of up to 18 000 tons annually, for 2008 the estimated production was 7000 tons. Currently, the plant is working 5 days a week in two shifts, 12 hours a day and is employing three people. The producer is not following any standard but it has its own production criteria and quality is followed at all times. Raw material is of good quality and dry cutter chips, no binding agents are used in the pellet production. The plant is designed in a way that there is possibility to add a second pellet press in the future. The plant has good possibilities to increase its production in the future if pellet demand grows. The plant is located in an industrial area where are many different wood industries (beside the raw material source, planing mill, there are furniture industry, wood construction firms and Kuhmo Oy’s sawmill).
3.1. Raw material transportation

Most of the pellet plants are located near to their raw material supply (sawmill, wood industry, furniture industry etc.) which is lowering the transportation costs. Raw material is transported short distances by conveyors. Especially many small and medium scale pellet plants have been built next to an existing raw material source. For larger plants raw materials are transported from many sources by truck. Raw materials are collected from areas near to the pellet plants; mainly from large sawmills.

Versowood: Most of the raw material (65%) is transported by trucks from the Versowood company’s sawmills and wood processing facilities located around southern Finland, the rest is transported pneumatically in a tube from the saw and planing mill next door.

Vapo Ilomantsi: In Ilomantsi the pellet plant’s raw material is mainly fresh sawdust which comes from Vapo’s own sawmills and other nearby sawmills, transportation is done by truck. Sawdust is also imported, by truck, from the Impilahti sawmill in Russia. The plant uses around 500 000 m³ of sawdust a year. Trucks are weighed on the scale when they arrive at the plant and again after unloading the raw material, in order to determine the amount of raw material coming to the plant.

M-Pelletti Oy: Raw material is transported pneumatically in a tube from the planing mill (AA-Puu Oy) which is located across the road from the pellet plant (Figure 6). Raw material is dry cutter chips; it consists of 75% spruce with the remainder being pine.
3.2. Handling of raw material at the pellet plant

Raw materials arriving at the pellet plant are stored inside if the plant does not have dryers and outside if there is a dryer. Only the largest pellet plants have dryers. From the storage the raw material is usually carried by a conveyor, feed screw, pneumatically or with a loading shovel to the production line.

Versowood: Raw material coming to the plant is dry and is stored inside two silos. Pneumatically transported material goes directly to the silos but raw material transported by truck is deposited at the receiving station where it is moved to the silo storage. The plant does not have a dryer since all of the raw material is already dry. Raw material goes by conveyor from the silo storage to the hammer mill and subsequently onto pelletizing pneumatically. Air used in the moving process is filtered and the dust is returned back to the process.

Vapo Ilomantsi: At the pellet plant, raw material is stored on an asphalt area (Figure 7), large enough for 2-3 weeks production. Part of the raw material is unloaded from the trucks directly to the warehouse (Figure 8) or it is moved there with a loading shovel. Warehouse storage has conveyors in the base of the floor which are transferring sawdust through sieves and a magnetic separator to the drying and finally to pelletizing.

M-Pelletti Oy: Raw material transported in the tube drops to the raw material storage area, a warehouse at the plant site (Figure 9). Full storage is enough for 2-3 days pellet production. A loading shovel is used to move raw material in the storage closer to the conveyor (Figure 10). In the bottom of the storage there is a conveyor lifting raw material and transferring it to the pellet plant, which is in the next building. From the separator after pelletizing, fines are returned back to the raw material storage and used again in the pelletizing process.
3.3. Handling of pellets at the pellet plant

After the pellets are pressed they are cooled, sieved for fine particles and finally are stored or packed depending on the delivery method. The pellets are stored at the plant site in large silos or in warehouses for bulk deliveries. In many cases sacks’ packing is not fully automatized and requires some extra work. Figure 11 illustrates the filling of large sacks in the Haapavesi plant, the sacks need to be placed in the packing device manually and the funnel is filled with pellets, closing of the sacks is done manually. Moving the large sack at the plant storage is done with a fork lift or sometimes by hook (Figure 12).

Versowood: After pelletizing the pellets are cooled and sieved, fines are collected and returned to the process. Bulk pellets are stored in two silos and parts of the pellets are packed into large and small sacks.
**Vapo Ilomantsi**: Fine materials are sieved in many stages; right after production the vibrator is separating the fines, from there the pellets are moved, through tubes, to the storage where they are sieved using a wind separator. In each stage where pellets are lifted or dropped they are sieved in order to keep their quality. After production the pellets are stored in a silo (Figure 13) or in the warehouse (Figure 14). The volume of the silo storages is 50 tons. If it becomes empty extra pellets can be moved from warehouse storage using the loading shovel to chutes (Figure 15) where suction lifts the pellets, they are sieved and moved to the silo. In the bottom of the silo there is a wind separator separating the fines once more before the pellets are loaded onto pneumatic trucks (Figure 16) and delivered to the customers. In Vapo’s Ilomantsi pellet plant the loading shovel is used to load pellets onto trucks and railroad carriages (Figure 17 and 18).
In Ilomantsi the packaging of pellets is done by a local potato farmer (2 km from the pellet plant), he collects the bulk pellets from the plant with a tractor and a trailer (Figure 17) and brings pellets to a warehouse in his farm. The packaging system is simple (Figure 19), on the left is a self-made unloading chute where the trailer is emptied, suction lifts pellets to the top to a wind separator which removes the fines before the pellets are packed in large sacks. The farmer is mainly packing large sacks (500 kg) since the demand for small sacks is low and they are also more time consuming to do. Small sacks are packed to order, filling is done with the same machinery, as used for large sacks, but the small sacks are closed with a machine (Figure 20) while the large sacks are closed manually. Sacks are stored in the same space were the packaging is done (Figure 21). Large sacks are moved inside the storage and loaded onto the trucks with a fork-lift, which can lift four sacks at a time (Figure 22).
M-Pelleti Oy: There is only one stage were fines are separated from the pellets and it is after cooling, the fines are returned to the raw material storage. Pellets are packed or stored straight from the production line. The packing machine for the large sacks is connected to the pellet production line (Figure 23) but the packing for the small sacks (Figure 24) is not and requires filling the “storage” sack (on the top of the packing machine on a loading pallet). The sack is loaded in a large sack machine and is lifted back with a fork-lift. For deliveries, small sacks are packed inside a large sack, 25 small sacks in one large (~400 kg) sack (Figure 25). The sacks are stored inside (Figure 26) or outside under cover. The most of the pellets are going straight from the production line, using an elevator, to the silo storages, which are the only bulk storages at the plant site. Pellets in bulk are stored in two silos (Figure 27, each can contain 20 tons of pellet) they are used for loading pneumatic trucks.
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 15-40 kg are usually packed onto interchangeable pallets and delivered to retailers. The share of small sacks in the pellet market is very small, partly because there is no efficient small sack packing capacity in Finnish pellet plants. Large sacks, 500-1000 kg, are sold straight from the plant or through retailers. Large sacks are recycled and they are refundable, but many times they are used only once or twice since during use they become worn and dirty.

In Finland, a large share of the pellets (bulk) are transported straight from the pellet plant to the customers. Pneumatic trucks are used when delivering pellets to households or medium size customers, for large scale users pellets are delivered by large normal trucks. The equipment for bulk deliveries varies; from normal trucks and specially designed pellet tanker trucks (Figure 28), to existing machinery used for animal feed deliveries (Figure 29 & 30). The minimum amount of bulk deliveries by truck is 3 tons. New trucks have an integrated weighing scale which allows accurate delivery and billing. The container of older trucks is divided into sections for suitable delivery amounts (Figure 31). 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.

**Versowood:** For the domestic market Versowood is selling its HOTTI pellets directly from the plant, as well as through the internet shop and retailers. Small sacks of 20 kg are sold on a pallet (40 sacks) and the delivery of large sacks, 500 kg, are done by truck. Bulk pellets are delivered by the company’s own pneumatic truck. The share of deliveries for the domestic markets is: 5% small sacks, 55% large sacks and 40% of pneumatic truck deliveries. Exported pellets are loaded onto trucks at the plant and delivered to Loviisa harbour. Versowood has built pellet storage at the harbour site; with storage space for 10 000 tons of pellets. Pellets are exported to Sweden and Denmark, typical shipping size is about 2400 tons.
**Vapo Ilomantsi:** A transporters pick up the bulk pellets directly from the pellet plant and loads them onto pneumatic or normal trucks. The local farmer collects the pellets for packing with his tractor and trailer. After packing, trucks collect the pellet sacks directly from his farm. The bulk pellets travel to Kokkola or Joensuu harbour by rail where they are loaded and shipped for export.

**M-Pelletti Oy:** The company is delivering bulk pellets straight to the customers, delivery is done by a local contractor who is using the same truck for animal feed deliveries. Bulk deliveries are done over a 300 km radius, sacks are mainly delivered to the Kesko retailer chain. Most of the production is sold in bulk (60%), the rest are packed into large sacks 35% and small sacks 5%.

**Pellet Lager storage and loading centre:** Åland Islands are separate from mainland Finland and do not have their own pellet production since sawmills capacity is not large enough to support pellet production. Despite this there are many households using the pellet heating system. In Långnäs there is a unique pellet storage and loading centre owned by Rundbergs Bil & Service (Figure 32). Since the pellets need to be transported by ship they are packed onto the large containers. In the loading centre, the containers are emptied into a tipping trough (Figure 33). Extra loading and long transportation is causing more crumbling, hence the pellets are sieved in the loading centre before they are passed along the conveyor to the silo storage. There are nine large silo storages which have a loading tube in the bottom from which pellets are moved to a pneumatic truck. Transportation costs are minimized since the pellets are packed onto the containers which are used to transport the wastes from Åland Island to a waste burning plant in Riihimäki on the mainland. The waste transportation is done by the associated company of Rundbergs. The containers are washed and dried before pellets are loaded. Since the containers have to be transported back to Åland Islands, the extra costs from transporting the pellets is very small. The local transportation company has four tanker trucks for delivering oil, with one of them having a changeable tanker for pellets (Figure 34).
In Finland a large part of the pellet users are private households. According to the Finnish Pellet Energy Association the number of households using pellets could be five times more than present. There is a lot of potential since today Finland has only around 15 000 household using pellets. There is a growing interest in pellet heating and the estimates for 2012 is there would be 50 000 households using pellets. Most of the new users would come through restoring the old oil heated houses as well as the builders of new houses choosing pellet heating system. Additionally, because of the high price of the electricity some of the electrically heated houses could be encouraged to change to pellet heating. In 2006 there were around 290 000 residential buildings using oil heating and around 470 000 were heated with electricity. Pellets are expected to replace some of the firewood used in the fireplaces; this is supported by the increase in sales of pellet stoves and pellet baskets for use in fireplaces. The development of pellet users is also depending on the taxation of fossil fuels. At the moment the total heating cost difference between the pellets and fossil fuels is relatively small. The state is not providing subsidies to private households for changing to pellet heating systems, which is partly slowing the pellet heating system development. Without subsidies the investment cost of changing to pellet heating system can be very high.

4.2. Expected number of pellet producers in the next 5-10 year period

As of the end of 2008 there were 24 pellet plants operating, with a further five plants planned or being constructed. With all these plants being online the total pellet production capacity is estimated to be around 1.16 million tons. The Finnish Pellet Energy Association estimates one million production tons will be reached in 2010. Reaching this level can be done with the existing and forthcoming pellet plants if they work to their full capacity. The total production estimate for 2020 is 1.5 million tons of pellets which would require establishing new pellet plants or enlarging the existing plants.
5. BOTTLENECKS

5.1. Bottlenecks related to pellet raw materials

In the future a “lack” of raw materials, especially cut-ter ships and dry sawdust, can raise the pellets prices. There are insufficient good quality raw materials for increasing production. For example, currently (winter 2008 -2009) there is a lack of raw materials for pellet production due the decreased number of saw-ings, this is expected to raise the pellet prices. Addition-ally particleboard and fibreboard industries are compet-ing with pellet plants for raw materials. Bark would be one possible raw material for pellets but it is usually combusted at the debarking place, typically in pulp mills, or used for landscaping or garden-ing purposes. New raw materials are needed which would be compatible with existing pellet production structures and users’ equipment (storages and boil-ers). Raw material supply needs to be cost-efficient as transportation distances can not be too long. Rus-sian wood tariffs on timber exports is reducing the amount of round wood coming to sawmills, thereby reducing the raw material for pellets. At the end of 2008 the economical situation had reduced the output from sawmills throughout Finland which can effect to pellet production.

There are many potential new raw materials for pel-lets but at the moment their suitability for pelletiz-ing is being researched (for example in PELLETime project). Forest residuals have a large potential but the handling and drying needs to be optimal in order to decrease the corrosive agents which can cause problems in small scale boilers. At the moment sawdust is imported to Vapo Ilomantsi pellet plant from a saw-mill in Impilahti (Russia) but now there is pellet plant under construction next to the sawmill which will be stop the raw material transportation to Finland.

5.2. Bottlenecks related to pellet supply / transportation

In Finland, the distances are long and transporting costs of raw materials, as well pellets, can be very high in some areas. For small/medium scale pro-dusers the profitable pellet delivery radius is about 300 km. If the number of pellet users is growing the pellet supply needs to be directed to the domestic markets instead of the export market. There are suf-ficient pellets produced which could be used on the local market instead of being transported abroad. The pellet production for 2008 could be used for heating around 75 000 detached houses but at the moment there are only 15 000 houses heated with pellets. Increasing the number of users in the domes-tic market requires the development of a transpor-tation network and associated equipment, mainly pneumatic trucks for bulk deliveries, for good and fast pellet delivery. Currently typical pellet delivery is two weeks from the ordering time. Pellets disintegrate during long distance transport, loading and unloading which can increase the amount of fines and reduce the pellets’ quality. For the domestic market a large share (71%) of the pellet deliveries are done in bulk which, compared to sacks deliveries, is causing more crumbling. The main reason is probably the use of old trucks not designed for pellet deliveries and how the unloading is done by the driver. However, bulk deliveries are more eco-nomic, efficient and cheaper than deliveries of small sacks. In Finland, there are no standards for pellet deliveries and not all transport workers are trained to handle pellets. A large amount of research has been done regarding the handling of pellets and ma-chinery used to minimize pellet crumbling during pneumatic deliveries with some recommendation being made.
6. SWOT ANALYSIS of the pellet raw material and pellet supply systems

Strength: Raw materials are renewable and domestic. Pellets are environmentally friendly; they do not add CO2 emissions. Pellets do not freeze or become mouldy so they can be stored outside. Pellets are compact and have large energy content, they are easy to handle and transport, and they have small storage need. In Finland there are plenty of potential raw materials for pelletizing as well as great potential to increase the number of pellet users. There is enough domestic pellet production to increase the number of users without the need of pellet imports.

Weaknesses: Fresh sawdust, bark and logging residuals require drying before they can be used for pelletizing which can be a limiting factor for small and medium scale producers. Dryers would require more investment and the cost can be too high to be profitable for small scale production. High raw material prices, as well as high transport costs of raw materials if the pellet plant is not close to the raw material source are also an issue. In some parts of Finland distances from the pellet plant to the customers can be long which increases the pellet transportation costs. The low amount of pellet users which often makes the delivery network inefficient. Pellets may crumble during transportation and during unloading especially when transported by pneumatic truck if the pellet quality is not good. Currently there is no pellet standard as a result there can be large variation between the pellet producers’ products. Also there are no standards for pellet storages or quality of pellet logistics (compared to Austria).

Opportunities: There are many potential new raw materials for pellets (bark, reed canary grass, logging residuals etc.). New pellet plants all over Finland reduce the transportation cost as pellets users are closer to the producers. Development of small scale pelletizing units which can be moved close to the raw materials supplies. Development of pellet handling methods where the grinding of pellets is minimized both in the plant, transport and also in the consumers’ storage, implementing into practice the research results done regarding these topics. If the number of pellets users is growing, some of the pellet exports should be directed towards the domestic markets which would reduce the transportation costs. Pellet market could be local instead of global; there is a lot of potential which is currently exported.

Threats: There are insufficient good quality raw materials (e.g. dry sawdust and cutter chips). Potential new raw materials do not produce good quality pellets at the moment. Sawmill production is decreasing which effects the raw material supply. The uncertainty of raw material supply in the future is delaying the establishment of some of the new pellet plants.

7. CONCLUSIONS

Ensuring the good quality of pellets through the whole production, delivery and handling chain is important in order to increase the use of pellets and sustain the ability to compete with other fuels. The pellet supply system is quite well established and is working well in Finland; many plants are delivering bulk pellets straight to the customer which is reducing the decrease in quality, is economic and efficient, also pellet sacks can be bought from many places. Nevertheless in the future the increasing number of pellet users requires an organized delivery network and good equipment for pellet deliveries. The constant research of pellets also includes quality control in storing and pneumatic loading/unloading, based on the research some recommendations (possibly a standard) could be made about pellets handling and logistics (for example Austria has standard for pellet handling and logistics). In the most developed pellet markets (German and Austria) pellets are mainly delivered in bulk which is the case also in Finland. Bulk pellets are more economical than packed pellets, they are usually coming straight from the pellet plant and have no packing materials, while small sacks are packed on a pallet and wrapped with plastic, and sold via retailers. In Finland the pellets markets are more based on bulk deliveries, probably due to the cheaper price and the ease of ordering the pellets twice per year instead of filling the boilers storage from the sacks.
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