EFORWOOD
Sustainability Impact Assessment of the Forestry - Wood Chain

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EFORWOOD

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PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	x
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1 Introduction

This report gives an overview of the manufacturing model processes that will be studied in the work of the case studies in EFORWOOD.

M4 is dealing with the manufacturing processes within EFORWOOD. To limit the amount of data collection some model mills have been defined for the 3 value chains Fibre, Solid wood and Bioenergy. These model mills will represent the main processes, covering 60-80% of the European industry, regarding Fibre (Pulp and paper industry), Solid wood and Bioenergy.

The industry processes defined are:
Fibre

- Integrated Newsprint
- Woodcontaining Paper
- Wood Free Paper
- Containerboard
- Cartonboard
- Bleached Chemical Pulp

Solid Wood

- Saw Milling (hardwood and softwood sawn timber)
- Joinery (doors and windows)
- Building components (including panel products)
- Wood based indoor furniture (kitchens)

Bioenergy

- Pellets
- Heat production (simplified process)
- Combined heat and power production (simplified process)

A general description of the model processes is given in this report . The description shall be seen as a way of very generally giving one example of how the process can look like. However, in reality all mills are unique.

To further limit the amount of data and also to make it possible to find all the data needed for ToSIA database, 4 regions in Europe have been identified. Industries located in countries within the same region are assumed to have the same level of technology in the processes, the same production capacity (size) and uses the same raw material. In the cases where the country-specific data can be found they will be used but in the cases the data are not availble an assumption will be used by using the data for another country in the same region.

2 The Fibre value chain

For the fibre value chain, 6 different processes have been defined representing the different kind of pulp and paper mills in Europe.

The processes defined are:

- Integrated newsprint
- Wood containing paper
- Wood free paper
- Containerboard
- Cartonboard
- Bleached chemical pulp

KCPK is responsible for the description of the Integrated newsprint mill.
STFI-PF is responsible for the description of the Model Mills for Wood containing paper, Wood free paper, Containerboard and Cartonboard. These model mills are based on theoretical mills that have been developed within the framework of the Swedish national research project called FRAM in collaboration with Ångpanneföreningen AB The system analysis in the "Future Resource-Adapted Pulp Mill" program (FRAM, 2003-2005) is a continuation of the work carried out in the "Ecocyclic pulp mill" program (KAM, 1996-2002) [www.stfi.se].
KCL is responsible for the description of the Bleached chemical pulp mill.

2.1 Pulp and paper process –an overview

Wood pulp is made in several stages.
First the bark is removed from the wood. This can be done with or without water. The bark is generally recovered to use as fuel in the pulp and paper making process. The cellulose fibres that keep the wood together are then separated. This can be done in number of ways. A short summary of different pulps is given below.

GW (groundwood): The wood can be crushed with grinders (huge grindstones) and then soaked in water to produce groundwood.

TMP (Thermomechanical pulp): The wood can be crushed with refiners using steam at high pressures and temperatures to produce TMP. TMP differs in quality from GW.

CTMP (Chemithermomechanical pulp): In addition to refiners, chemicals can be used to break up the cellulose fibres.
GW, TMP and CTMP are all considered as mechanical pulps Mechanical pulps are used for products that require less strength, such as newsprint and paperboards.
The mechanical pulps tend to turn yellow in time, because of the binding material, lignin, in the pulp.

Kraft pulp: Chemical pulp (called kraft pulp or sulphate pulp) is produced by combining wood chips and chemicals in huge vats known as digesters. The effect of the heat and the chemicals dissolves the lignin that binds the cellulose fibres together, without breaking the wood fibres. The fluid that contains lignin and other dissolved material is then evaporated and used as fuel, so-called black liquor. Kraft pulp is used for materials that need to be stronger or combined with mechanical pulps to give a product different characteristics.

Recycled pulp: Pulp can also be made out of recovered paper and paperboard, so-called recycled paper. By mixing with water and applying mechanical action the hydrogen bonds in the paper can be broken and fibres separated again. Recycled paper is most often used to make paperboard, newsprint or sanitary paper. Paper made from wood pulp can typically be recycled four-seven times before the fibres become too short. To solve this problem recycled paper is usually mixed with virgin wood pulp to ensure a high quality paper.

The pulp produced up to this point in the process can be bleached to produce a white paper product. The chemicals used to bleach pulp have been a source of environmental concern. Today the pulp industry uses bleaching agents as chlorine dioxide, oxygen, ozone and hydrogen peroxide.

The wastewater effluent can be a source of pollution if not taken care of. It contains lignins from the trees, high biological oxygen demand (BOD) and dissolved organic carbon (DOC), along with alcohols, chlorates, heavy metals and chelting agents. Reducing the environmental impact of this effluent is accomplished by closing the loop and recycling the effluent where possible. The most important way to mitigate the impacts is the biological effluent treatment.

In the Kraft process, the largest volume byproduct from the pulping process is black liquor. This liquor contains the pulping chemicals and the lignin from the trees. The lignin is high in heat content, so this weak black liquor (about 15% solids) is concentrated to heavy black liquor (usually 65-80% solids) by use of multiple effect evaporation. The heavy black liquor is burned in a recovery boiler. The energy released is used to produce process steam and electricity in steam turbines. The chemicals fall to the bottom of the boiler in a semi-liquid state called smelt. The smelt then flows out of the boiler and is dissolved in water or weak wash to form green liquor. The green liquor is then clarified. Burned lime (CaO) is added to the clarified green liquor to convert a majority of the sodium carbonate (Na_2CO_3) to sodium hydroxide (NaOH). The resulting liquor is called white liquor. The white liquor is used as pulping chemicals and the process begins again. The spent lime ($CaCO_3$) is then calcinated in a lime kiln to yield CaO to be used again.

This recovery area is very important for the kraft pulp process but does not exist in mechanical pulping process. The chemical pulping process is self-sufficient in energy while the mechanical pulping process requires a lot of electricity. However, the yield in the chemical pulp is only about 50% while the yield for mechanical pulp is about 95%.

Besides the fibres, pulps may contain fillers such as chalk or china clay, which improve the characteristics of the paper for printing or writing. Additives for sizing purposes may be mixed into the pulp and/or applied to the paper web later in the manufacturing process. The purpose of sizing is to establish the correct level of surface absorbency to suit the ink or paint.

After bleaching the pulp mixture is sent to the paper machine. A paper web is produced and then the water must be removed from it in order to create a usable product. This is accomplished through pressing and drying. The methods of doing so vary between different processes used to make paper, but the concept remain the same. Pressing the sheet removes the water by force. Once the water is forced from the sheet, another absorbent material must be used to collect this water. Drying involves using air and or heat to remove water from the paper sheet. Various forms of heated drying machines are used.

The paper may then undergo sizing to alter its physical properties for use in various applications.

Paper at this point is uncoated. Coated paper has a thin layer of material such as china clay applied to one or both sides in order to create a surface more suitable for high-resolution halftone screens. Coated or uncoated papers may have their surfaces polished by calendaring. Coated papers are divided into matt, semi-matt or silk and gloss.

2.2 The pulp and paper model mills in the 4 regions

JPC´s internal database has been used to define the furnish and the mill sizes for the different regions.

DIP: De-inked paper
BSKP: Bleached softwood kraft pulp
BHKP: Bleached hardwood kraft pulp
RP: Recycled paper

The regions, group of countries, defined for the fibre value chain are presented below:

Group 1 = Central Europe
AUSTRIA
BELGIUM
DENMARK
FRANCE
GERMANY
IRELAND
NETHERLANDS
SWITZERLAND
UNITED KINGDOM

Total paper and board production capacity: 45 000 thousand tonnes / year
Total market pulp production capacity: 2 800 thousand tonnes / year

<u>Mills (median capacity) and example furnish (per ton of fibre):</u>

1. Integrated Newsprint (280 000 tonnes/year), 100% DIP
2. Woodcontaining paper (290 000 tonnes/year), 10% DIP, 35% kraft pulp (BSKP), 55% mech.pulp Note: coated, 40 % minerals
3. Woodfree paper (110 000 tonnes/year), 100% kraft pulp ((BSKP:BHKP = app. 1:2) Note: coated 45% minerals
4. Containerboard (75 000 tonnes/year), 100% RP Note: Testliner
5. Cartonboard (65 000 tonnes/year), 50% RP, 30% DIP, 20% kraft pulp Note: WLC 10% minerals
6. Bleached Chemical Pulp (135 000 tonnes/year) Note: BSKP

Group 2 = Southern Europe
SPAIN
ITALY
PORTUGAL
GREECE
MALTA
CYPRUS

Total paper and board production capacity: 16 000 thousand tonnes / year
Total market pulp production capacity: 2300 thousand tonnes / year

<u>Mills (median capacity) and example furnish (per ton of fibre):</u>

1. Woodcontaining paper (50 000 tonnes/year), 40% kraft pulp (BSKP), 60% mech. pulp Note: coated, 42 % minerals
2. Woodfree paper (25 000 tonnes/year), 100% kraft pulp (app. BSKP:BHKP = 1:3) Note: uncoated, 20 % minerals
3. Containerboard (20 000 tonnes/year), 100% RP Note: Recycled fluting
4. Cartonboard (60 000 tonnes/year), 85% RP, 15% DIP Note: WLC, 10% minerals
5. Bleached Chemical Pulp (205 000 tonnes/year), Note: BHKP

Group 3 = East Europe
CZECH REPUBLIC
HUNGARY
POLAND
ROMANIA
BULGARIA
SLOVAK REPUBLIC
LATVIA
LITHUANIA
ESTONIA

Total paper and board production capacity: 4 600 thousand tonnes / year
Total market pulp production capacity: 700 thousand tonnes / year

<u>Mills (median capacity) and example furnish (per ton of fibre):</u>

1. Woodfree paper (10 000 tonnes/year), 100% kraft pulp (app. BSKP:BHKP = 1:2) Note: uncoated, 20% minerals
2. Containerboard (20 000 tonnes/year), 100% RP Note: Recycled fluting
3. Bleached Chemical Pulp (65 000 tonnes/year) Note: BHKP

Group 4 = Nordic Countries
FINLAND
NORWAY
SWEDEN

Total paper and board production capacity: 27 000 thousand tonnes / year
Total market pulp production capacity: 7500 thousand tonnes / year

Mills (median capacity) and example furnish (per ton of fibre):

1. Integrated Newsprint (270 000 tonnes/year), 50% DIP, 50% mech. pulp
2. Woodcontaining paper (310 000 tonnes/year), 35% kraft pulp (BSKP), 65 % mech.pulp Note: coated, minerals 40 %
3. Woodfree paper (185 000 tonnes/year),100% kraft pulp (BSKP:BHKP = app. 1:2) Note: uncoated, 20% minerals
4. Containerboard (290 000 tonnes/year), 100% kraft pulp Note: Kraftliner, 16 % minerals
5. Cartonboard (180 000 tonnes/year), 55% kraft pulp, 45% mech. pulp, Note: FBB 10% minerals
6. Bleached Chemical Pulp (190 000 tonnes/year), Note: BSKP

2.3 General Process Description of the Model Mills in the Fibre chain

A very general process description of the model mills is given. Each mill is unique so the technology can’t be described in details, this is meant to give an overview of the pulp and paper processes as they look like generally today.

2.3.1 Bleached Chemical Pulp

A simplified scheme of kraft pulping process is presented in Figure 1. Kraft pulp production process begins with wood handling, where dry debarking is the most environmentally friendly technology to produce bark with a lower water content. It leads to a reduced discharge of organic substances in effluent and a better energy balance in the mill. Bark – either softwood or hardwood bark - is combusted in the bark boiler. The pulp which is coming from cooking phase contains both fibres and spent cooking liquor (black liquor). About half of the wood is dissolved in cooking. Black liquor is removed from the pulp in the washing stage and led to the chemical recovery system. Closed screening decreases effluent discharge by reducing total waste water volume. After cooking the delignification can be continued by oxygen delignification. The organic matter that is dissolved during oxygen delignification can be recovered and led to the chemical recovery system. ECF bleaching (Elemental Chlorine Free) is used in the bleaching plant.

The recovery system in a kraft pulp mill recovers the inorganic pulping chemicals, produces process heat and electric power and recovers organic by-products like tall oil. Kraft pulp mills are normally self-sufficient in heat and electric power. Weak black liquor from washing has an approximate dry solid content of 14-18%. Before burning, the black liquor is evaporated in order to gain dry solids between 65-76/78%. Improved high dry solids (HDS) are combusted in recovery boiler. A roughly estimate is that if the dry substance of black liquor is 70%, sulphur emission from recovery boiler is zero. The smelt leaving the recovery boiler is dissolved in the water or in the weak white liquor to produce 'green liquor'. The green liquor is clarified and causticized in lime kiln with lime in order to produce white liquor for pulping. In causticizing stage Na_2CO_3 is converted to NaOH. $CaCO_3$ (lime mud) that is formed in this stage, is washed and calcined to regenerate the lime. External fuel (heavy fuel oil) is needed in the lime kiln because the lime mud burning is a high-temperature reaction. In this chemical recovery stage, total reduced sulphur (TRS) will be reduced by the odorous gas handling systems.

Finally, waste water from the process is treated in an activated sludge plant with additional nitrogen to feed the bacteria in the biosludge.

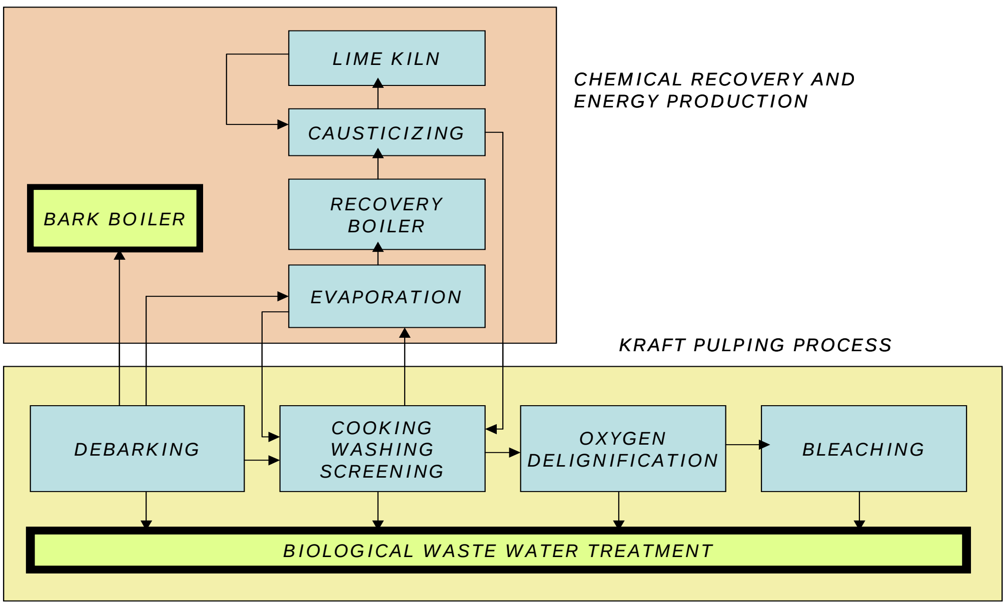

Figure 1. *Process phases in kraft pulping*

Kraft pulp mill used in Eforwood case studies represents a modern pulp mill, using either softwood or hardwood as raw material (depending on case study). 30% of wood raw material is chips, 70% is stem wood. The process technology can be described as follows:

- Debarking: dry (assumption is that 12% of undebarked wood is bark)
- Yield in kraft pulping process for both softwood and hardwood: 50%
- Bleaching: ECF bleaching (reduced ClO2 consumption), kappa 14, brightness 89 ISO
- Black liquor dry substance (%): 75%
- Recovery boiler effiency (%): 67%
- Back-pressure turbine constr.factor: 0.20
- Recovery boiler flue gas: high efficiency ESP (electrostatic precipitation) + scrubber
- Lime kiln: LMD (lime mud drying)
  Lime kiln fuel: heavy fuel oil

  Lime kiln flue gas: high efficiency ESP (electrostatic precipitation)
- LVHC (low volume high consentr.) incineration: separate boiler
  HVLC (high volume low consentr.) collection: >90%
- Bark boiler:
  Total efficiency 0.87

  Fluidized bed boiler
- Waste water treatment: activated sludge plant
- Drying included in market pulp production

2.3.2 Woodfree paper –Integrated fine paper model mill

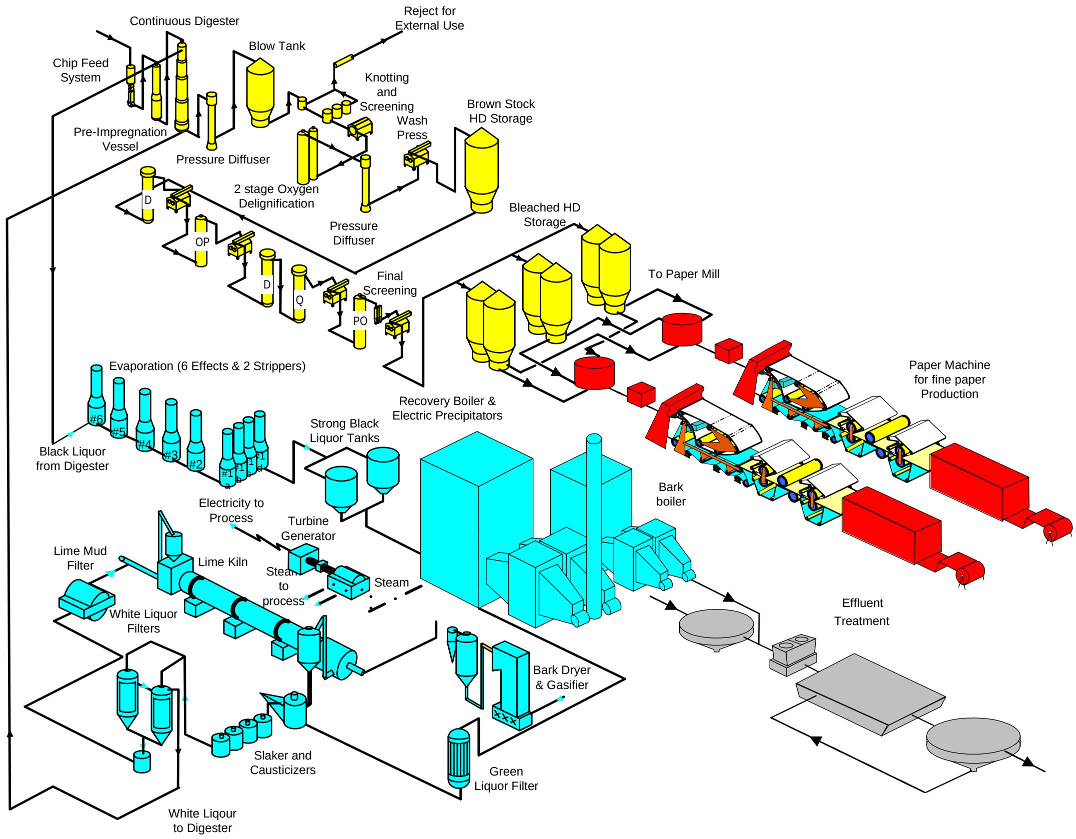

Figure 2. *A fine paper model mill including the fibre line, recovery area, steam generation, bleach plant and the fine paper machines.*

Pulp mill

The pulp mill in the integrated fine paper mill is the same as in the market pulp mill described above.
The steam production in the recovery boiler is however not enough to meet the steam demand in the integrated fine paper mill. A power boiler burning bark is therefore used to produce the required additional steam.

Paper mill

There are two paper machines, referred to as PM1 and PM2. Both PM1 and PM2 produce uncoated fine paper from softwood and hardwood.
The fine paper model mill is approximately self-sufficient in steam consumption whereas a third of the power consumption must be bought.
A simple block diagram for PM1 and PM2 is shown in *Figure 3*.

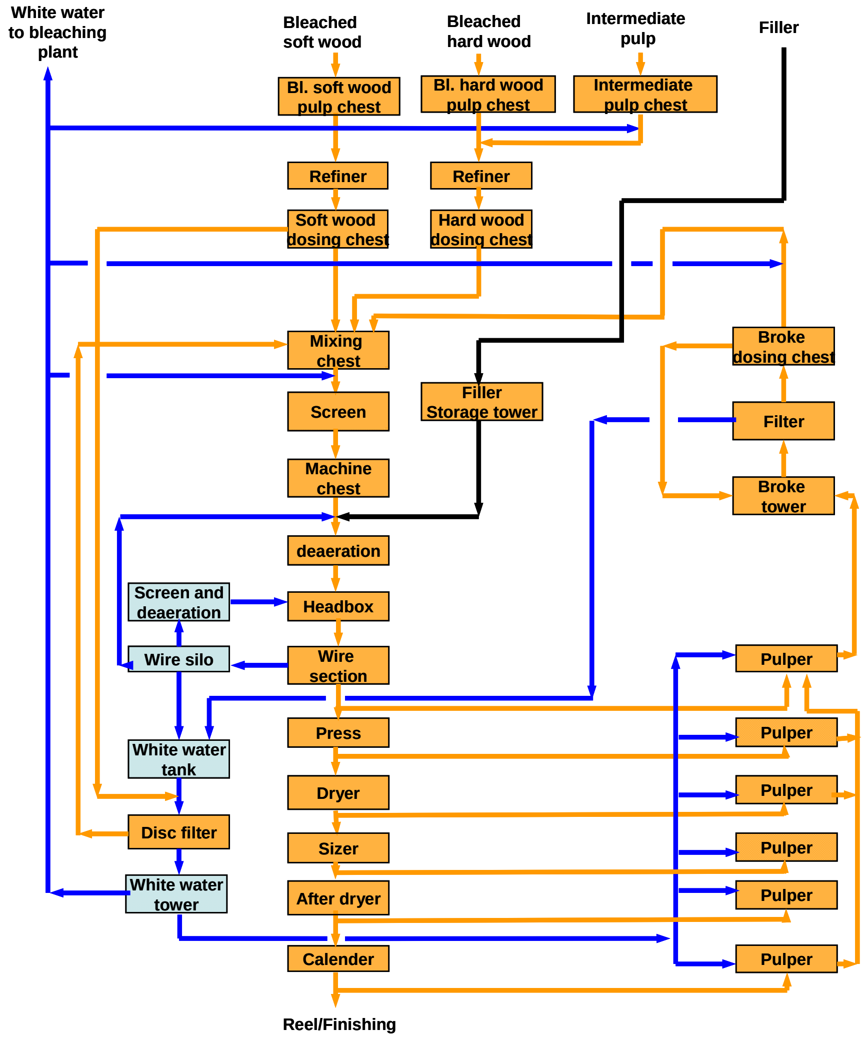

Figure 3. *Block diagram showing the process concept of the fine paper machines.*

Stock preparation

Bleached hardwood and softwood are diluted after their respective MC-storage tower and pumped to the pulp chests. Hardwood and softwood can be refined separately to optimise their properties.

Since there is not a perfect plug-flow through the pulp mill, there will be some intermediate pulp produced when changing from hardwood to softwood. This intermediate pulp is stored in a MC-tower and added to the paper macine furnish in a controlled way.

Paper machine

The paper machine is based on a concept to allow for a high quality fine paper production at a high machine efficiency and high speed.

The wire section is a modern twin wire section to give the best paper uniformity with regard to formation, basis weight profile, ash profiles and sheet structure.

The press section is designed for optimum runnability of the machine by means of a closed web run from the wire section to the dryer section.

The dryer section consists of a pre-dryer section and an after dryer section. The pre-dryer section is a combination of drying cylinders in an upper row and vacuum assisted rolls in a lower row integrated with an air handling system including web stabilising equipment for increased runnability and minimum energy consumption. The sizer after the pre-dryer section is adding surface size to both sides of the web by means of an application roll system to increase strength properties of the paper.

Energy systems and balances

The mill is very energy efficient and black liquor and falling bark are sufficient to produce the energy needed for process steam consumption and cogeneration of power in the back-pressure turbine. The back-pressure power generation is not enough and additional power must be bought. A minor amount of bark surplus is sold.

Energy aspects of the paper machine

The main input of energy to the paper machine is steam for drying of the paper. Most of the power consumption takes place in motors for pumps, screens, drives and refiners in the paper mill. Most of this energy is going into the process flow as thermal energy and contribute to keep the system temperature on a high level. A high level improves the dewatering on the wet end and minimises bacteriological and slime problems.

Water system and balance

The mill is designed with a very low process water consumption. There is also a consumption of water for cooling purposes in the mill. Almost all cooling is however made with a closed cooling system with the water circulating over a cooling tower requiring only make-up to compensate for the evaporated water and a minimal purging to prevent build-up in the system.
The warm water system is the main fresh water consumer in the paper mill. Warm water is mainly used for high pressure cleaning showers in the wire- and press sections and for dilution of different chemicals. Warm water is received from the kraft mill. The paper machine white water system consists mainly of a white water tank for paper machine excess water connected to a disc filter save-all. Clear filtrate from the disc filter is used for shower purpose in the wet end and is also stored in a white water storage tower to be used for consistency control and for broke dissolving. The surplus clear filtrate is pumped to the bleach plant.
A correct dimensioning and use of the storage buffer volumes also mean minimal variations in the flow of waste water to the external treatment plant which should result in higher cleaning efficiency and lower investment and operating costs for the external treatment plant.

Effluent Treatment

The effluent treatment is the same as described for the market pulp mill above.

2.3.3 Containerboard and Cartonboard –Kraftliner model mill

The kraftliner model mill has two paper machines with the same design. One machine normally produces unbleached liner and the other white top liner. Unbleached kraft pulp is produced in the integrated kraft mill, whereas the bleached pulp is purchased.

Apart from the kraft pulp also a considerable amount of recycled fibres is used, especially in the unbleached liner.

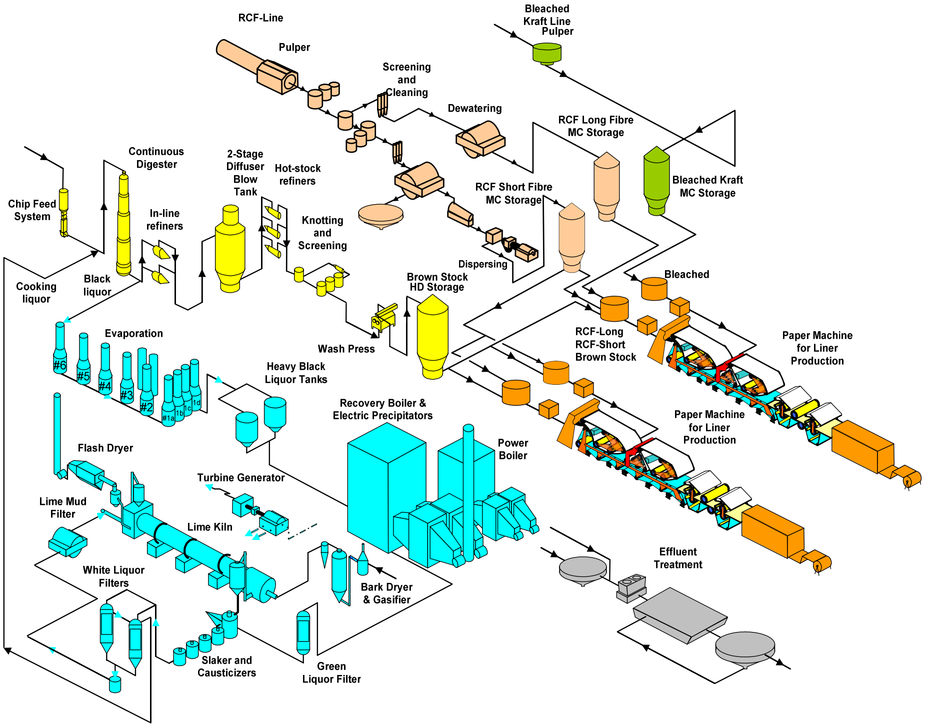

Figure 4. *The kraftliner model mill including the fibre line, chemical recovery, steam and power generation, liner machines, and effluent treatment.*

Fibre Line

The debarking is performed in dry debarking drums with a closed re-circulation of sprinkling and de-icing water. A portion of the bark is gasified and utilised as fuel in the lime kiln; the rest is burned in the power boiler together with purchased bark.

Cooking

Cooking and delignification is performed in a continuous digester.

Screening, refining and washing

The pulp from the digester is refined in two parallel inline refiners. The refined pulp is washed in a 2-stage atmospheric diffuser washer and falls into the blow tank. After the blow tank, the pulp is further refined in three parallel hot stock refiners and then screened. The pulp is washed in three stages

- Hi-Heat washer in the digester,
- 2-stage atmospheric diffuser after the in-line refining,
- Final wash press after hot stock refining and screening.

Chemical Recovery

The chemical recovery and energy system have basically the same process solution as the market pulp mill, described above.

The steam production in the recovery boiler is not enough to meet the steam demand in the integrated kraftliner mill. A power boiler burning bark is therefore used to produce the required additional steam.

Recycled Fibre Plant

The raw material for the recycled fibre plant consists of old corrugated containers, OCC, which are delivered in bales.
After dewiring and bale breaking the paper is fed to a continuous high consistency drum pulper. It is then screened in three stages.
The pulp is fractionated into long and short fibre fractions. The fractionation reduces the investment cost as well as the operating cost of the plant as separate treatment of the fractions can be made.
The long fibre fraction is dispersed in a disperser plant. The first stage consists of a pre-heater. The disperser treats the pulp mechanically so that hotmelts, stickies and other contaminants are dispersed.
The reject handling separates the various types of rejects and thicken them to a dry content that is suitable for the next step of the cycle, i.e. incineration, landfill or raw material for other processes.
The only chemicals that are required in the RCF plant are flocculation chemicals for the dissolved air flotation (DAF) and the sludge dewatering. Polymers are dissolved in fresh water and added to the water to be treated in the DAF.

All substances that are dissolved in water in the process will be found in the wastewaters from the process. The amount of COD dissolved is very much dependent on the raw material for the recycled fibre.

Paper mill

There are two paper machines, PM1 and PM2.

- PM1 is aimed to produce unbleached kraftliner, with up to 50 % recycled fibre in the base ply.
- PM2 is aimed to produce white top liner.

Stock preparation

The bleached kraft pulp, purchased in bales, is slushed in pulpers, diluted and stored in a storage tower. The pulp is then pumped to the pulp chest on PM2. There is a refiner between the pulp chest and the dosing chest.
The RCF long fibre pulp is diluted and then refined in a low consistency refiner before it enters the dosing chest. The refining improves the tensile and tear strength as well as the ply bond and increases elongation
Each ply has a set of mixing and machine chests.

Paper machine

The paper machines are based on a concept to allow for a high quality liner production at high machine efficiency.
The base ply head box is of the cross profile dilution type. The top ply headbox is of conventional type.
The base ply and top ply former are gap formers to give the best paper uniformity with regard to formation, basis weight profile and sheet structure at these high speeds.

The press section is designed for optimum runnability of the machines by means of a closed web run from the wire section to the dryer section. A high dry content of the web leaving the press section is an important factor for the runnability of the press section. The press concept is two straight shoe presses. The final dryness after the press section is about 50 %. After the first press, a steam box increases the temperature of the web to increase dewatering. Another important feature of the steam box is to control the moisture profile of the final paper.
The first part of the dryer section is a single tier dryer, designed for high speed. The dryer is a combination of drying cylinders in an upper row and vacuum assisted rolls in a lower row integrated with an air handling system including web stabilising equipment for increased runnability and minimum energy consumption.
The one-nip calender is of soft calender type to give optimum surface properties. The liner is finally winded up on the reel.

Energy systems and balance

Much effort has been devoted to the energy efficiency of the process concept, but also considering operability and payback. The key features of the energy system is the same as in the integrated fine paper mill.

Energy aspects for the paper machine

The main input of heat energy to the paper machine is steam for drying of the paper out from the press section. The dryness of the paper after the press section and the efficiency of the paper machine (need for re-drying of broke) are the main factors affecting the steam consumption in the paper machine.
The main of the power consumption takes place in motors for the drives, pumps, screens and refiners in the paper mill.

Water system and balances

The mill is designed to have very low water consumption.. In addition to this there is also a consumption of water for cooling purposes in the mill. Almost all cooling is however made with a closed cooling system with the water circulating over a cooling tower, requiring only make-up to compensate for the evaporated water and a minimal purging to prevent build-up in the system.

The white water flow is counter-current from the liner machine to the RCF. Normally rejects are the only contaminated streams out from the paper machine.
The kraft pulp leaves the kraft mill at 30 % dryness. White water acts as pick-up water and dilutes the pulp to medium consistency before the MC-storage tower.
The only fresh water to the RCF plant is sealing water.
The filtrate from the reject handling and the screw press is treated in a dissolved air flotation unit (DAF). This treatment reduces the fines and ash content in the pulp as the screw press washes these out. The effluent from the RCF plant is the treated water from the DAF unit.

Effluent treatment

Biological sludge will be dewatered to about 10 % in a centrifuge, mixed with deinking sludge and return fibre sludge and further dewatered on a screw press. This sludge will be incinerated in the bark boiler.

The water supply and treatment is basically the same as in the market pulp mill, see above.

2.3.4 Woodcontaining paper –Magazine paper model mill

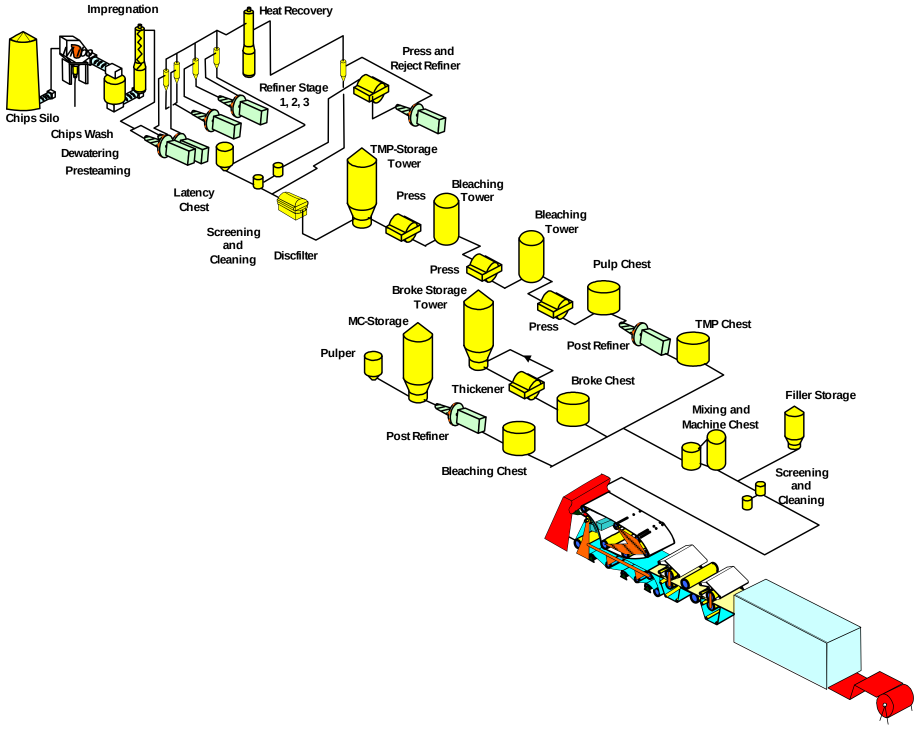

Figure 5. *The magazine paper model mill*

The TMP plant is designed to produce a low freeness pulp for SC-paper. The bleach plant is a two stage process with peroxide and alkaline as the main bleaching chemicals. The target brightness of the TMP is 75 % ISO.
The paper mill has one paper machine for SC-paper production.

The mill is self-sufficient in steam from the TMP process when running. Generated steam is mainly used for drying but also for heating purposes of different positions in the mill.

Technical concept

Figure 6 shows the proposed concept for the TMP plant. The main line refining is made at high consistency in three stages. The rejects from the screening and hydro cyclone cleaning plants are dewatered and further refined at high consistency in a two stage reject refining.

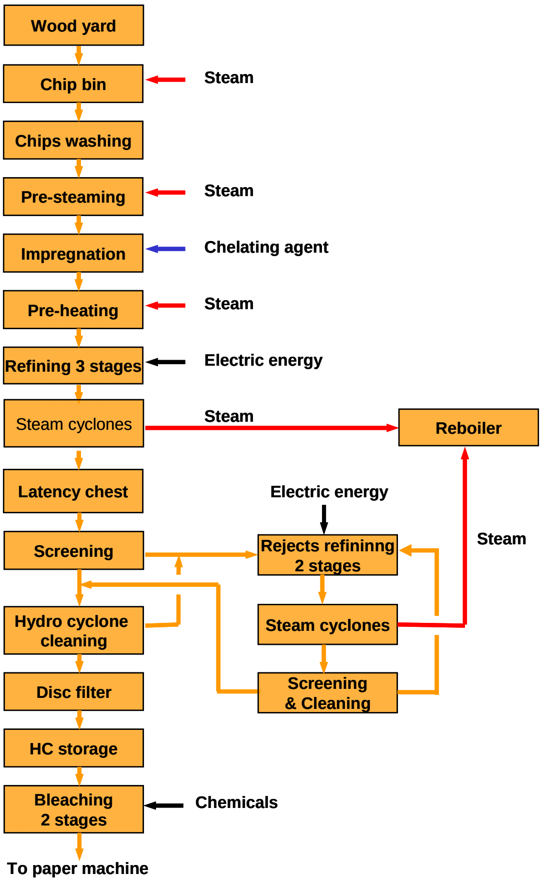

Figure 6. *Block diagram showing the TMP process concept for the magazine paper model mill.*

Wood yard

The debarking is important for the bleachability and the bleaching economy and thus the final paper quality and production cost.

TMP plant

After pre-steaming and chip washing the chips are going to another pre-steaming chip bin to moisten, soften and for air removal before compression in a screw. The compressed chips are fed into the bottom of an impregnation vessel to absorb water and get a more uniform moisture profile before entering the refiners. Together with the fresh water a chelating agent, EDTA, is added to remove metal ions to improve the bleaching efficiency and save chemicals later on in the process.
Chips from the impregnator are fed into the atmospheric pre-heater and are then transported with a plug screw to the pressurised refiners. Pulp together with generated steam is blown out from the refiners. After each refiner the steam is separated from the pulp in a pressurised cyclone. The separated steam is sent to the re-boiler for production of clean steam to the paper machine. The pulp is after the third refining stage diluted to 3 % and discharged to the latency chest.

Screening and rejects handling

The main line screening concept consists of slotted pressure screens in two stages. The rejects from the primary screens are diluted and pumped to the secondary screen. Accepts from both stages are taken forward to the cyclone cleaning.
The reject from the secondary screen is refined at about 30% consistency in two stages. The steam produced in the refiner is taken to the re-boiler. Fibre from the reject refiner is screened and cleaned. The accept from the screens is mixed with the main screening accepts ahead of the cyclone cleaners. The reject is further treated in another 3-stage cyclone cleaner plant to remove foreign particles, sand etc. The accepted pulp from the cleaners is via the bow screen recycled to the reject tank for further refining.

Accepted pulp from the main-line screens, reject screen and the second cleaning stage is mixed and taken to a 5 stages cyclone cleaning. In each cleaning stage about 40 % is rejected. The accepted pulp from the first cyclone stage is taken to the disc filter before the bleach plant. The accepted pulp from the second stage is taken in cascade back to the first stage.

Bleaching

Bleaching to about 75 % brightness is carried out in a two stage MC/HC bleaching process with hydrogen peroxide.
The pulp is mixed with the bleaching liquor and is then transferred to the MC bleaching tower. The pulp is discharged from the tower at medium consistency and pumped to a press. In this press extractives and COD, dissolved in the bleaching process, will be washed out. After the press, the pulp is again mixed with bleaching chemicals before the HC-bleaching tower.
After the final press, paper machine white water is used for dilution and sodium bisulphite is added to stop the bleaching reaction. The pulp is pH-adjusted with acid and then pumped to the TMP-chest of the SC-paper machine.

Paper Mill

The paper machine is designed to produce SC-paper from low freeness TMP, bleached softwood kraft pulp and filler. A simple block diagram of the paper machine process is shown in *Figure 7*.
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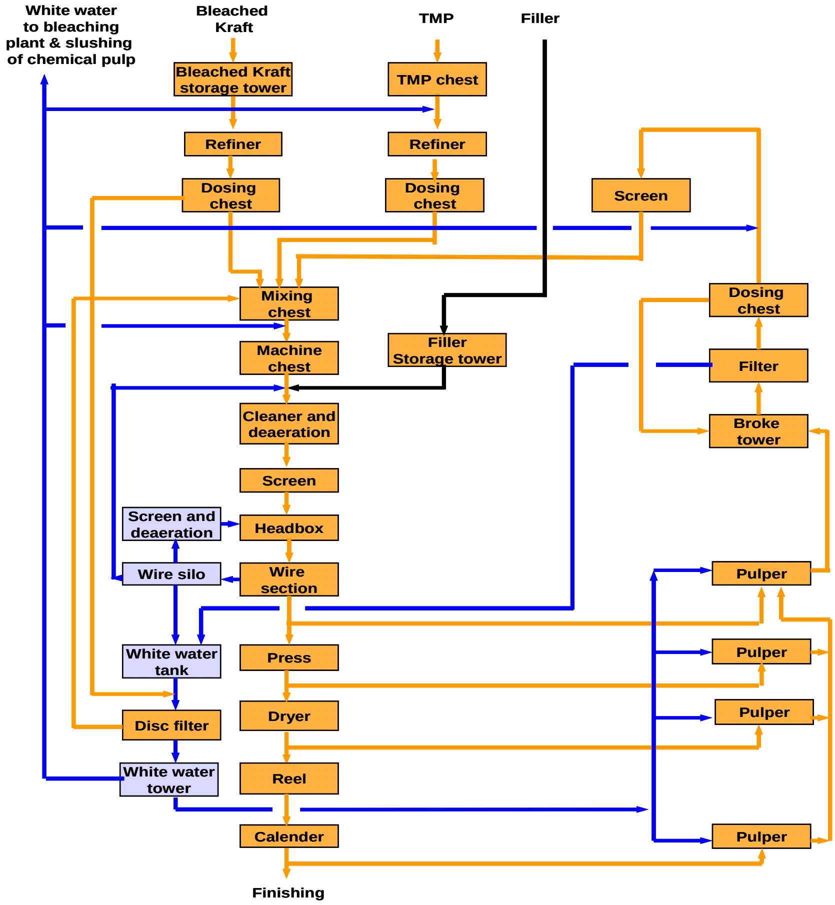


Figure 7. *Block diagram showing the paper machine process system of the magazine paper model mill.*

The paper machine itself is based on a concept to allow for a high quality SC paper production at high machine efficiency. The wire section is a modern twin wire section to give the best paper uniformity with regard to formation, basis weight profile, ash profiles and sheet structure.

The press section is designed for optimum runability of the machine by means of a closed web run from the wire section to the dryer section. The press concept is two straight shoe presses followed by a single felted conventional nip for improved paper surface properties. The final dryness after the press section is about 50 %. After the first press, a steambox increase the temperature of the web to increase dewatering.

The dryer section is a combination of drying cylinders (45-50) in an upper row and vacuum assisted rolls in a lower row integrated.

After the machine the paper is super calendered in two off-machine super calenders, re-winded, wrapped and stored before shipment to the customers.

Water management

Almost all dissolved substances in the integrated mill system is coming from the TMP process and bleaching process. To make the paper machine system as clean as possible and to achieve good bleaching conditions it is important to have a series of dewatering and dilution stages with counter current white water flow between paper

machine, bleach plant and TMP-mill. Practically, this means fresh water is added on the paper machine and contaminated excess white water is withdrawn from the TMP-mill and bleach plant.
The warm water system is the main fresh water consumer in the paper mill. Warm water is mainly used for high pressure cleaning showers in the wire- and press sections and for dilution of different chemicals.

Energy aspects of the paper machine

The main input of energy to the paper machine is steam for drying of the paper. The efficiency of the paper machine (need for re-drying of broke) and the dryness of the paper after the press section are of big importance for the steam consumption of the paper machine.

Environmental Aspects

The absence of a chemical recovery system in mechanical pulping means that all substances that are dissolved in the process during pulping and bleaching will be found in the waste water from the process. Yield (for the TMP and bleaching plant) in the range of 93 % may seem high but it means that about 65-80 kg/ADt of COD are dissolved in the wastewater. This is very high compared to chemical pulping with wash losses below 10 kg/ADt. The bleaching and the refining process contribute most to the dissolution of COD. The charge of alkaline in the bleaching is the main factor determining the COD-dissolution.

Effluent and water treatment plant

Effluent treatment comprises pre-treatment (cooling equipment and neutralisation), primary treatment and biological treatment. Water from mill should preferably be treated in a primary clarifier. In order to obtain better sludge separation in the primary clarifier bentonite and polymer will be dosed. Primary sludge will be sold for fibre reuse in fluting mill or similar.

For biological treatment a biofilm reactor with suspended carriers followed by an activated sludge system will be used. The activated sludge system comprises aeration basin and secondary clarifier.
Biological sludge will be dewatered in a centrifuge and sold as soil conditioner.

2.3.5 Integrated newsprint -Integrated newsprint model mill

The integrated newsprint model mill uses recovered paper as input and in some cases (Nordic countries) also TMP (Thermo Mechanical Pulp). The production of TMP is considered the same as described above for the magazine paper mill and will therefore not be considered here.

Stock preparation

The raw material input consists mainly of a mix of recovered newsprint and magazines. The recovered paper is fed with a conveyor into one or two drum pulpers. Drum pulpers are large, long (horizontal) rotating tubes where water and some (de-inking) chemicals are added to the fibres to separate them and make them swell. After that, a series of cleaning steps follows to get rid of the contamination (that is always part of the raw materials) and to de-ink the fibres. Cleaning and de-inking stages always take place in newsprint mills but the order of operation may vary from mill to mill. See for an example of a de-inking plant concept with flotation de-inking figure 8. In several screening steps the fibres and water are first separated from large contaminants like large plastics, and then in cyclone screening steps from smaller contaminants like staples, glass and small plastics. Next, the fibres are de-inked, which occurs during a process that is called ‘flotation’. During flotation, bubbles are formed by compressed air, which during flotation to the surface, take with them ink particles that stick to the surface of the bells. After de-inking a further (fine) screening step occurs that removes the smallest particles (e.g. glue) that are still in the pulp. The cleaned pulp is now thickened by water removal in disc filters. The removed water is recycled. Thickening of the pulp is followed by a dispersion step, where the pulp is thoroughly mixed to disperse any remaining contaminants. After dispersion, a second dilution, flotation and thickening step can follow, before the pulp (DIP) is ready for paper making. Some bleaching steps are needed to deal with the wood containing paper that can be part of the raw material input.

Paper machine

The pulp (either TMP or DIP or a mixture of these) is pumped from the storage towers and diluted to the appropriate consistency. The fibres are evenly distributed over the width of the paper machine by a head box. With the help of gravitational forces and vacuum, the first water is removed from the web in the forming section to a consistency of about 20%. In the following section, the press section, water is further removed with pressing roles leaving a consistency of about 50%. The sheets enter the drying section of the paper making process. In this section, which is covered by a hood, water is further removed from the web by means of steam heated cylinders and hot air under the hood. Upon leaving the drying section, water content in the paper is only about 9%. The final treatment of the paper is surface treatment by soft calendars that function in a way similar to ironing.

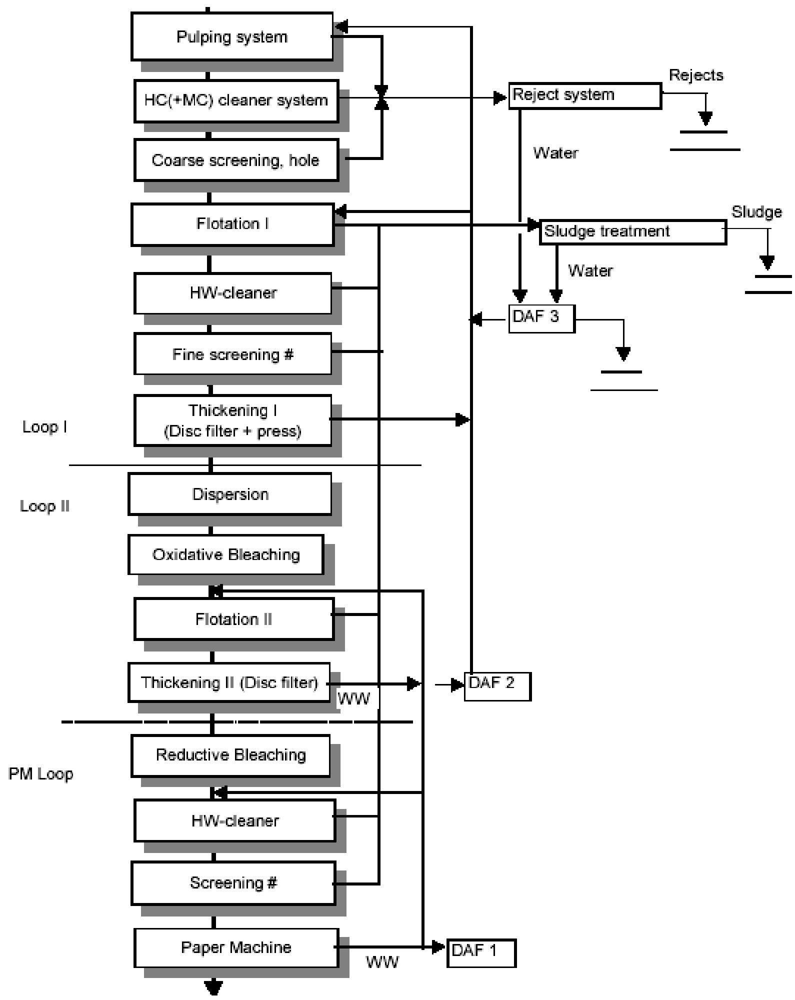


Figure 8. Example for an overall plant concept for (improved) newsprint
There are also other approaches to newsprint line process configurations
LC = Low Consistency; MC = Middle Consistency; HC = High Consistency; HW = Heavy Weight; DAF = Dissolved Air Flotation; Oxidative bleaching (peroxide): for brightening the fibre stock and reduction of fibre mottling effect; Reductive bleaching (Hydrosulfite, FAS): for colour stripping
SOURCE: IPPC- Reference document on Best Available Techniques in the Pulp and Paper industry (2001)

Water management

For the production of graphic papers from recovered paper, a systematic separation of the individual water loops based on the counter current principle is essential. De-inking lines can consist of various configurations and there can be two, three or in some cases four loops. In order to control the loads of unwanted substances in the process water and to maintain the fines and ashes at a controllable level in the process water loops, some internal cleaning of the water circuits is carried out by dissolved air flotation (DAF).

Energy aspects

The production of (TMP) is the most electricity demanding part of the production process, whereas steam demand is highest in the drying section. Since the integrated newsprint mill uses either recovered paper or TMP, there is no energy production from black liquor or bark.

Reject and sludges

Rejects (various types) and sludges are generated during different cleaning steps, due to contamination of the feedstock (recovered paper). Sometimes rejects can be used for new purposes (i.e. as a fuel or as a raw material for other products) in that case it should be considered a by-product and not a waste.

3 The Solid Wood value chain

In Figure 9 a general process description of the solid wood chain is given.

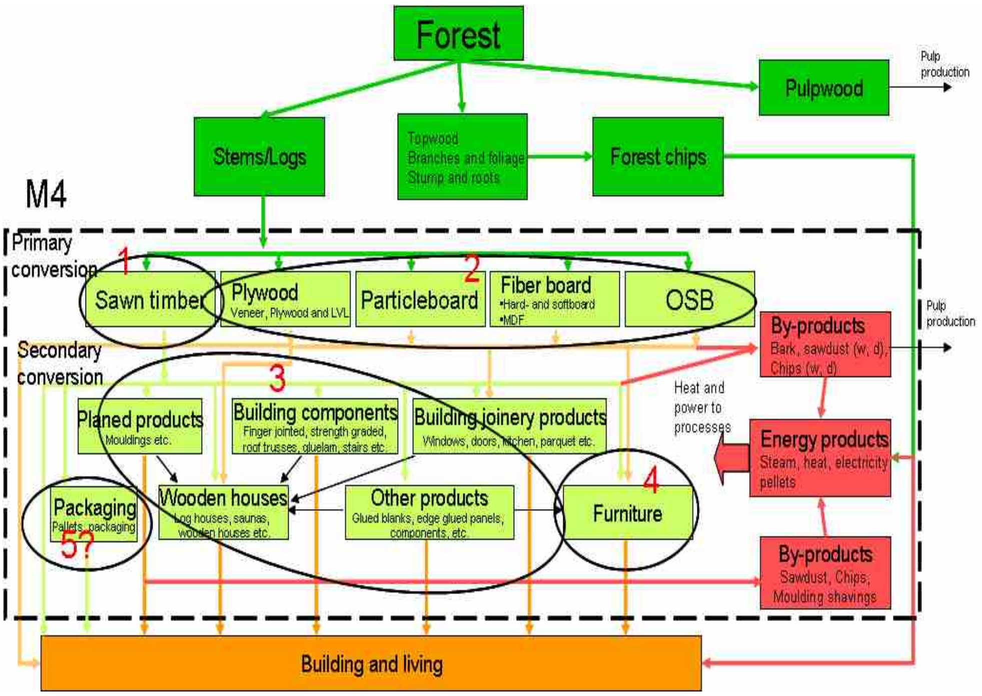


Figure 9. *Principal description of solid wood chain in M4.*

The values in “operating data” tables have to be defined by countries or by regions. In the wood processing industry many products in plethora of types and sizes are involved in the forestry wood chain. Therefore, to account for median/average representative values some products were set as default to demonstrate transitional nature of input, output and by-product resources. To report on typical processes in production the following model mills were selected. These will be used selectively on country-by-country basis to uphold a close to reality scenarios. In other word, the most relevant mills will be used for each case study, scenario, and so on.

A - Primary conversion: 2 model mills
- model mill 1: sawn timber mill - product: sawn timber
- model mill 2: panel board mill - product: panel board

B - Secondary conversion: 4 model mills
- model mill type 3: windows and doors
- model mill type 4: roof truss
- model mill type 5: internal wall, external wall and floorings
- model mill type 6: furniture mill

BRE and VTT are together responsible for the following descriptions of the model processes.

3.1 The solid wood model mills in the 4 regions

Solid wood chain model mills are for the production of:

1. Sawn timber
    - softwood mills size classes by tonnes: a) bigger than 150 000, b) 50000-150000 and c) smaller than 50000
    - hardwood mill

2. Wood-based panels
    - Plywood, Particleboard and OSB

3. Building components
    - Strength graded timber finger jointed timber, , roof trusses, flooring, saunas, edge glued panels, components

4. Joinery
    - Doors and windows

5. Furniture
    - Wood based indoor furniture (e.g. panel furniture in kitchens)

The following section outlines countries and regions that will be studied.

Group 1 = Central and Southern Europe
AUSTRIA
BELGIUM
DENMARK
FRANCE
GERMANY
IRELAND
NETHERLANDS
SWITZERLAND
UNITED KINGDOM
SPAIN
ITALY
PORTUGAL

Mills to be selected according to primary or secondary conversion from the following list

A - Primary conversion: 2 model mills
- model mill 1: sawn timber mill - product: sawn timber
- model mill 2: panel board mill - product: panel board

B - Secondary conversion: 4 model mills
- model mill type 3: windows and doors
- model mill type 4: roof truss
- model mill type 5: internal wall, external wall and floorings
- model mill type 6: furniture mill

Group 2 = East Europe
CZECH REPUBLIC
HUNGARY
POLAND
ROMANIA
BULGARIA
SLOVAK REPUBLIC
LATVIA
LITHUANIA
ESTONIA

Mills to be selected according to primary or secondary conversion from the following list

A - Primary conversion: 2 model mills
- model mill 1: sawn timber mill - product: sawn timber
- model mill 2: panel board mill - product: panel board

B - Secondary conversion: 4 model mills
- model mill type 3: windows and doors
- model mill type 4: roof truss
- model mill type 5: internal wall, external wall and floorings
- model mill type 6: furniture mill

Group 3= Nordic Countries:
FINLAND
NORWAY
SWEDEN

Mills (median capacity) and furnish used

Sawn timber

sawmill capacity 300 000 m^3 sawn timber output
sawmill capacity 150 000 m^3 sawn timber output
sawmill capacity 25 000 m^3 sawn timber output

Panelpoducts (plywood and particle board)

plywood mill capacity 100 000 m^3 plywood output
particleboard mill capacity 120 000 m^3 particle board output

Prefabricated buildings

solid wood panels 120 000 m^3 panels output
gluelam 75 000 m^3 gluelam output
windows 100 000 units output
wooden houses 15 000 units output

Furniture

Kitchen furniture 350 000 units output

Comment [PC1]: This text does not represent the above introduction – it is a bit strange and confusing However, I assume this is representative of VTT so will leave it just flagging it as a discrepancy as the division here is different to Dataclient & the selection for data collection THIS IS IN OUTPUTS AND THE ABOVE IS IN capacity!

3.2 General Process Description of the Model Mills in the Solid wood chain

3.2.1 Saw milling

Timber Production Processes - Today and Future Processes

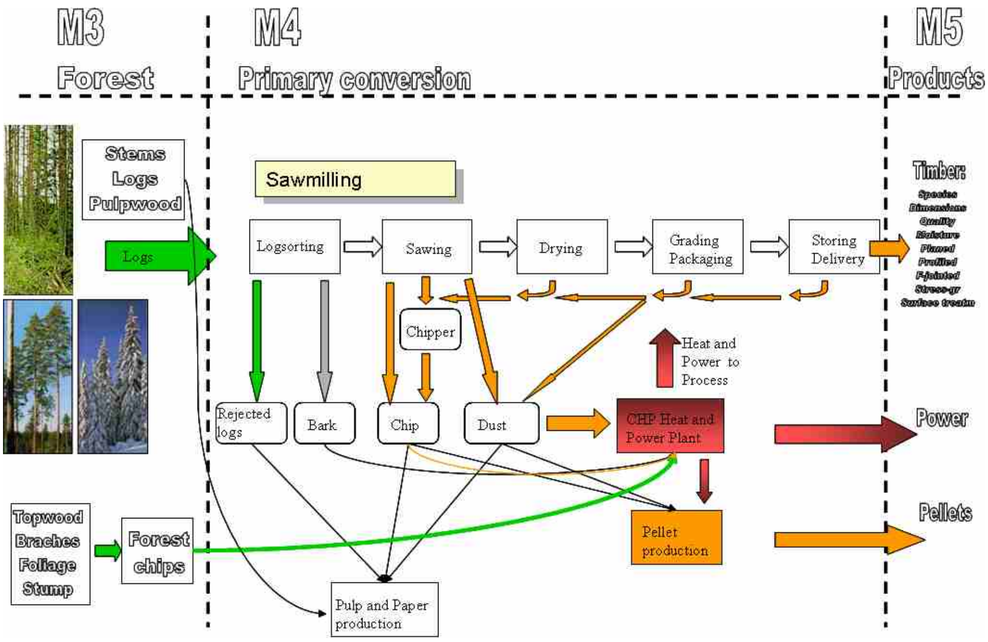


Figure 10. *Phases in the saw mill converting stems to sawn timber.*

Harvesting

Wood species to be exploited are Pine and Spruce. Harvesting operation produces wood raw material in form of stems and logs. The option is that the stems are transported to the mill because this offers excellent possibilities for optimisation of raw material allocation. In the later phases in the processes there are not possible to correct the failures mad in cross cutting of stems. If the stems are longer than 18 m, the tops of the stems are cut into the logs in the forest.

Cross cutting of stems

Stems are transported from the forest to the mill. Shape and x-ray scanning of stems provides data of geometry and internal properties i.e. knots of stems and logs. Scanning result of individual stems is transferred into optimisation software systems calculating most profitable crosscutting procedure based on order file and demand profile of the desired products.

Sorting of logs

Sorting station is estimated to consist of 40 – 100 bins. Number of bins is enough for avoiding resorting of logs. Tight log classification supported by internal log characterization allows almost "individual sawing approach". Allocation of sorting bins is depending on the product demand.

Following categories are considered.

1. saw logs to be sawn normally with fixed sawing set-up without any major set up changes between logs
2. length sorted saw logs – specific length requirements
3. saw logs which are sawn individually cut by cut with specific sawing system into high value added products

Sorting of logs is based on products or sawing set-ups. Quality of the logs – internal characterization-is the main criteria in the sorting operation. Sorting optimization software calculates best possible sawing. A sorting bin consists of log to be processed with the same set up which means higher capacity in the sawing line.
The optimal positioning i.e. rotation orientation of the log is marked with line on the top end of the actual log. The line is marked with ink jet writer. The logs can also be individually marked i.e. using RFID technology. The marking provides an address in the data base in the information system controlling overall sawing process from the cross cutting terminal to the final end products. Behind the address stem / log properties, sawing set-up options and corresponding output is estimated. Sorted log batches are stored on the log yard.

Sawing operation

The sawing system may consist of one or two sawing lines operating in three shifts, five days a week.

For sawing of big logs and high quality logs a special sawing system is used. System is based on single cut approach. Just before sawing operation the log is scanned producing accurate shape and quality information. Optimisation software system creates the log model. Based on the log model and product demand, optimisation software calculates the position of next cut and orientation of top and butt ends of the log yielding maximum value yield. After the execution of the cut the surface characteristics of opened face are recorded. Based on this information new log model and next optimised cut is determined. Repeating this procedure the sawing of log is value optimised. Some parts of the log i.e. thick flitches or cants can be transported to multiple re-saw and or cross cut saw in order to make value added components.
Sawing system should support control system based on identification of pieces based on marking technology.

Handling of wet sawn timber pieces

After sawing operations sawn timber pieces are transversal transported. Just after sawing there is scanning system for detecting quality features of all four sides of the piece. Extra information i.e. annual ring orientation can be received through scanning

of ends of timber pieces. Based on scanning information the individual timber members are addressed to the tray sorting layer or sorting bin. Use of sorting system is optimised through software. Tray sorter provides carefully handling of pieces and possibility to optimise the material flow.
Dimensions, lengths and especially quality and properties of sawn timber members determine the drying program. Scanning results information for "collecting" right pieces into right bins and further to drying.

Drying of sawn timber

The design values for kiln drying are 10 – 12 % and to 16 – 18 %. For these purposes can be used progressive kilns and batch kilns. The most significant areas which has to be taken into account when choosing kiln are to achieve the target moisture content (MC) and minimise or limit MC gradients and to minimise or prevent distortion of pieces during drying and in service conditions.
The deformation which occurs in sawn timber during and after the drying process is the most important reason for down grading timber during primary processing. The deformations that occur during and after drying are related to the characteristics of the raw material (e.g. grain angle, density, juvenile wood content, compression wood, knots), kilning schedules and technologies, and post kilning conditioning treatments. Many properties to avoid this can be measured from logs and green timber.

The final moisture content of a piece of dried timber and its uniformity throughout the section is regulated by the drying process. The moisture content of the timber can influence dimensional changes that occur when in use. Excessive dimensional changes can be avoided if the timber has been dried to a moisture content similar to that which it will attain when in use.
Splits and checks which occur on timber surfaces after drying is a common result of intensive kiln drying. These can be avoided with correct drying schedules.
Drying will also affect the final colour of the timber, higher temperatures resulting in darker colouration. Drying will also affect the behaviour of knots and flow of resin in coniferous timber.

Final sorting and packaging

After drying sawn timber pieces are transported transversally. Final sorting station is provided by scanning system for detecting quality features of all four sides of the piece. Annual ring orientation can also be measured. Based on scanning and length information the individual timber members are addressed to s specific sort or channelled to the dry mill.
In the final phase on manufacturing sawn timber is packaged.

Chips are sold to pulp industry.

Reference Sawmill

A sawmilling industry can be described using 2 or 3 capacity levels. Each level has certain number of sawmills representing region's or country's Sawmilling Industry.

3.2.2 Wood-based panels

3.2.2.1 Plywood

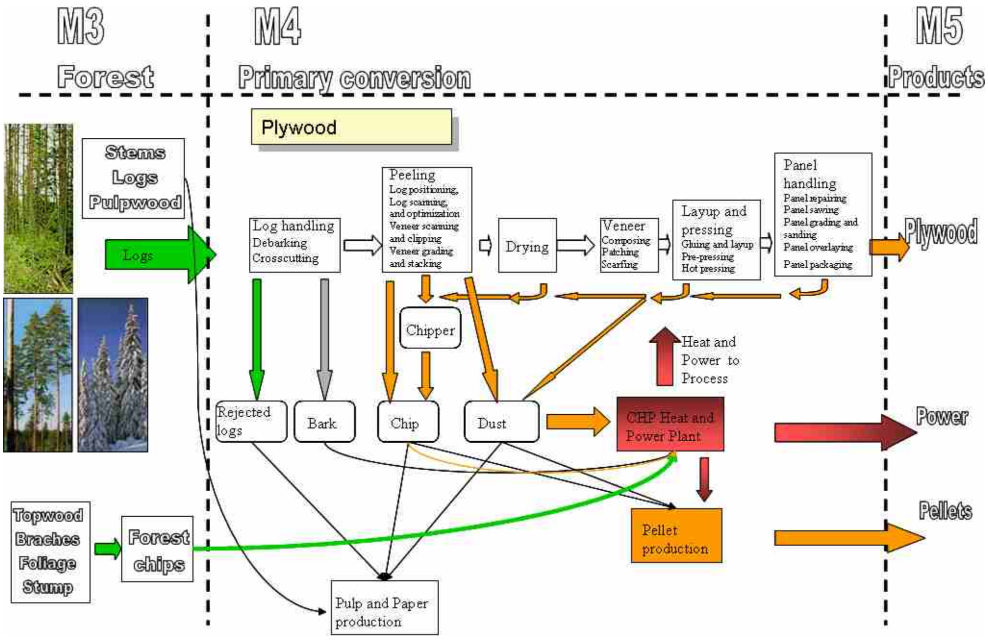


Figure 11. *Phases in the manufacturing process of plywood.*

Log handling

Logs are fed with a front loader onto the log handling line, which comprises: debarking, metal detecting, cross cutting and block sorting.
By products from this line are: bark, which will be refined and used for energy, saw dust, which will be mixed with bark, and rejected blocks, which are cut and chipped and used for fibreboard.
Debarked blocks are conditioned in chambers with hot water sprays before fed in to the mill. A front loader used to transport blocks in to and out of the conditioning chambers.

Block conditioning

Debarked blocks are conditioned in chambers with hot water sprays. Each chamber holds blocks enough for 4 to 5 hours of operation. Totally chambers hold blocks enough for two days of operation. The water is mainly heated with dryer exhaust air through a scrubber and partly with steam through a heat exchanger. Conditioning temperature is abt. 50…70 °C. Water is mechanically filtered and its
pH is controlled with NaOH.

Peeling

Peeling line with bin stacker system transforms blocks into veneer. Sheets and randoms are stacked automatically. Peeled sheets are graded automatically according to moisture level into two grades; sap wood and heart wood.
By products are round-up- and clipping waste as well as cores are chipped for fibreboard.

Veneer drying

Veneer is dryed with veneer roller dryer. The veneer grading takes place on the drying line. Sheets are fed automatically side by side in to the dryer. The dryer is steam heated. Full and half sheets are graded on the drying line under control of one supervisor. Veneers are graded according to moisture content, visual appearance and strength.
Veneer moisture content is measured with a moisture meter. Veneers with too high moisture content are stacked in one bin for redrying. Visual defect analyzer is used to grade veneers according to their visual properties. Veneers are also graded according to their structural properties.
By products are rejected green and dry veneer sheets will be chipped for fiberboard or energy. Exhaust air from dryer is led into scrubber for washing and for heat recovery.

Veneer composing

The veneer composers installed for recovering sheets with defects and composing sheets into bigger dimension. Outcome from the composers is core or cross ply veneer.
By products are dry clipping waste will be chipped for energy.

Veneer scarfing

Veneers are scarfed in the in-line scarfing saw so no separate scarfing operation is needed. This will reduce labour requirement as well as veneer inventory in the mill.
Veneer sawing takes place in the scarfing saw, which is equipped with pneumatically movable trimming and scarfing saw units.
By products are scarfing waste for energy and rejected sheets chipped for energy.

Lay-up and pre-pressing

A curtain coater is used for glue application. Lay-up is performed by the fully automatic dual tablet lay-up system with programmable lay-up recipes.
Edge hoggers are used for cleaning the lay-up edges after pre-pressing.
By products are edge hogging waste for energy, rejected sheets chipped for energy, washing water remixed into glue and glue waste sent to glue supplier for waste handling.

Hot pressing

Normally is used the hot press, which is capable producing plywood in customer lengths. Nominal capacity is chosen according the customer (340 days/year). Heating of the press is with hot oil. After hot pressing the billets are examined with a blow detector and transferred to the billet handling line.

Billet handling

The billet handling line is connected directly to the hot pressing line. Billet handling includes: sanding of billets when required, cross cutting and rip sawing, grading and stacking and packaging including strapping and wrapping.
By products are saw dust for energy, rejected billets chipped for energy, edge trimmings chipped for energy.

3.2.2.2 Particleboard and OSB

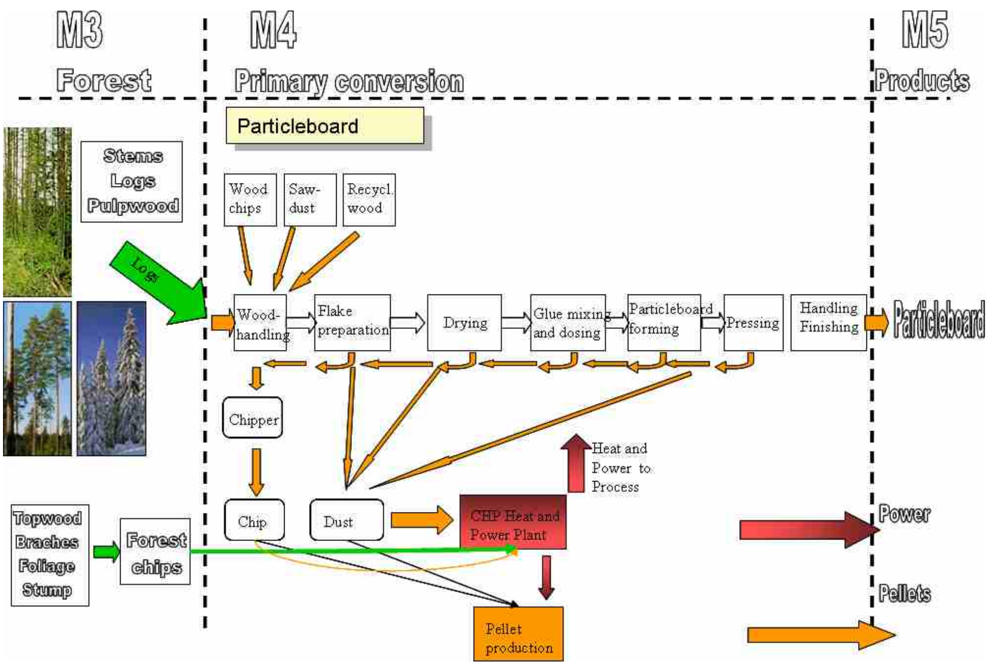


Figure 12. *Phases in the production of particleboard.*

Woodhandling

The use of roundwood is declining in favor of woodchips, sawdust and recycled wood. In many instances, the particleboard plant must deal with all kinds of raw materials at the same time and often in mixed forms.
Processing roundwood include debarking system and chipping of debarked logs.

Flake preparation

High-quality particleboard can be manufactured from a variety of raw materials: recycled wood (urban wood waste), clean chips, saw dust or mixtures. The raw material screening and cleaning are key processes in regard to end-product quality and efficient use of raw material.
The screening process makes it possible to eliminate a significant amount of dust and contaminated fine fractions from the raw material to help improve board surface quality and color. Cleaning system removes impurities with high efficiency by classifying the raw material into suitable size classes for optimum separation.

Drying

Flake drying is done in pre-dryer, single-pass dryer and three-pass dryer.
The single-pass dryer is a long-retention dryer incorporating pneumatic-mechanical conveying of the flakes. The three-pass dryer provides for pre-drying in the interior pass, whereas the final drying is accomplished in the second and third passes using a longer retention time. The flakes are dried by hot gases and with direct contact to the internal dryer elements.

Glue mixing and dosing

In-line gluing system is suitable for large-capacity particleboard lines and smaller lines operating with wide product range. The batch gluing system is suitable for small- and medium-capacity particleboard plants operating with long production series.
The flake dosing bin series includes single- and double-belt models for different capacity needs. The bins are equipped with dust suction nozzles and belts with scrapers to keep the dosing bin clean.
Glue blenders must provide uniform glue distribution due to large chamber volume and long retention time. A constant filling level is maintained by a discharge gate, guaranteeing an optimum gluing result. The blenders are designed with a self-cleaning geometry. The inside wall is made of wear-proof steel to ensure a long lifetime.

Particleboard forming

Accurate and stable mat forming make it possible to produce high-quality panels at low densities, without compromising the uniform surface quality, physical properties or thickness tolerance.
The larger flakes can be placed on the outer core, which improves cross-directional and bending strength. The controlled flake classification enables quick and easy adjustment for different grades of panels, e.g. for furniture, flooring or building materials - a feature that helps to meet a wide range of customer needs.
The elimination of oversized particles is carried out with the roller bed and reject belt conveyor. This prevents damage to press platens and steel belts caused by large and heavy particles, such as dust balls or glue.

Pressing

Continuous press provides equally high performance in continuous pressing for particleboard production. It increases capacity by 10-20%, minimizes thickness tolerances of produced boards, increases board quality, minimizes maintenance, and keeps building costs to a minimum.
Efficient heat transfer is ensured by a large area of contact between the steel belt and the heating platen. The temperature difference between the heating platen and the belt surface is very small. The press can be run with lower heating oil temperatures, which results either in energy savings or capacity increase.
In multi-opening presses the construction with fatigue-safe columns, solid steel plate yokes and a unique cylinder design guarantees the longest press life.
The single-opening press is designed to improve profitability of low-capacity production lines.

Handling & finishing

Panel handling is one of the key processes in board production. Panel handling equipment features press outfeed lines, sanding lines, cut-to-size saw lines and packaging lines

Energy supply in panelboard production

Panelboard production is energy intensive. Reducing energy consumption can mean substantial savings in operating costs. Energy plant utilizes waste from panel production to produce most of the energy required to run the plant. The plant can be fueled by anything from bark and start-up fiber to sander dust and rejected panels. Plant can also use low-grade fuel from outside the plant such as sawmill chips and recycled wood materials unsuitable for production.
Moisture control in the dryer is perhaps the single most important control loop in the entire panelboard process.

The energy plant can also supply heat to other process stages without compromising f.ex dryer control. Thermal oil for continuous press, steam for refiner system and heat for almost any other stage can be supplied. The dryer control is maintained by heating the thermal oil in a separate flow from the main flue gas flow to the dryer.

3.2.2.3 The manufacture of MDF

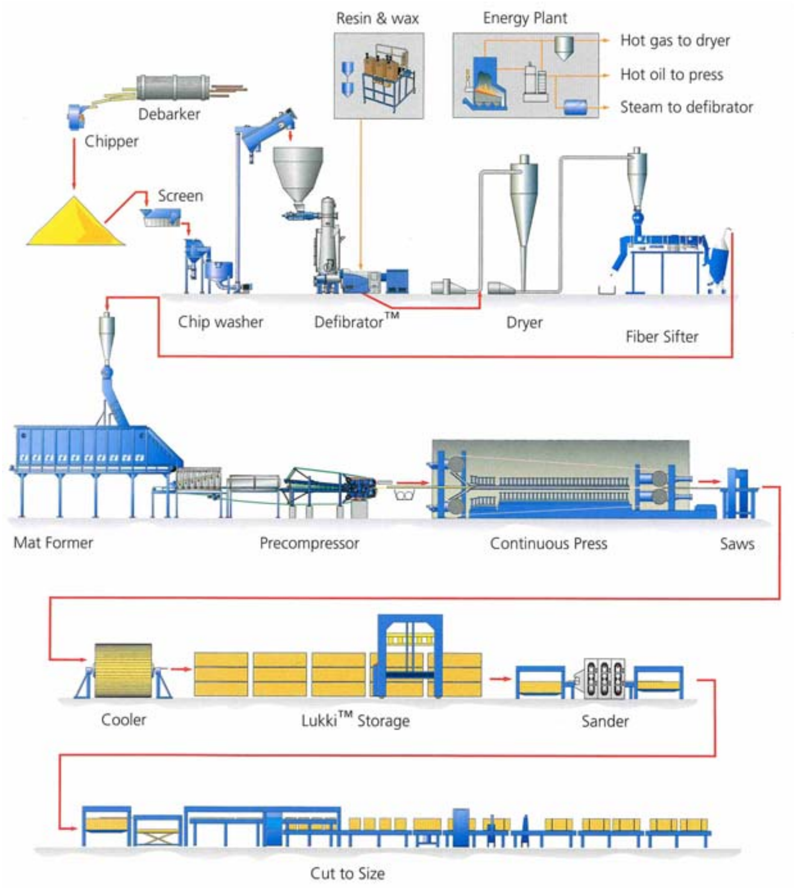


Figure 13. *MDF production process (Metso).*

Raw materials

Softwoods and hardwoods in mixed proportions as determined by local timber availability, in the form of roundwood, slabwood, forest thinnings and sawmill and factory residues can be used for the manufacture of MDF. Slabwood and roundwood are converted into chips with a typical dimensions of 20 mm in a chipping machine. Alternatively, supplies of chips cut from timber residues are obtained directly from sawmills.

The wood chips are screened to remove undersize material, typically less than 5 mm, and oversize material, typically in excess of 40 mm. Chips within the acceptable size range are then treated when necessary to remove adhering dirt and particularly grit which can have a detrimental effect on the life of cutting tools used process the manufactured boards.

Fibre preparation

The chips are steamed for several minutes under pressure at a temperature of about 160 oC and then forced into a narrow gap between the rotating discs of a refiner. Individual fibres or fibre bundles, mechanically abraded from the surfaces of the steam softened chips, pass from the refiner to the dryer. Here, the wet fibres including some residual steam are combined with a hot flue cases from a gas burner and the mixture passes at high velocity along a flash drying tube. At the end of the tube, the dried fibres are separated from the steam and hot gases in a cyclone and stored in a bin which supplies the board forming machine.

Resin binder addition

The fibres in boards for normal interior use are bonded with urea formaldehyde (UF) resin. Mixed urea / melamine, or other resins can be used as binders where improved properties such as increased resistance to moisture are required for boards for use in damp conditions or outside. Additives can be introduced at the same time as a resin binder to impart special properties, flame retardancy for instance.

Two methods of resin addition are in common use. With the more frequently used blowline addition process, the resin binder is mixed with the wet fibres as they enter the drying tube. Alternatively, the resin can be mixed with the dry fibres in a blender just before the mat is formed.

Forming

The dried fibres within a well defined size range are deposited on a moving screen passing through a forming machine. A vacuum unit below unit below the screen removes some of the air from the mat as it forms and assists the felting of the fibres. By contrast with particle board forming, the lightness of wood fibres in relation to their large surface area prevents close packing of the mat particularly when manufacturing thicker boards. Under these conditions, improved forming of thicker boards can be achieved by laying thinner mats on the carrier screen and stacking two or three mats together to make up the required thickness prior to pressing. This procedure does not have any detrimental effect on the performance of the pressed boards.

Pressing

Pressing equipment and conditions vary considerably from mill to mill but generally boards are pressed in two stages. The fibre mat is first consolidated by pressing between continuous steel bands wrapped round heavy duty steel rollers positioned to from a nip of decreasing thickness. The mat with its thickness considerably reduced, is the convoyed to the main press, a continuous steel band press or a drum press as used in the Mende process for manufacturing thin particleboards.

Finishing operations

The boards emerging from the press at high temperature, up to 180 ^{o}C, are allowed to cool with both surfaces exposed to the air in a carousel cooling unit. The surfaces of cooled boards are then sanded with 60 to 80 grit belts to remove any weakly bonded fibres caused by resin precure on the surfaces in contact with the press plates and to bring the board to the specified thickness. These calibrated boards are then finish sanded with 100, 120 or sometimes finer grit belts to provide a smooth surface for the more demanding surfacing applications such as direct painting or thin foil laminating.

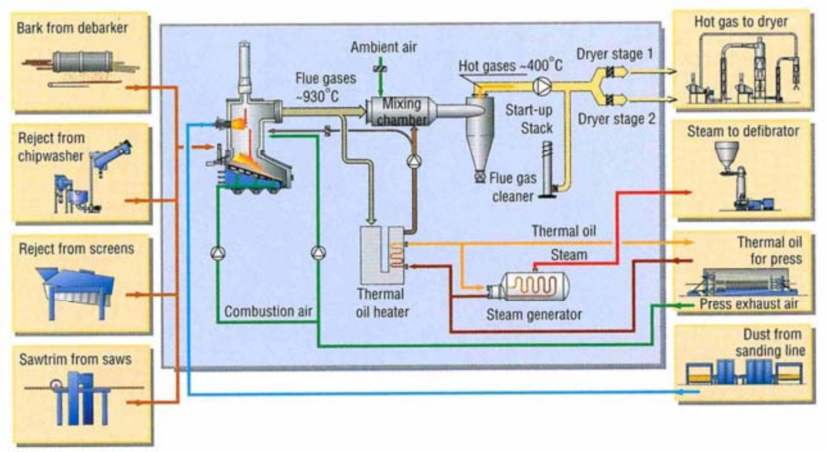


Figure 14. *Heat production from side products (Metso).*

Building components

In the following description of mills producing building components: 1) Mouldings, 2) finger jointed, 3) strength graded, 4) roof trusses, 5) gluelam, 6) edge glued panels, 7) glued blanks, 8) components, 9) stairs, 10) windows, 11) doors, 12) kitchen, 13) parquet, 14) log houses, saunas, wooden houses . These will not be all included in the project but were given consideration when selection of representative processes was made. It is an informative section with basic descriptions that outline the nature of each forestry-wood-chain manufacturing process.

3.2.2.4 Moulding

Description of moulding process.

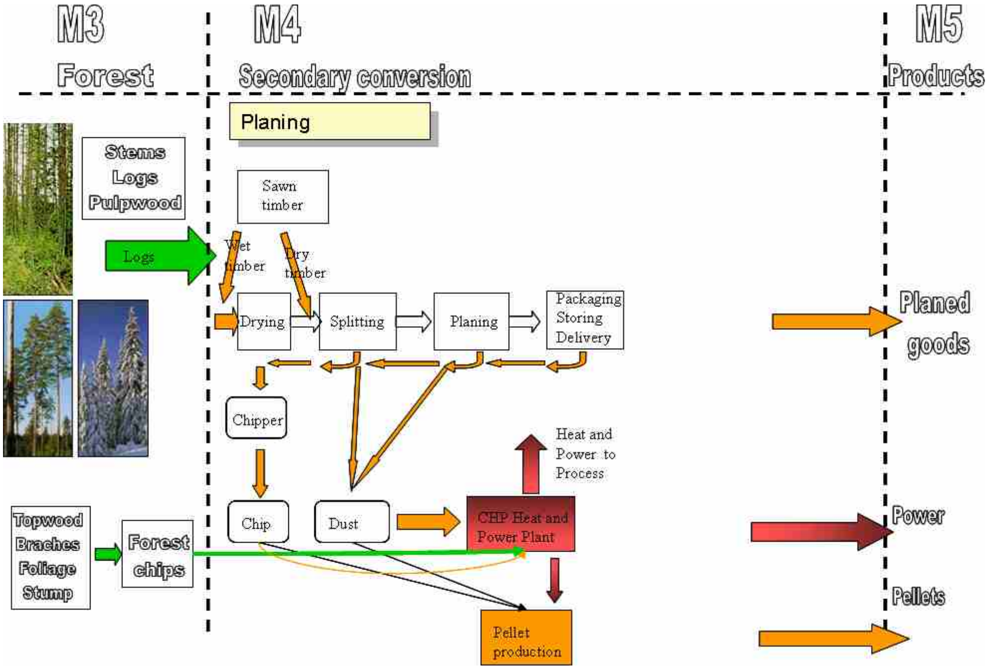


Figure 15. *Production of planed goods.*

3.2.2.5 Finger jointing

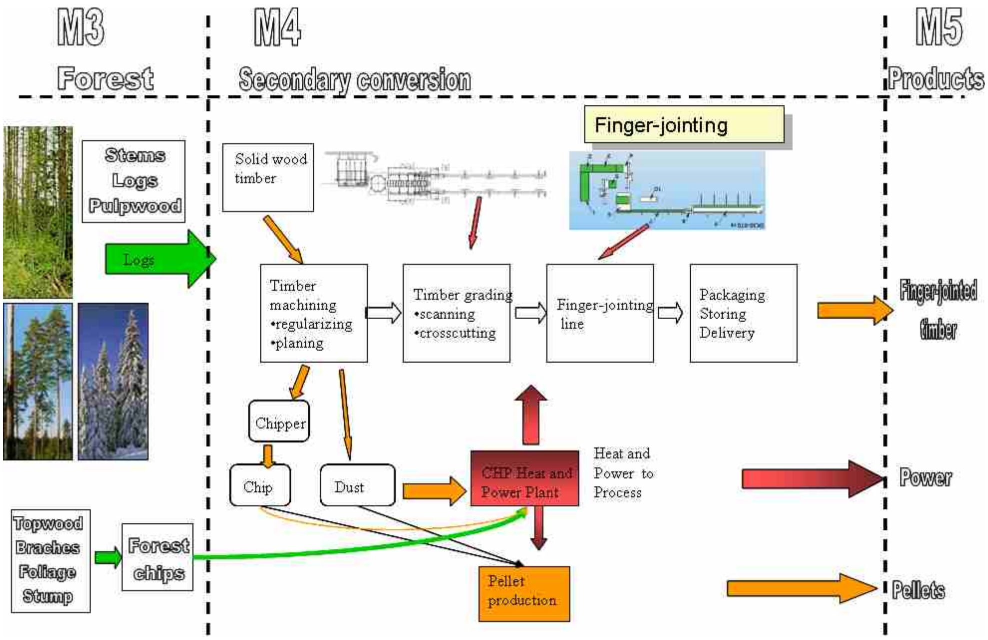


Figure16. *Production process of finger-jointed timber.*

Finger-jointing lines transform residual wood into valuable high-end products. Horizontal and vertical finger joints can be used. Finger-jointing lines can be divided to longwood lines or shortwood lines. According the feeding system finger-jointing lines can be divided also a) longitudinal feed, b) traverse feed and c) batch feed

The capacity of finger-jointing line is depending of dimension of finger-jointed timber and average timber length to be jointed. The capacity is growing when the average timber length to be jointed is growing. But after the certain average length the capacity is depending the capacity of the press

Longwood lines

Longwood lines are normally used for the production of glue-laminated timber, solid structural timber, duo- and trio-beams. The individual milling cutters are designed for the relevant customers' requirements by individual capacities. For example, more than 10 connections/min with vertical or horizontal finger jointing can be achieved with more sophisticated construction. High performance finger jointing lines with front side or extrusion presses are technically ripened and tested and proved.

The double milling cutter for a package width of up to 600 mm, a package height (lamella width) of up to 300 mm and a package length of 800 – 6000 mm. Loading and pressing systems (extrusion presses) 6 m and/or 12 m up to approx. 80 m/min.

The single milling cutter is designed for a package width of 600 mm, a package height (lamella width) of 225 mm and a package length of 200 – 3000 mm. Milling and gluing of the second side are effected after a swiveling motion of 180° of an onboard turntable. Any type of glue can be used. The press process is carried out as an endless length with an extrusion press or as fixed length with various front side presses (6 / 7.2 / 9.3 / 12 / 15 m). The average capacity is about 1.5 packages / min.

Shortwood lines

In accordance with your requirements the machines can be upgraded on the basis of a flexible modular system. The specific use of modules does not only allow standards but also customer-specific solutions – for finger-jointing lines with wood entry lengths smaller than 1000 mm but also customer specific solutions with wood entry lengths larger than 1000 mm.

The horizontal single-board milling cutters are the. Up to 180 parts per minute in continuous run and 12 press cycles. Heavy-duty components such as automatic feed and front side control can be additionally integrated.

Pieces of wood not complying with the quality criteria are without glue application extracted from the further process. Tool systems with diameters of 225 to 270 mm HS or HW equipment can be run.

3.2.2.6 Roof truss production

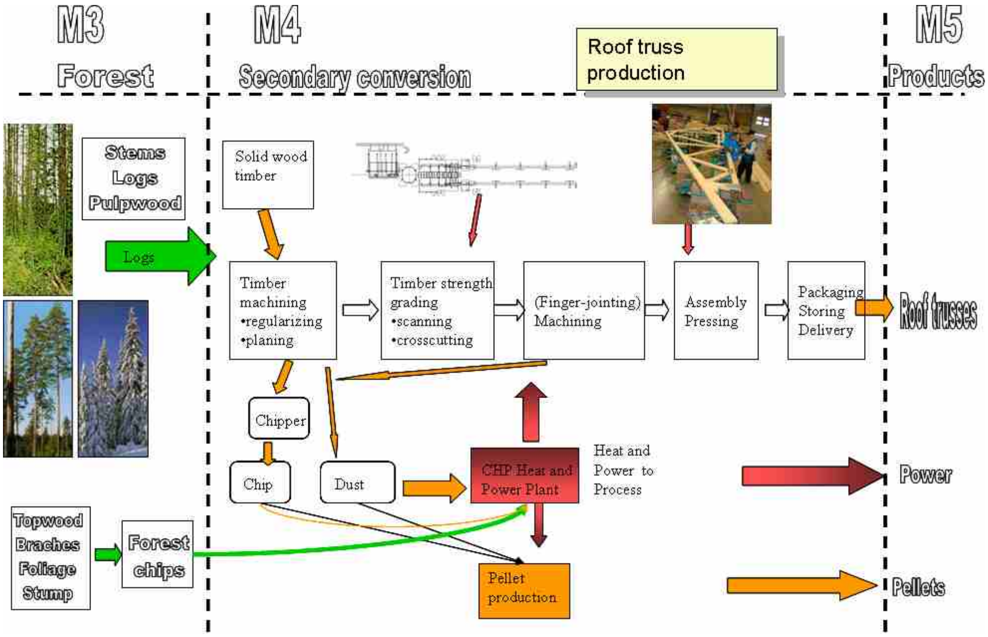


Figure 17. *Principle of production of roof trusses.*

3.2.2.7 Gluelam production

Glulam manufacture is carried out in much the same way regardless of manufacturer or country. **Error! Reference source not found.** shows, schematically, a sketch of the manufacture.

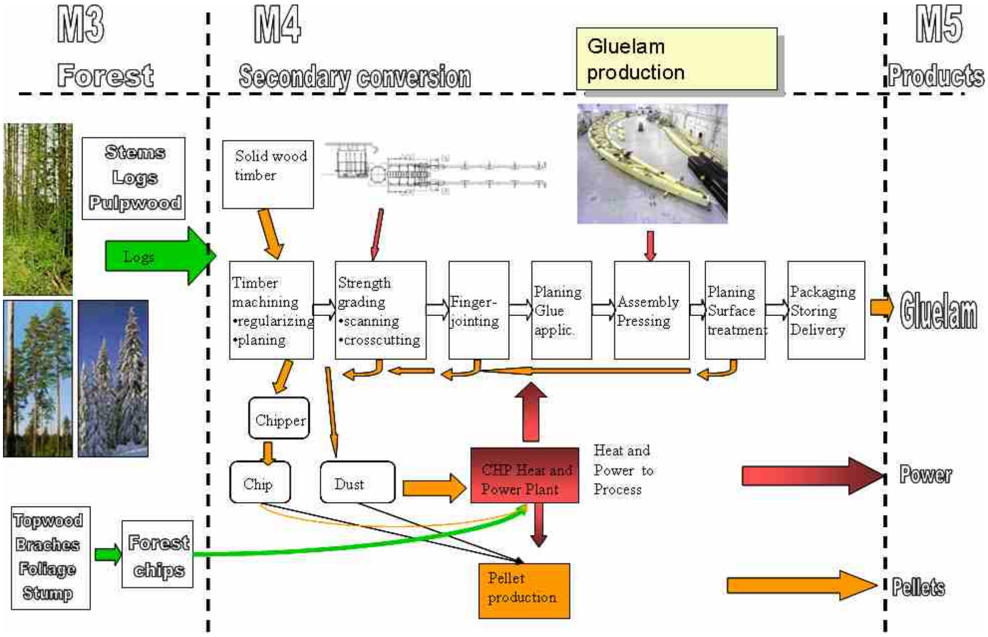


Figure 18. *Phases in the production of gluelam.*

The raw material

The raw material is strength graded timber, in the Nordic countries usually spruce, but for construction expected to be exposed in the long term to damp conditions pressure treated pine is also used. Normally dried, strength graded timber is supplied direct from the sawmill. The moisture content in the laminates shall be 8—15% when they are glued together. The difference in moisture content between adjacent laminates may not exceed about 5%. The strength of the glueline will then be optimal and the moisture content in the finished construction will be balanced, avoiding troublesome splitting. Some fissures will always occur in the timber, but this has generally no ill effects on the load bearing capacity of the construction.

Strength grading

The cross-section of the gluelam can be built up of laminates with approximately the same strength, " homogeneous gluelam". To utilise the strength of the timber to best advantage, however, it is customary to use timber of higher quality in the outer laminates of the cross-section, where stresses normally are highest, " combined glulam". In the factory it is therefore necessary to have space to store at least two strength classes of laminate timber at the same time.

Finger jointing

Finger jointing joins the timber into laminates. The laminates are cut to the required length and placed on top of each other. For combined gluelam, attention must be paid to the placing of the inner and outer laminates. To reduce internal stresses the laminates are turned so that the core sides face the same way throughout the cross-section. The outermost laminates are however always turned with the core side outwards.

The glue in the finger joints is allowed to harden for some hours before the flat sides of the laminates are planed and immediately glued.

Glue application and pressing

The laminate packages are then lifted over to gluing benches and the necessary pressure applied. This operation must be carried out before the glue hardens, after an hour or so, the exact time depending on glue type and room temperature. The laminates may be bent when the pressure is applied, producing cambered or curved forms. The glue then hardens in controlled moisture and temperature conditions, possibly with the application of heat. Straight beams can alternatively be produced in a continuous high frequency press.

When the glue joints have hardened, the pressure is released and the gluelam components are lifted from the benches to a **planning** machine where the sides are planed to the required degree of finish.
Then follows the **final working** of the component, e g fine sawing of, hole drilling and pre-drilling for connectors. Exceptionally, components receive a surface finish in the factory. Finally the components are checked visually and marked before being wrapped and loaded for transport to the building site or to storage of finished goods.

Gluelam manufacture demands great care, e.g. during the cutting of the finger joints, preparation and application of the glue, application of pressure, measurement of pressing time etc. To guarantee an even and high product quality, the manufacturer must have a well-documented system of quality control, with a continuous internal control which ensures that samples are regularly taken to check the strength of glue joints and durability.

The quality system

The quality system shall be approved by a special certification organization and the internal control shall be monitored by an external, independent inspection body which makes unannounced inspection visits to the factory.

In the Nordic countries, gluelam is marked with the “L-mark. In addition, each gluelam component shall be marked with:

- Manufacturer's name or other identification
- Strength class
- Glue type (I or II in accordance with EN 301)
- Production week and year or similar identification
- Manufacturing standard (EN 386)

Gluelam exported to other European countries may also need to be marked in accordance with the importing country's rules. Thus in Germany it must be marked with a “Gütezeichen”.

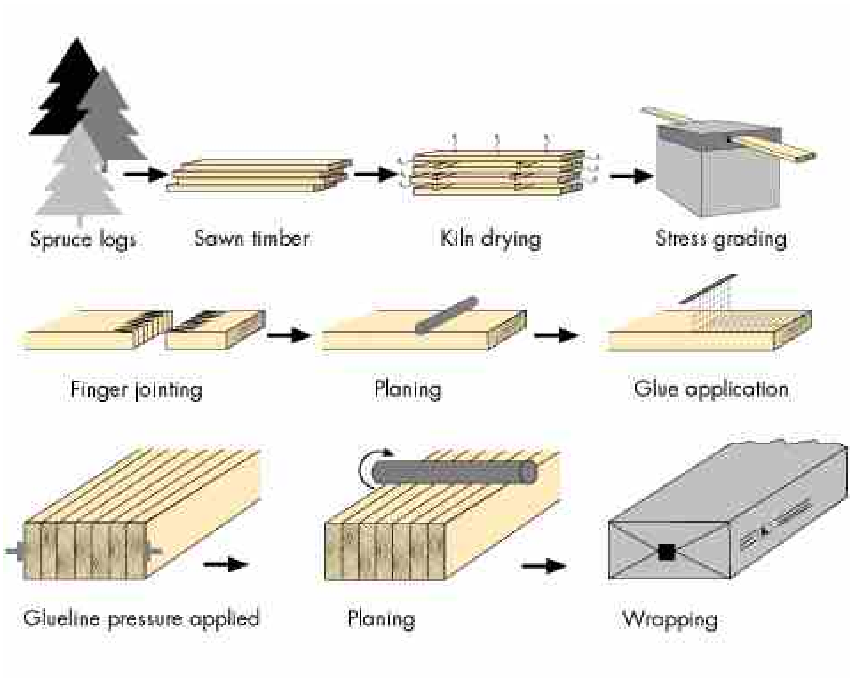


Figure 19. *Gluelam manufacturing.*

3.2.2.8 Edge Glued Panel/Board Production – Model Processes

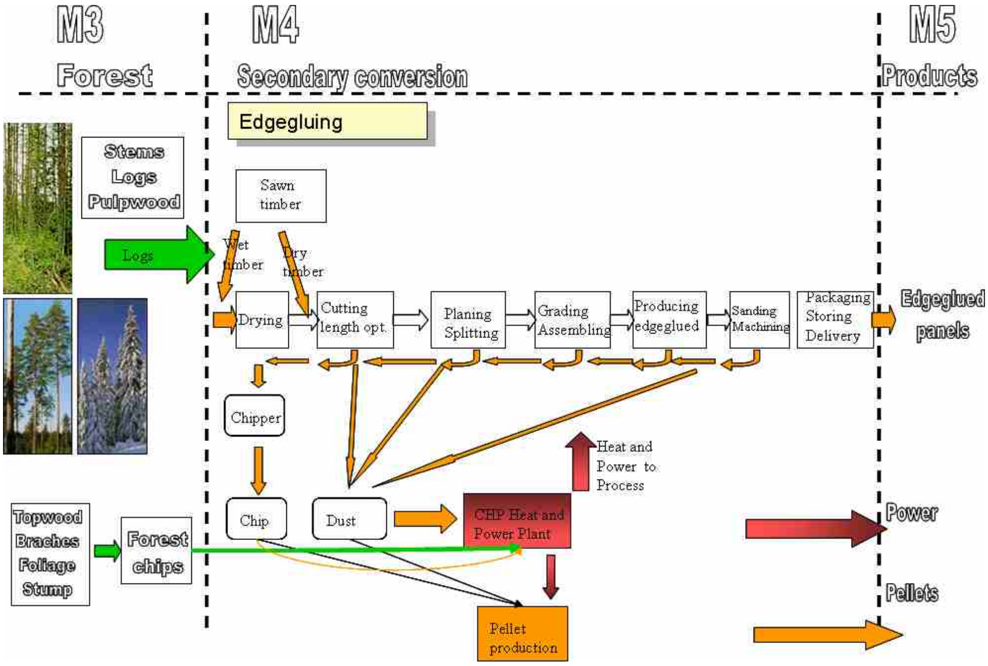


Figure 20. *General edge glued panel/boards production process steps.*

Edge glued panels/boards are an important component of many high quality furniture designs. Edged glued panels/boards may be used for exposed furniture parts (such as doors), furniture boards, table- and kitchen worktops, work bench boards, stair-treads/steps, stair-strings, handrails and risers, cheek boards, construction boards, shelf bottoms, door-casing- and door-frames, window-sills.

Drying (option)

Procedure of wood drying is given 3.1 drying of sawn timber.
The timber must be dried to moisture content appropriate for the environment of its intended end-use (8±2% for most of European countries). The timber must be equalized to insure the moisture content is uniform, and conditioned to eliminate drying stresses in the timber which may result in warped panel components when the timber is cut into parts. Also the moisture content must be maintained during wood storage and manufacturing process.

Machining of Panel/Board Components

The scanner device can be used in optimising cross cutting saw lines and in quality grading after planing machines, where wood is being graded.
Dried sawn timber is machined in planing machine. Machining is done either planing first or splitting then or vice versa. Both are done in same planing machine and same

time. Machined parts must be straight, have parallel and square edges, and surfaces of good quality, otherwise it may result in cupped panels and joint failure.

Gluing and Pressing

Glue quality and spread levels should be regularly monitored. Supervisors should observe clamp operators to assure operators are attentive and visually check glue spreads on each component. Pressure levels, cycle times (stand time and press time), and conditioning times should be monitored.

The construction of the hot pressing needed when handling urea glues and the strength of the friction press. This allows pressing both hard and soft wood types.

The press consists of two parts but it operates on continuous basis: the “hot area” of the front part activates the glue quickly and decreases the pressing time dramatically. The back area of the press is a cooling area, from which the board slabs are moved to further processing. The glue applicator allows up to 300 m/min feeding speed for the laths. Also smaller quantities can be processed; it takes less than one minute to change the linear measure of the board.
Press can be used as part of an automatic edge gluing press line.

- Variable glue interruption in through feed direction for production of panels with variable dimensions
- Multi-line processing of short work pieces
- Optimum utilization of the pressing section and increased flexibility for product dimensions
- Product-oriented joint pressure adjustment
- Processing of soft- and hardwood
- Option: Cross-cut saw, dividing and milling saws

Special cutting devices can been used in cutting framework components, splitting glued components in connection with the edge gluing press and in the front and at the back of planer for dimensioning the components.

Reference Edge Glued Panel/Board mill

A edge glued panel/board industry can be described using different capacity levels. Each level has certain amount of mills and these are forming a region's or country's Edge glued panel/board Industry.

Each capacity class has its own reference mill.

3.2.2.9 Window production

Raw material (wood)

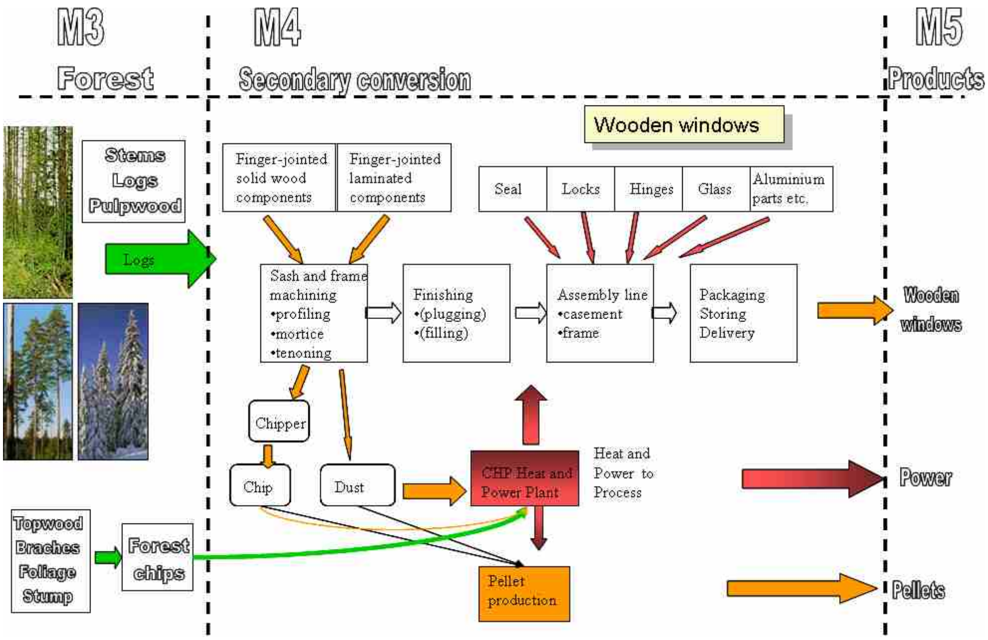


Figure 21. *Manufacturing of wooden windows.*

If the factory is using sawn timber as its raw material, it is assumed that sawn timber is refined either in process ”Production of glued blanks” or ”Component production” and after that blanks/components/half-finished products are transferred to window production.

Wooden window factories are nowadays largely assembly plants. All materials are coming as ready as possible and ready to assembly.

- Window glass
- Aluminium parts
- Locks, hinges and other supplies/assemblies
- Wood raw material: a) finger jointed solid wood blanks (6m) or b) laminated blanks (6m)

Sash and frame machining

Sash and frame material is first cross cut to custom-made lengths. After that the joints are machined to both ends and the timber parts are profiled.

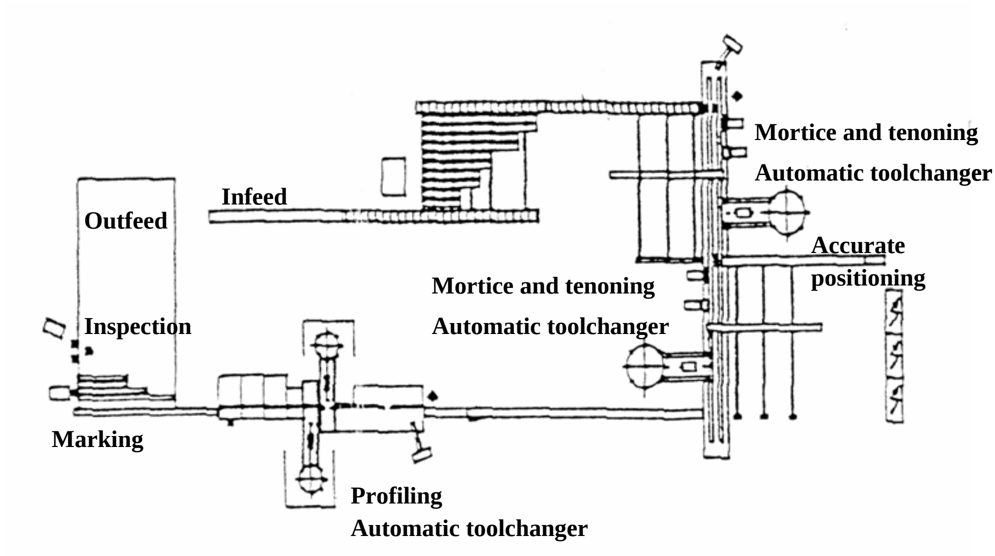


Figure 22. *Sash and frame machining (example).*

Finishing

The woodwork is finished at the factory. Finishing of wood parts is done as components.
The paints used are weatherproof, water-borne and polyurethane paints. Alternatively, the woodwork can be painted with special tints. In addition, the backside of the frame has been primed.

Assembly

All parts, like sealing, locks, hinges glass and wooden parts are assembled in sash and frame line.

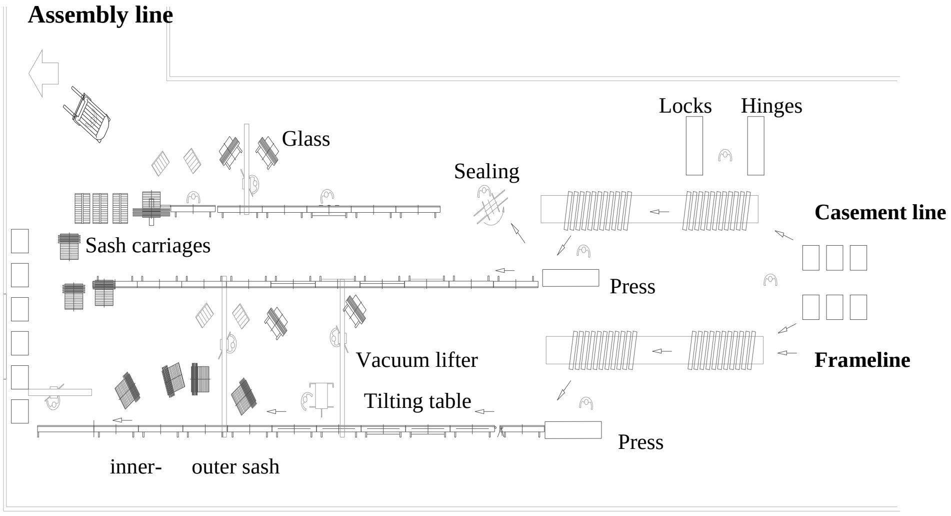


Figure 23. *Wood window assembly line (example).*

Packaging, storing and delivery

Normally the windows are packed onto packing stands into bundles that are hooded with protective plastic.

3.2.2.10 Production of wooden houses

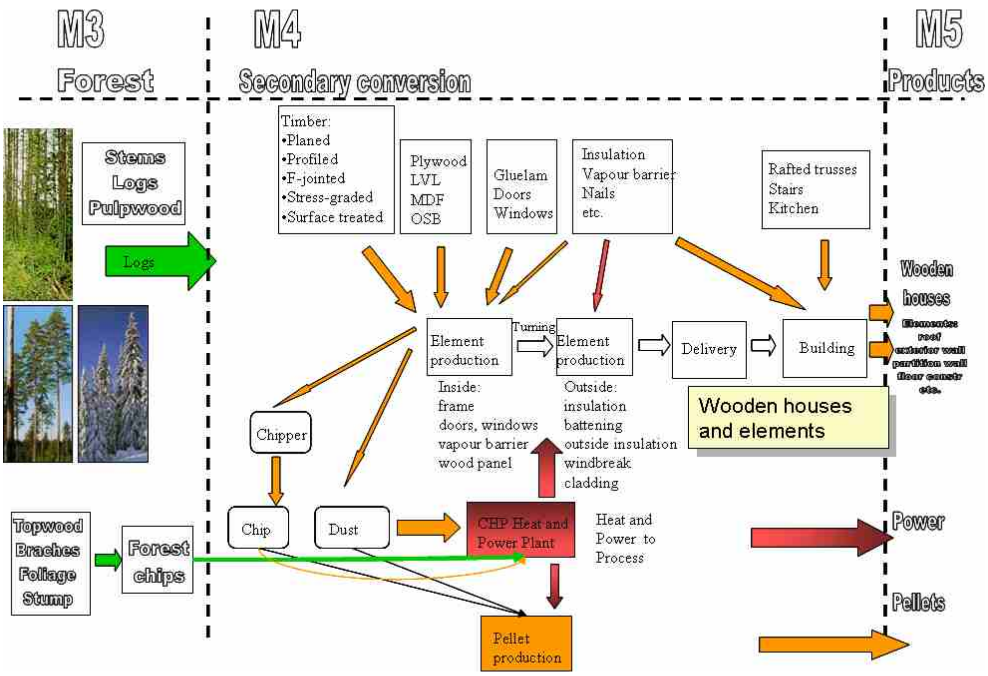


Figure 24. *Production principle of wood houses and wooden elements.*

Example of base floor element; same type of descriptions are also made for intermediate floor, external wall, internal wall (load bearing and light), roof construction.

3.2.3 Furniture

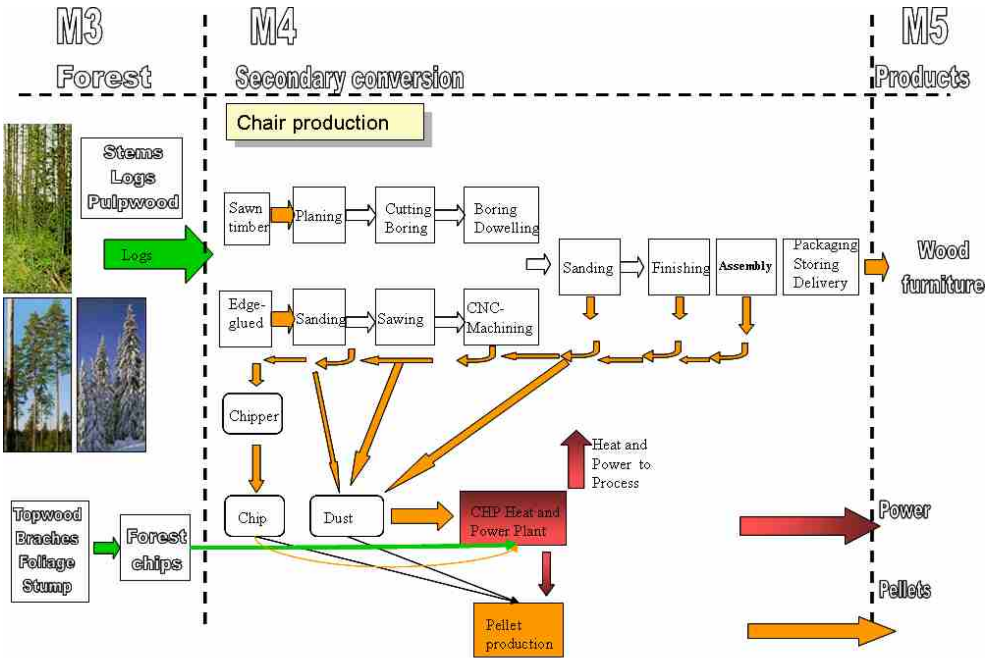


__Figure 25.__ Phases in solid wood chair production.

4 The Bioenergy Flows within M4

VTT is responsible for the description of bioenergy and pellet production model processes in this chapter.

Bioenergy is an Eforwood value chain covering over 50 % of the wood raw material utilisation. For the modelling work bioenergy is though a little bit complex as about 80 % of the utilisation today is integrated to the solid wood and pulp and paper processes. In other words – wood industry by-products like bark, wood chips and black liquor is combusted within the industry producing heat and electricity mainly for internal use, Figure 26. Typical for wood-to-energy from this group is that the amounts of wood derived fuel produced depends on the paper and solid wood production; it is a by-product! Some extra wood residue is produced within forest industry that is sold as fuel chips to the market. This can be considered as a product going from M4 to M5 but as the “production process” from waste to chip include no processing or include a simple crushing or chipping process we suggest that this will “process” will be neglected to simplify the modelling work.

Firewood production is in many areas representing the second biggest group of biomass-to-energy production and utilisation. However, this resource and its utilisation is important when studying biomass resources but in practical not so important when looking at employment and turnovers as most of the firewood is produced in private forests and never attending the market. Firewood is dealt with as a forest raw material flow (firewood) going directly from M3 to M5 and ending up as energy in M4.

The third group of biomass-to energy within Eforwood is forest residue from clear cuttings, thinnings, etc. This group is today representing less than 5 % of the biomass-to-energy flow but will be an important and growing option for the future as there are big untapped resources available in the forests. The forest industry already use some forest residue in their fuel supply but another important option for this fuel resource is to use it within CHP or HP outside industry (the chip is then going directly from M3 to M5).

Forest industry both sell and buy electricity and heat to some extent. Usually there is no surplus to sell but there are other reasons behind the selling. It may be advantageous the forest industry to sell green electricity to the market but buy at the same time the same amount of nuclear electricity. Another option is that the power plant next to the industrial complex have been outsourced, buy the by-product wood fuel and combust it together with other fuels (eg. peat, coal). The power plant produces heat and power and sell some of the produced energy back to the industry (process heat and stem as well as electricity) and rest of it to the market (district heat and electricity). Integrated solutions like this usually improve the energy economy but will be a challenge for the modelling work.

For the case studies, M4 suggest a simplified modelling approach for Bioenergy where the bark and black liquor combustion within Pulp and Paper industry will be part of the processes, heat (or CHP) production within solid processing will as well be part of the main processes. Bioenergy utilisation will be recognized as indicators within these processes. Furthermore, if some heat or electricity is sold the flows will as well appear as indicator data. Pellet production is recognizes as a own process within solid wood processing.

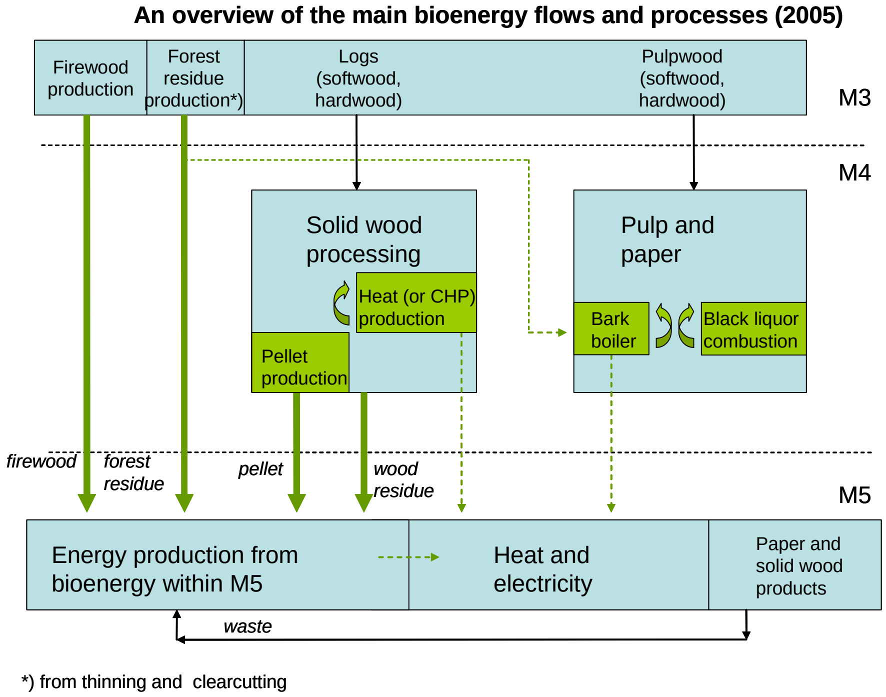


Figure 26. *Main bioenergy flows and processes*

4.1 Pellet production

The pellet production process utilize wood residue (wet or dry sawdust) as the process raw material. The production process includes several process steps described in Fig. x. The production process starts with pre-treating the raw material before introducing it to the main production step, the pellet press. The extent of pre-treating needed depends of the quality of the raw material. The pre-treatment process normally consists of some kind of crushing and screening. Drying is not needed if the wood residue orginate from dried timber.

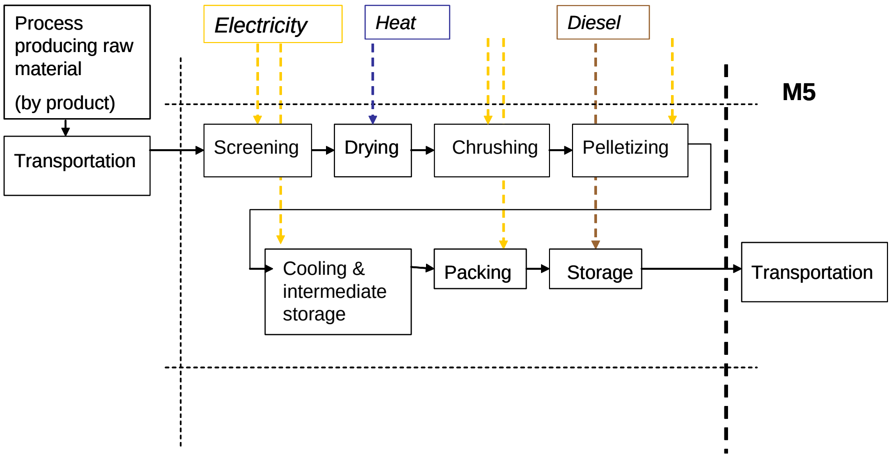


***Figure 27**. General process description of pellet production*

Pre-treated raw material is carried by a feed screw to the pellet press, where pellets of the required size are produced. Steam may be used for improving the performance of the pelletizing. The compression process causes the raw material to heat up, releasing lignin which binds the material together. This gives the pellets their regular shape and shiny surface. After the manufacture step the pellets are cooled down before they are taken to storage. Wood pellets are typically supplied in the following ways: single small bags, small bags on pallets, bulk delivery for small consumers and bulk delivery for large consumers.

Economical aspects

The production costs for wood pellets are mainly influenced by the raw material costs and, in the case of using wet raw materials, by the drying costs. Depending on the framework conditions these two parameters can contribute up to one-third of the total pellet production costs. Other important parameters influencing the pellet production costs are the plant utilisation (number of working shifts per week) as well as the availability of the plant. For an economic production of wood pellets at least three shifts per day at 5 days per week are necessary. An optimum would be an operation at 7 days per week. A low plant availability also leads to greatly increased pellet production costs. A plant availability of 85–90% should therefore be achieved. Wood pellet production is possible both in small-scale (production rates of some hundred tonnes per year) as well as in large-scale plants (some ten thousand tonnes per year). However, especially for small-scale units it is very important to take care of the specific framework conditions of the producer, because the risk of a non-economic pellet production is considerably higher than for large-scale systems.

The economy of pellet production cannot be studied at the level described above within Eforwood. However a simple calculation model that describe the production costs can be further developed. The cost of the raw material can be evaluated upon the market prise for saw dust as energy. Furthermore, the average market prise for pellets in different countries is quite well known.

Social aspects

The employment rate of a pellet plants depends on the plant utilization rate, which influate on eg. number of shifts per week. The amount of personnel for each shift vary. Additional personnel (administration, marketing etc) is also needed. An average figure defined as person year/1000 t pellets will be given for describing the employment aspects of pellet production.

Environmental aspects

The environmental performance of pellet production in connected to energy consumption which strongly depends on the quality of raw material used for pellet production (affects the need of energy for eg. drying). Another parameter affecting energy consumption is the pelletizing technology used.
The amount of energy needed is a sum of the energy need of sub processes; the energy input needed during the production chain is usually a blend of electricity, heat, steam and diesel (they cannot be summed together without defining eg. primar energy input). Data describing energy consumption of the process may be grouped as electricity (net) as kWh/t pellets, steam (net) as kWh/t pellets, heat (net) as kWh/t pellets and diesel (net) as kWh/t pellets (or l/t pellets).

The emission level of producing electricity, heat and steam depends on how it will be produced. Eg. the heat needed at a pellet plant is normally produced by wood residue or using produced pellets; the electricity is normally bought externally. If external electricity is used, country specific emission rates for electricity might be the most simple one to use.

Because of the reasons above, total energy use (gross kWh per t pellets) and greenhouse gas emissions (kg CO_2 equivalents/t pellets) for the test chain can only be described very crudely. In the case studies we will provide data of total net energy use (electricity, heat, steam and diesel) for average pellet production processes.

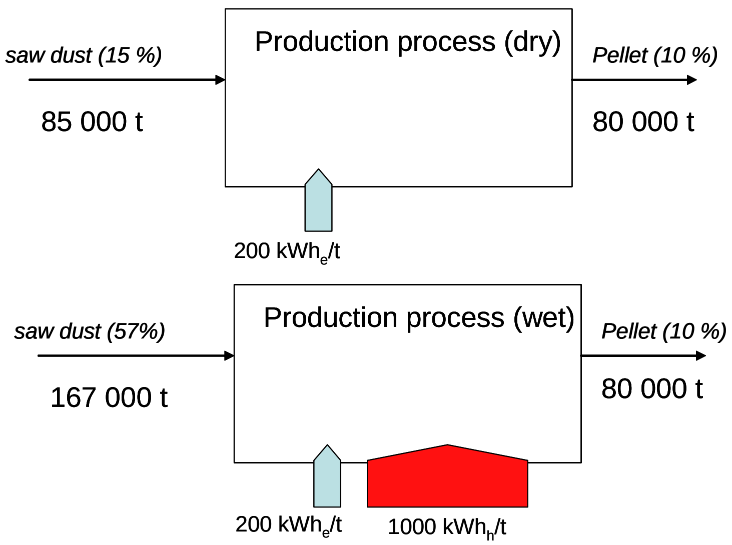


Figure. 28. *Very general energy and material flows for pellet production (80 000 t/yr)*

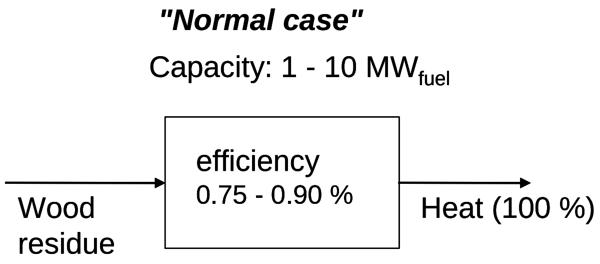
4.2 M4 internal heat (and power) production, solid wood

Mechanical forest industry produces a lot of biomass by-products like bark, sawdust and wood chips. The by-products are most often enough for generating the energy needed at the factory. However, own co-generation of heat and electricity is still rare which means that the factory usually produce the heat needed at site and buy the electricity from the grid. Own by-products are used in a primary boiler and other fuels such as oil or natural gas are used in secondary boiler producing heat at peak loads. Some units may have only boilers using external fuels (investments costs for solid fuel boilers are higher than for oil of natural gas). The furnace technology use for heat production can be based upon different technologies (fixed, moving or rotary grate) as well as on fluidised bed technology.

The heat load needed at a saw mill is rather stable and temperature needed for eg. lumber drying rather low (about 120 C) which means that it would usually be technically possible to produce all the heat and electricity need in a small scale CHP plant (1 - 20 MW) utilising the own saw mill by products if the solution would be feasible enough economically. Some of the solid wood production processes (like eg. veneer production or pellet production) are sometimes integrated with other units (eg power production and district heating) which means that a bigger power plant can be built, electricity can be produced but that the production unit is only one of the customers.

Real data about the amounts and quality of fuel input (saw mill wood-to energy by-products) is probably not measured so although the utilisation of heat (per amount of main product produced) can be estimated the real process efficiency can only be roughly estimated (0.75 – 0.85 %). The SIZE of a single saw mill process or the energy demand of the integrated processes affect of course the capacity of the wood-to-heat process to be chosen (saw material output):
< 5 000 m^3 250 kW
< 100 000 m^3 max 5 MW

The size of the heat load is important to recognise if we in the scenarios want to evaluate the potential of CHP production within saw mill industry but modelling 2005 and wood-to-energy flows there is no need to specify the size of the plant producing heat.



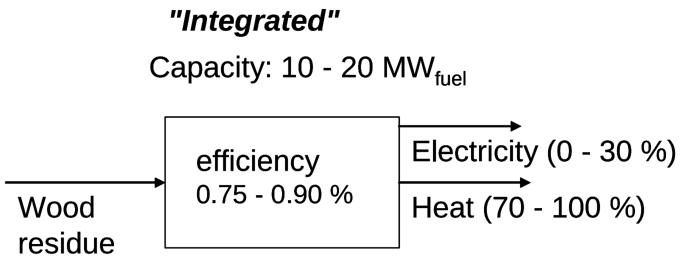


Figure 29. *Simplified process boxes that might be used for explaining wood-to energy flows within saw mill industry. The upper process "normal case" should be used if no more exact data is available.*

The solid wood processes produce more wood fuels that they need themselves so part of the wood by-product produced is utilised within pellet production(saw dust) and sold to M5 heat and CHP processes (eg. bark and fuel chips).

4.3 M4 internal heat and power production, pulp and paper

The bark and black liquor boiler processes are integrated into the pulp and paper processes. The pulp and paper processes need more energy than the wood by-products can offer so practically no wood fuel is sold from these units.

It is though important to recognise that the wood material and energy balances of eg. mechanical and chemical pulp production are completely different, Figure 30. In the chemical process about 50 % of the wood raw material is processed to black liguor and this is why there is so much wood based energy available for heat and electricity in this process. In the mechanical process roughly 90 % of the wood raw material can be found in the pulp and only 10 % is available as energy and this process needs a big surplus of external electricity! Furthermore, the paper production unit produce practically no combustible by-products itself and is most often integrated to pulp production.

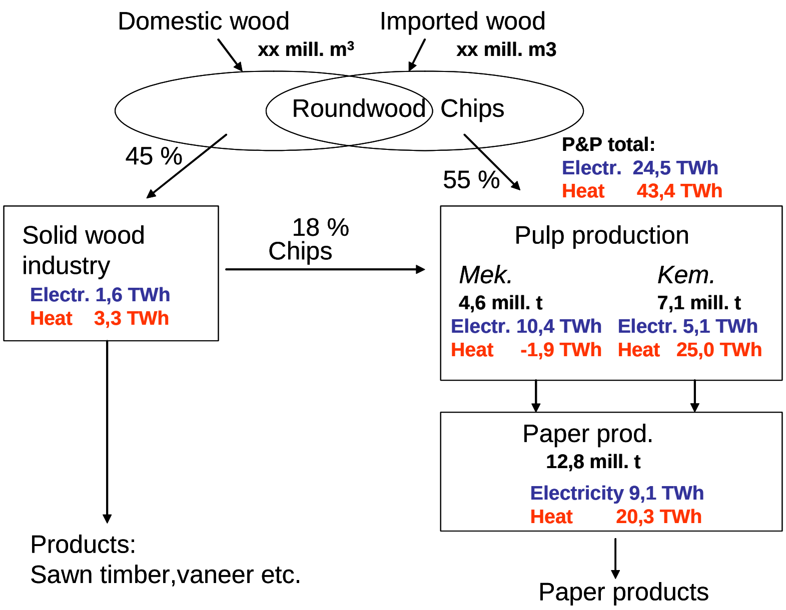


Figure. 30. *Principle picture of material flow distribution and structure of energy consumption within Finnish forest industry.*

4.4 Bioenergy in case study countries

In this chapter some data about bioenergy utilisation in the case studies are presented. These biomass figures contain also other biomass resources than wood if no specifications are made.

For M4 it is important to identify the following bioenergy flows:

Solid industrial by-products: The total amount produced, how it is converted to heat and electricity within forest industry and what amounts are flowing as a fuel product (wood residue, chips) to M5. Present in all case studies.

Liquid industrial by-products: The total amount of energy produced from black liquor. This product stays within M4. Not present on B-W case study.

Forest residue: the total amount leaving M3 and what part of it ends up as a fuel within forest industry (Pulp and Paper). The main part of these resources will probably flow directly from M3 to M5.

Refined wood fuels: Pellets (and briquettes) produced and flowing as a fuel product to M5. The present situation will be mapped in all case studies although the production and utilisation is most remarkable in the Scandinavian case study.

The following additional bioenergy flows appear in M5:

Residental firewood: flowing from M3 to M5, not part of M4. Remarkable part of the of wood-to-energy flow in the Scandinavian and B-W case studies.

Wood residue (construction and demolition wood, packing and paper waste, not paper recirculated to M4): this flow is born when wood and paper products end up as waste. Parts of this flow ends up at landfills and parts are used for energy production within M5.

Figure 31 shows the wood biomass resources used for covering energy consumption in the countries where the case studies will be performed.

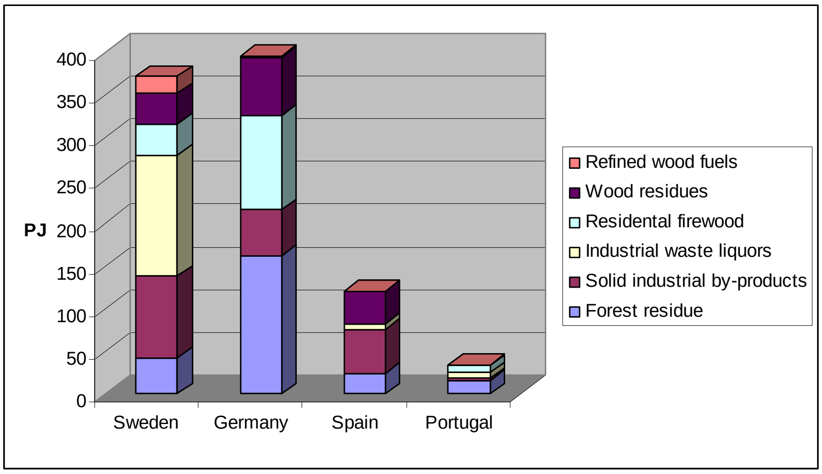


Figure 31. *The magnitude of wood biomass resources used for energy (2004) in Eforwood case study countries (Information source: EUBIONET).*

Bioenergy within Pulp and Paper industry

In 2004 bioenergy accounted for 638.8 PJ in pulp and paper industry in Europe (CEPI energy figures 2004) which is about 50 % of the total energy consumption within pulp and paper industry. Pulp and paper industry accounts on average 23 % of the bioenergy use within EU20.

5 Discussion and further work

The model processes described in this report for the three different value chains that are represented in M4 will be used in the case study and also in the EU-FWC. As already pointed out these are very generally descriptions and modifications have been made in the case studies to fit into the rest of the chain.

Within EFORWOOD 4 different scenarios will be studied;

- Climate change and mitigation policies
- Environmental regulation policies
- Consumption and lifestyle changes
- Technology development

M4 will be responsible to initiate the Technology development scenario that will be applied in the Scandinavian case study.

How the different scenarios will affect the model mill processes described above in different ways will be worked out during the next 12 months period of Eforwood.

The following deliverables are recommended for further information about the model manufacturing processes and the data collection associated to them.

PD 4.1.8 “Report describing the way of handling the data collection needed in ToSIA, by suggest useable databases, define groups of products and set up autonomous trend factors” Already approved

PD 4.1.9 “Report describing the Manufacturing processes in the European cases” is due to month 40 (February 2009) and will in more detail describe the manufacturing processes included in the EU-FWC.

D4.4.2 “Report on M4 modelling approach evaluation” is due to month 36 (October 2008)