EFORWOOD
Tools for Sustainability Impact Assessment

Updated report on the Forest-based Case Study "Scandinavian regional case"

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Preface

This report is a deliverable from the EU FP6 Integrated Project EFORWOOD – Tools for Sustainability Impact Assessment of the Forestry-Wood Chain. The main objective of EFORWOOD was to develop a tool for Sustainability Impact Assessment (SIA) of Forestry-Wood Chains (FWC) at various scales of geographic area and time perspective. A FWC is determined by economic, ecological, technical, political and social factors, and consists of a number of interconnected processes, from forest regeneration to the end-of-life scenarios of wood-based products. EFORWOOD produced, as an output, a tool, which allows for analysis of sustainability impacts of existing and future FWCs.

The European Forest Institute (EFI) kindly offered the EFORWOOD project consortium to publish relevant deliverables from the project in EFI Technical Reports. The reports published here are project deliverables/results produced over time during the fifty-two months (2005–2010) project period. The reports have not always been subject to a thorough review process and many of them are in the process of, or will be reworked into journal articles, etc. for publication elsewhere. Some of them are just published as a "front-page", the reason being that they might contain restricted information. In case you are interested in one of these reports you may contact the corresponding organisation highlighted on the cover page.

Uppsala in November 2010

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PD2.0.5: Updated report on the forest-based case study "Scandinavian regional case"

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1 Summary

This updated report provides an overview of the agreed terms of reference of the task force "Scandinavian regional case" and the management structure for this case study. It summarises discussions on the structure of the case study "Scandinavian regional case" to date, and activities undertaken and further steps by all partners involved to define the boundaries of the regional case study "Scandinavian regional case" and organise and manage communications, data collection and quality assessment of the data provided for the agreed set of sustainability indicators to feed into the ToSIA database. Furthermore, it exemplifies the work performed within the case study up to date. As the management strategies defined for the case study were introduced during the project period the basic forest data reflects the situation as it was 2005. The "Scandinavian regional case" was appointed a forest-defined case, in comparison to the Iberian and the Baden-Württemberg, which are consumption defined and region-defined, respectively. This means that the present case deals with the whole forest chain from the production and harvesting of the trees to the end-user of the forest product produced with the origin of the wood from Västerbotten. In M2 the present status of forest area in 2005 have been described and divided in five different decided management regimes, i.e. close to nature forestry (pine and spruce), combined objective forestry (birch and mixed), and intensive even-aged forestry (mixed). The sustainability of these different management regimes will be further explored during the following steps of the project. In M3 the transport of the annually cut trees from the woods to the industries (saw mills, kraft mills and fine paper mills) are described. The further processing of the cut volumes are defined and presented in M4. The wood chain in the Scandinavian case ends with the processes dealt with in M5, i.e. the producer-consumer interaction, which are divided into the three groups; distribution of the finished product from the producer to the end user, use of the wooden products, and recovery and the end of life routes for the wooden products. The end products defined by M4 are e.g. wooden houses, gluelam, windows, furniture, planed goods, particleboards, plywood, sawn wood, pellets, and bio energy. This report thus presents preliminary results and therefore the final outcome of the case study will be completed and somewhat changed in the future development stage of the project. The basic outline of the case study could be further examined through the information given in the two Appendices.

Key words*: forest-wood chain, regional case study, sustainability impact assessment.*

2 Agreed Terms of Reference/ Role of the task force

The Task Force agreed on the following tasks to define the regional case study "Scandinavian":

- to define the region of interest in its physical, geographical or political boundaries (1)
- to define the relevant single chains (from M2 to M5) covering 60-80% of wood material present in the region defined (2)
- to agree upon the interfaces between all modules (i.e. type and structure of data, additional information required such as quality requirement for specific chains) (3)
- to define all processes within each chain, and links between the different chains (4)
- to provide an verbal overview of the case study to describe the links and interfaces between modules and chains defined (5)
- to agree upon measures to verify consistency of data across modules and single chains (6)
- to evaluate outputs of ToSIA (Tool for Sustainable Impact Assessment) for different scenarios/different weighting of indicators according to MCA on the case study level and provide interpretation of the results (7)
- to establish permanent links of communication and information flow between all partners involved to ensure common understanding of tasks and agreement on approaches (8)
- to ensure that all deadlines concerning the definition of the case study, data collection and provision to M1 are met (9)

3 General structure of case study “Scandinavian regional case”

The case study “Scandinavian regional case” is one of three case studies undertaken within the EFORWOOD framework. This case is forest defined and aims to describe the network of forestry-wood chains in Västerbotten, Sweden (Figure 3.1) including exports out from the region.

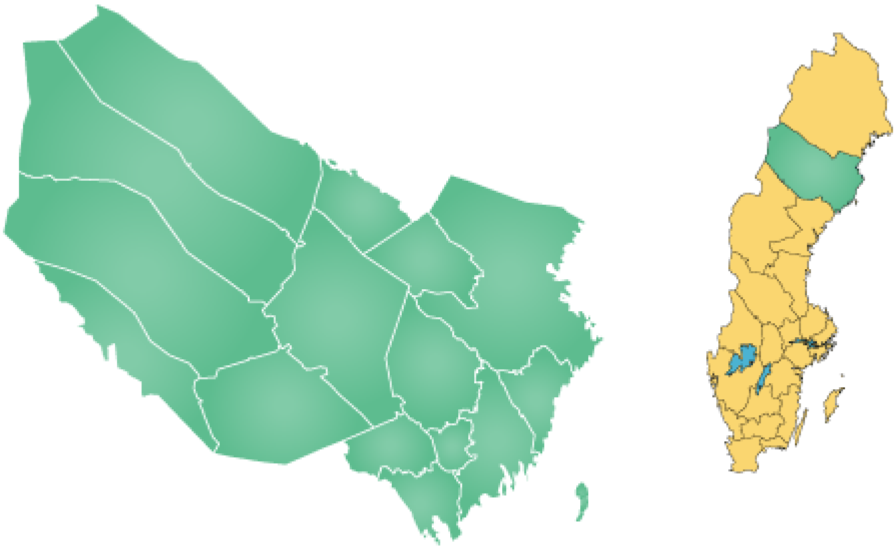


Figure 3.1 *The location of Västerbotten in Sweden, Scandinavian case study area (From http://www.regionfakta.com/StartsidaLan.aspx?id=1786).*

- The case study “Scandinavian regional case” is chosen to represent the boreal European forestry-wood-chains which, in comparison to the Baden-Württemberg case, are characterised by a small variation in forest types based on large scale silvicultural management, stands dominated of pine (*Pinus sylvestris* L.), spruce (*Picea abies* (L.) Karst.), or of mixtures of the two species with or without broadleaved species (most commonly birch, *Betula spp*.). The stands in the region are mainly even-aged and the dominating harvesting techniques include the highest technology available at present, i.e. harvesters and forwarders. The management strategies defined for the case study are close to nature forestry in pine and spruce, combined objective forestry with pine, spruce, birch and mixed species, intensive even-aged forestry with pine, spruce and mixed species. The dominating transport from the forests to industry includes road transport with 60 t trucks. The main wood industry products include saw logs, pulpwood and fuel wood of pine, spruce and birch, forest wood chips, and stumps. The main industries are sawmills, Kraft pulp mill, fine paper mill and CHP plants. The produced goods from the forest wood chain in Västerbotten consist of e.g. wooden houses, gluelam, windows, furniture, planed goods, particleboards, plywood, sawn wood, pellets and bio energy.

The total area of Västerbotten is 5 486 000 ha, with a forest cover of 58%. The population in 2005 was 257 652 inhabitants, i.e. on average 4,7 people/km^{2}. The proportion of forest land divided on ownership categories in 2005 was 35,3% public forests, 21,8% private companies, and 42,9% non-industrial private forest owners (Figure 3.2).

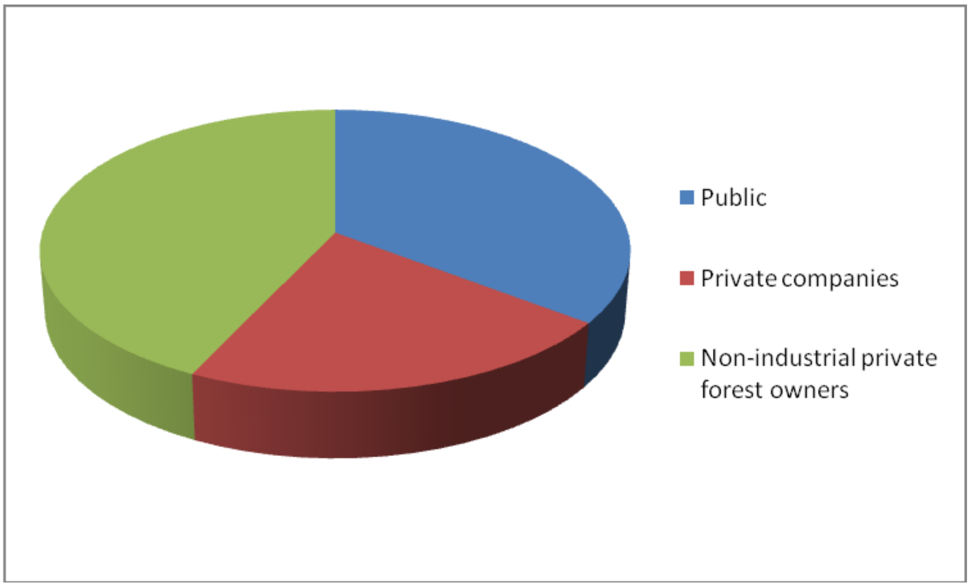


Figure 3.2 *The proportion on ownership categories of forest land in Västerbotten, Sweden. (Data from NFI. http://www-riksskogstaxeringen.slu.se/).*

4 Status report on the preliminary definition of the regional case study "Scandinavian"

1. The Scandinavian case is based on the whole County of Västerbotten, and the agreed single chains should cover 60-80% of wood harvested in the region. Besides the three main species we agreed upon M2 presenting all species in the case study area. However, only pine, spruce, and birch are included in the case study. It was also decided that M3 should investigate if there were differences between the different parts of Västerbotten regarding the logistics.
2. The reference year for the Scandinavian case study was agreed to be 2005. However, this year was exceptional in some cases (see below) and impossible to attain figures for in other cases. Therefore, the mean values for the years 2001-2005 will be used instead.
3. M2 has collected the basic forest data for the Scandinavian case study. All figures in section 5 below refer to the forest area in Västerbotten, i.e. the area that is suitable for forest production and where the annual production is higher than 1 m^3/ha, year.) As already stated, all figures represent the situation within the period 2001-2005. The year 2005 has not been chosen because it was an exceptional year regarding cutting also in northern Sweden, not just following the storm Gudrun in southern Sweden. That year 33% more wood than the average during 2001-2005 were cut.
4. The basic forest resources data for Västerbotten have been transferred to M3, which has carried out calculations of costs, time expenditure, use of fuel and lubricants and harvested timber. M3 has also allocated cut volume to industry products and described to wood flow from the forest to industries within and outside Västerbotten.
5. The M3 data have been submitted to M4 which described the utilization of the wood flow and the consumption in more detail for the fiber chain and the solid wood chain.
6. The wood flow from M4 was submitted to M5 who examined the further use of the products produced within Västerbotten.
7. The total outline of the Scandinavian case study can be seen in Appendices 1 and 2.

5 M2 - Forest resources (Erik Valinger)

5.1 Work description

In order to establish the status of the reference forests of Västerbotten for the reference year 2005 data from the Swedish National Forest Inventory (NFI) was used. The data material is based upon annual stratified sampling of plots. The sample plots are clustered in rectangular tracts. There are two types of tracts; temporary tracts which are only inventoried once, and permanent tracts which are re-inventoried with 5-10 years interval. The sampling mean error for the reference area is 2.7% for forest area (ha) calculations and 2.2% for growing stock (m^3) calculations for Västerbotten.

5.2 Forest area

The total forest area of Västerbotten comprise 1 861 000 ha (inland), and 1 318 000 ha (coastal), i.e. a total of 3 179 000 ha (in these areas forest area without trees are included).

5.3 Species

The proportion of Scots pine, Norway spruce and Birch dominated forests is approximately 70% of the total area (Table 5.1).

***Table 5.1** Species area distribution in Västerbotten*

Forest type	Proportion inland, %	Inland, ha	Proportion coastal, %	Coastal, ha	Total proportion, %	Total, ha
Pine[1]	39.3	730 799	49.3	649 523	43.4	1 380 323
Spruce[1]	27.6	514 170	13.4	176 761	21.7	690 930
Birch[1]	4.8	89 533	3.5	46 182	4.3	135 715
Other[2]	22.1	411 046	27.3	360 722	24.3	771 768
Lodgepole pine[1]	3.9	72 798	2.3	30 017	3.2	102 815
Bare ground	2.3	42 738	4.2	55 203	3.1	97 941
Total, ha		1 861 083		1 318 408		3 179 491

[1]Pine, spruce, birch and lodgepole pine (Pinus contorta) dominated forests (>70% of basal area)
[2]Mixed conifer forests (No conifer species >70% of basal area) + Mixed forests (between 40% and 60% broadleaved trees)

5.4 Cutting classes

More than 50% of the forest areas can be managed with thinning, i.e. cutting classes C, E and D1. About 20% of the area can be clear-cut, i.e. D2. The definitions of the different cutting classes can be found in Table 5.2. As can be seen in the table there are 15 m^3 left after clear cut in this region, mostly due to stated recommendation within the Swedish Forestry Act and the regulations in FSC and PEFC for Sweden.

***Table 5.2** Cutting class distribution in Västerbotten*

Cutting class	Proportion of area, %	Area, ha	Growing stock, m3/ha
A	4.2	133130	15
B1	7.9	251617	10
B2 + B3	20.2	642490	19
C + E	36.2	1149856	107
D1 + D2	31.5	1002398	154
All	100	3179491	92

Clarifications on definitions:
A (Regeneration, bare ground)
B1 (Regeneration, plant forest. Mean height < 1.3 m)

B2 (Young forest, mean height between 1.3 m and 3 m)
B3 (Young forest, mean height > 3 m. Dominating and co-dominating trees smaller than 10 cm at 1.3 m)
C (Medium forest. Most dominating and co-dominating of trees larger than 10 cm at 1.3 m)
D1 (Adult forest. Age is lower than recommended clear-cut age)
D2 (Adult forest. Age above recommended clear-cut age)
E (Forest suitable for single tree selection)

For sites classified as pine forests the largest proportion of the area is within the cutting class thinning (C + E). 64% of the forest area is classified as being most suitable for pine (Table 5.3).

Table 5.3 *Area distribution in cutting classes for Scots pine in Västerbotten*

Cutting class, pine	Proportion of total forest area, %	Area, ha
A	3.1	99366
B1	5.4	172350
B2 + B3	15.9	505262
C + E	26.4	838662
D1 + D2	13.4	427569
All pine	64.3	2043209

For sites classified as spruce forests the largest proportion of the area is within the cutting class adult forest (D1 + D2, Table 5.4). 35.7% of the forest area is classified as being most suitable for spruce.

Table 5.4 *Area distribution in cutting classes for Norway spruce in Västerbotten*

Cutting class, spruce	Proportion of total forest area, %	Area, ha
A	1.1	33764
B1	2.5	79268
B2 + B3	4.3	137228
C + E	9.8	311195
D1 + D2	18.1	574828
All spruce	35.7	1136283

5.5 Age classes

When the area is divided in the following year classes it can be seen that 60% of the forest area in Västerbotten holds trees older than 41 years (Table 5.5).

Table 5.5 *Age classes distribution in Västerbotten*

Year class	Proportion of area, %	Area, ha	Growing stock, m3/ha
0-	4.0	127 160	11
3-	8.4	267 036	10
11-	10.6	336 974	14
21-	10.1	321 079	33
31-	6.8	216 172	64
41-	14.6	464 134	102
61-	10.3	327 437	141
81-	9.7	308 363	140
101-	8.5	270 215	154
121-	8.6	273 394	168
141-	8.4	267 036	164

5.6 Productivity

Almost 80% of the forest area has a productivity below 4 m^3/ha, year (Table 5.6).

Table 5.6 *Productivity classes distribution in Västerbotten*

Productivity, m3/ha, yr	Proportion, %	Area, ha	Groving stock, m3/ha
0-	6.2	196 787	74
2-	31.3	996 412	83
3-	39.9	1 270 021	98
4-	18.1	574 052	99
5-	4.1	129 164	102
6-	0.3	8 886	154
7-	0.1	4 169	184

5.7 Diameter distributions

The species Scots pine, Norway spruce and Birch constitute of more than 95% of the growing stock (Table 5.7). About 1% of the volume can be found in Scots pine and Norway spruce trees larger than 45 cm at breast height.

***Table 5.7** Diameter distribution for species present in Västerbotten*

Species	Diameter at breast height, cm									
	0-9	10-14	15-19	20-24	25-29	30-34	35-44	45-	Total	Proportion
	milj. m3									%
Pine	7.7	17.8	30.8	30.3	21.3	14.1	8.4	0.9	131.4	43.6
Spruce	9.4	17.4	24.0	21.6	15.9	11.3	7.6	2.9	110.1	36.5
Betula	12.5	13.6	10.5	5.5	2.4	0.6	0.3		45.4	15.1
Contorta	1.1	0.7	0.1	0.0					2.0	0.7
Populus	0.1	0.3	0.4	0.3	0.2	0.2	0.3	0.1	1.9	0.6
Alnus	0.3	0.2	0.1	0.0					0.7	0.2
Salix	0.2	0.3	0.3	0.3	0.2	0.1	0.2	0.0	1.6	0.5
Sorbus	0.1	0.0	0.0	0.0					0.2	0.1
Dry + wind-thrown	1.2	1.7	1.4	1.2	0.7	0.5	0.8	0.5	8.0	2.7
All	32.7	52.0	67.7	59.3	40.8	26.9	17.6	4.4	301.5	100

5.8 Increment

The total annual increment of Scots pine is 4 610 000 m^{3}, of Norway spruce 3 310 000 m, and of birch 2 000 000 m^3. The mean annual increment is 3.0 m^3/ha.

5.9 Dead wood

The mean amount of deadwood for Västerbotten is 7 m^3/ha. It can be seen that a trend is that the amount of dead wood increases with cutting class and year class (Table 5.8). To be classified as deadwood the diameter of the log should be larger than 10 cm.

Table 5.8 *Dead wood distribution within cutting classes and diameter classes in Västerbotten*

	Age class						
	-20	21-40	41-60	61-80	81-100	101-	All
Cutting class	Volume, m3/ha						
A	3		0	0		4	3
B1	7	0		18		9	7
B2+B3	4	3	4	1		6	4
C+E	1	4	4	5	5	11	4
D1	0			10	6	10	8
D2		0	2	15	12	19	18
Alla	5	4	4	5	6	16	7

When divided into the different species and development phases it can be seen that the described trend is even more pronounced (Table 5.9). Most dead wood can be found in sites suitable for single tree cutting of spruce, i.e. 29 m^3/ha.

Table 5.9 *Dead wood distribution within development phases for pine, spruce, birch and mixed forests in Västerbotten*

Species	Development phase	Area, ha	Standing, m3/ha	Lying, m3/ha	Total, m3/ha
Pine	Young	440569	1	4	5
	Medium 1	540364	1	3	4
	Medium 2	79271	2	5	7
	Adult	54007	5	6	11
	Natural regeneration	240018	3	3	6
Spruce	Young	132743	0	1	1
	Medium 1	85560	1	3	4
	Medium 2	43641	2	5	7
	Adult	289271	8	13	21
	Single tree cutting	33207	19	10	29
Mixed	Young	272027	0	3	3
	Medium 1	109145	3	2	5
	Medium 2	71765	3	3	7
	Adult	118085	5	6	11
Birch	Young	48768	0	5	5
	Medium	17060	2	1	3
	Adult	24128	7	12	19

5.10 Cuttings

The annual cutting area on forest land is 112 000 ha with a mean cut of 70 m^3/ha (Table 5.10).

Table 5.10 *Area and volume per ha of cutting in different silvicultural stages in Västerbotten*

Cutting	Inland, ha	Volume/ha, m3/ha	Coastal, ha	Volume/ha, m3/ha	Total, ha	Volume/ha, m3/ha
Clear felling	11 000	180	18 000	184	29 000	183
Thinning	8 000	43	26 000	70	34 000	63
Cleaning	16 000	4	21 000	6	38 000	5
Others	5 000	44	7 000	33	12 000	39
Total, ha	41 000	61	71 000	75	112 000	70

The mean annual cut for Västerbotten during the years 2001-2005 was 7.8 million m^3/year (Table 5.11). Approximately two thirds of that volume is cut in the coastal region.

Table 5.11 *Total volume of cutting in different silvicultural stages in Västerbotten*

Cutting	Inland, Volume/yr, m3/yr	Coastal, Volume/yr, m3/yr	Total volume/yr, m3/ yr
Clear felling	1 915 000	3 310 000	5 224 000
Thinning	365 000	1 808 000	2 173 000
Cleaning	66 000	126 000	192 000
Others	123 000	106 000	230 000
Total, ha	2 470 000	5 350 000	7 819 000

During the 2001-2005 period 50.1% of the cutting volume was Norway spruce (3 916 952 m^3/yr) 41.4% Scots pine (3 231 110 m^3/yr), and 8.5% Birch (661 752 m^3/yr) (Table 5.12).

Table 5.12 *Total volume of cutting in different silvicultural stages for pine, spruce, and birch in Västerbotten*

Cutting		Inland, Volume/yr, m3/yr	Coastal, Volume/yr, m3/yr	Total volume/yr, m3/ yr
Clear felling	Pine	527531	1634972	2162503
	Spruce	1281446	1570850	2852297
	Birch	105772	101774	207545
Thinning	Pine	228344	677324	905668
	Spruce	120208	821049	941256
	Birch	16586	301638	318224
Cleaning	Pine	16644	35075	51719
	Spruce	17194	12288	29482
	Birch	32547	78319	110865
Others	Pine	36246	74974	111220
	Spruce	71094	22823	93917
	Birch	16103	9017	25120
Total, m3/yr		2469714	5340102	7809817

5.11 Natural regeneration of pine

The potential areas for natural regeneration of pine areas (earlier defined silvicultural regimes in PD2.1.1 "Description of forest production processes: report including analysis and description of current production processes for various relevant sites and forest types") was established by using the following criteria's:

1. Ground vegetation should be dominated by myrtillus or species indicating less productive sites.
2. Cutting class D.
3. More than 50% of basal area should be pine.
4. Sites should be situated ≤ 300 m a.s.l.

About 7.5% of the forest land met the criteria's and could be regarded as potentially suitable for natural regeneration of pine (Table 5.13).

Table 5.13*Area suitable for natural regeneration of pine in Västerbotten*

Area	Ground vegetation	Cutting class		
		D1	D2	D1 + D2
Inland	< Myrtillus	24778	28445	53223
	Other	.	1903	1903
	Total	24778	30348	55126
Coast	< Myrtillus	79235	101170	180406
	Other	1242	3245	4487
	Total	80477	104415	184892
Total	< Myrtillus	104013	129615	233628
	Other	1242	5148	6390
	Total	105255	134763	240018

5.12 Single tree cutting of spruce

The potential areas for single tree selection of spruce areas (earlier defined silvicultural regimes in PD2.1.1 “Description of forest production processes: report including analysis and description of current production processes for various relevant sites and forest types”) was established by using the following criteria’s:
Ground vegetation should be dominated by myrtillus or species indicating more fertile sites.

1. Thinning- and Clear-cut forests (Cutting classes C and D).
2. More than 70% of basal area should be spruce.
3. Stand structure. From the diameter of the largest tree in diameter, four diameter classes are created by the construction of the quota dmax/4. The shares of the number of trees (n) within each diameter class are the basics in defining the stand structure classes. Suitable stands are stands with quotas n1/n2, n2/n3, n3/n4 > 1.0, all other are not acceptable.
4. Growing stock > 150 m3/ha.

About 1% - 6% of the forest land met the criteria’s and could be regarded as potentially suitable for single tree cuttings of spruce (Table 5.14). The difference between what was regarded as suitable and not suitable was that criteria 4 were not fulfilled for the column “Not suitable”.

Table 5.14 *Area suitable for single tree cutting of spruce in Västerbotten*

Area	Single tree selection, ha		
	Not suitable	Suitable	Total
Inland	97331	22182	119513
Coast	68650	11025	79675
Total	165981	33207	199189

5.13 Starting values for reference forests

Examples of the starting values for the reference forest of Västerbotten can be seen in the following figures (Figure 5.1- 5.5). The reference ages for the time of the planned silviculture measure varies between the stand types (Figure 5.15). As close-to-nature (CTN, pine and spruce), combined objective forestry (CO, mixed and birch), and intensive even-aged forestry (IEA, mixed) was not defined within EFORWOOD in the initial phase of the project, the following Figures (5.15-5.19) presents the division which was decided then. This means that in the above mentioned figures CTN-pine can be regarded as represented by Pinenr, CTN-spruce by Sprucest, CO-birch by Birch, CO-mixed and IEA-mixed by Pinetrad, Sprucetrad, and Mixed (the latter because fertilisation is hard to detect at the secretly laid out sample plots).

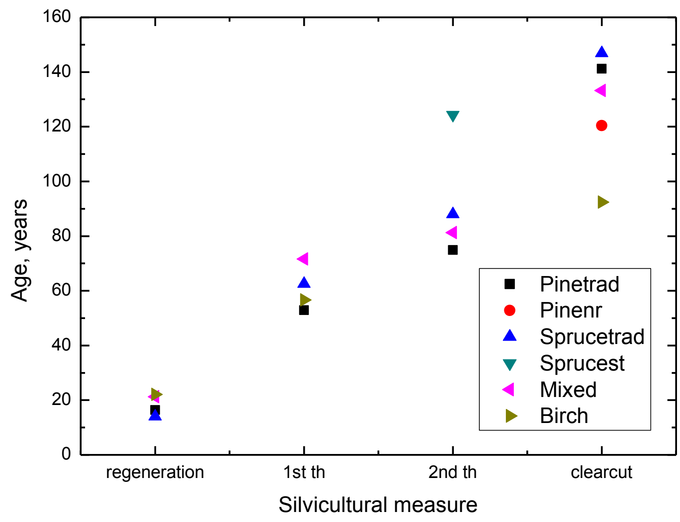


Figure 5.15 *Ages at different phases of development for the different stand types.*

As can be seen (Figure 5.16) there are up to 100 large trees at sites at the regeneration phase, which probably has to do with the demands of leaving trees at clear-cut for environmental purposes.

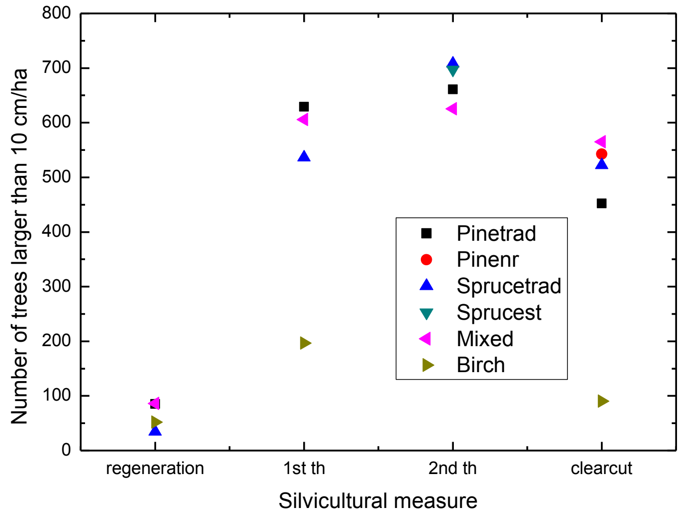


Figure 5.16 *Number of trees at different phases of development.*

There are almost 4 m difference in mean height between Scots pine and Norway spruce trees and sites which includes Birch at First thinning (Figure 5.17).

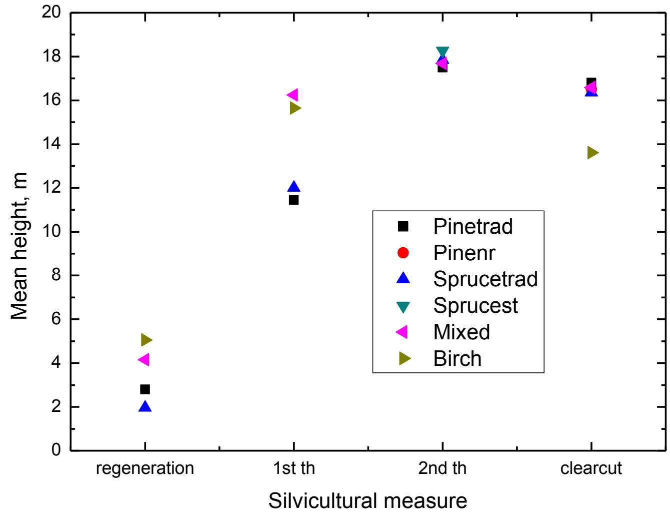


Figure 5.17 *Mean heights at different phases of development.*

The high initial growth of sites with Birch can also be traced when looking at the development of basal area over time (Figure 5.18).

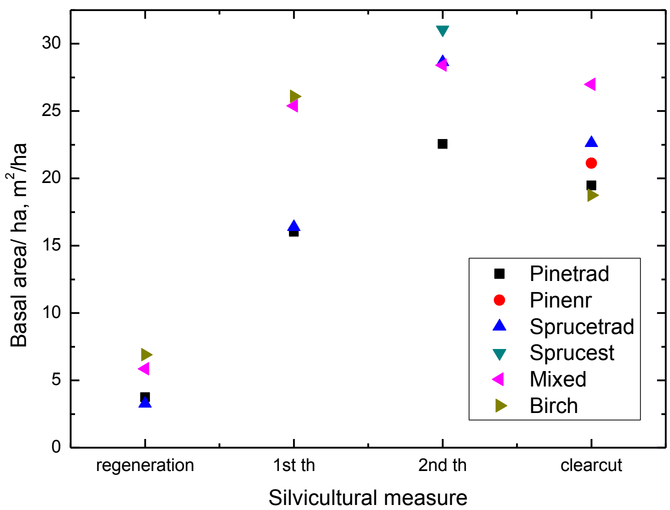


Figure 5.18 *Mean basal area at different phases of development.*

The highest volumes can be found at sites dominated by spruce at second thinning (Figure 5.19).

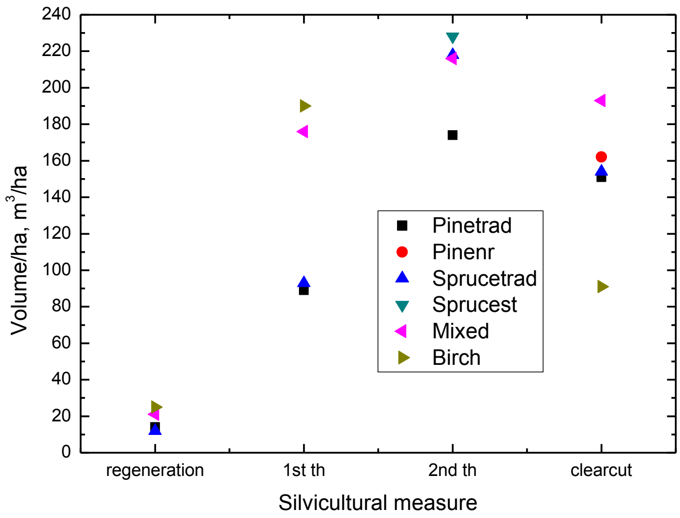


Figure 5.19 *Mean volumes at different phases of development.*

The figures above were some examples of data delivered to M3 for the Scandinavian case.

Since the preparation of these starting values new management strategies for the Scandinavian case study have been implemented, which means that there are now only five different management regimes that are considered, i.e. close to nature forestry (CTN, pine and spruce), combined objective forestry (CO, mixed and birch), and intensive even-aged forestry (IEA, mixed). The presented output in tables 5.15 and 5.16 are preliminary and will be further developed during the next step of the project. About 70% of all the forested area in Västerbotten belongs to the management regime combined objective mixed (Table 5.15), and that close to nature spruce and combined objective birch is sparsely represented. As only 2500 ha is fertilised annually in Västerbotten the management regime intensive even-aged forestry also has a low representation in present day's forestry practices.

Table 5.15 *Area suitable for the different management regimes in Västerbotten*

	CTN pine	CTN spruce	CO birch	CO mixed	IEA mixed
Percentage of forest area, %	18	2	1	70	9

Table 5.16 gives indications on volumes per ha cut and the standing growing stock for the different forest management strategies and development phases during 2005. The figures are based on preliminary calculations and may be revised during the following year of the project. The presented figures in this table are preliminary as more detailed knowledge of the situations when the different thinnings takes place, e.g. standing volume before each thinning, is needed.

Table 5.16 *Standing volume (m^3/ha) and volume (m^3/ha) cut for the different management regimes in Västerbotten*

Development phase	CTN pine		CTN spruce		CO birch		CO mixed		IEA mixed	
	Growing stock	Cut	Growing stock	Cut	Growing stock	Cut	Growing stock	Cut	Growing stock	Cut
Regeneration										
Young	14	5.1			25	5.1	17.5	5.1	21	5.1
Medium	89	63.7					119		176	
	174	63.7	228	63.7	190	63.7	203	63.7	216	63.7
Adult	162	150			91	91	166	156	193	184

6 M3 - Forest to Industry (Staffan Berg, Lars Wilhelmsson, John Arlinger, Lennart Moberg)

6.1 Work description

- Harmonized description of **machine parameters** within this case study and other cases.
- Identification of forest operations for eight chains, pine, spruce, mixed, birch, with variations even-aged and uneven aged.
- These chains contain operations
- They are described with stand data according to a designed parameter **data sheet**.
- With this data **costs, time expenditure**, use of **fuel** and **lubricants** and **harvested timber** volumes are to be calculated.
- Costs and productions are still not evaluated because it has not been possible to identify the **representative cuts in thinnings**.
- Harvested volumes can be modeled for allocation to **industry products.**
- To calculate results according to above in each process.

6.2 Description of harvesting operations

I Module 3 it has been developed a manual for treating machine operations in case studies (Berg et all, 2007). This manual was developed in order to help case studies participants to design the description of logging machinery (chain saws for motor manual felling and pre commercial thinning, fellers, harvesters, forwarders and skidders) in a comparative way. This includes a general description on how to calculate machine costs. Details are reported in deliverables D3.2.3 and PD3.4.2. Some decisions at the meeting in Scandinavian regional case group in March 2007 also had a bearing to this. The process of selecting indicators is monitored by the EFORWOOD Task Force on Indicators.

This manual gives additional guidance on input parameters, how to calculate e.g. costs and energy use per reference unit.

The case study groups define chains of relevant processes in the Forest Wood Chain. In this chain logging operations form the first thoroughly mechanized operations in processes that often are done with similar kind of machinery in all chains. Therefore a due description of machine work is also done.

6.3 Data sources and quality

As assistance in finding data, three clusters of data availability are exemplified and identified here below. These can be selected, individually per subclass, for recommendations by the data collection groups or for data collection by the scientist performing the collection.

A. Specific and empirical

- follow up routines from enterprises
- data from experiments or scientific measurements
- branch statistics.

B. Generic and derived

- official statistics
- weighting or scaling factors relevant for adaptation of generic data to specific data for the actual case. E.g. average data of costs per cutting form (final felling/thinning) is adapted to the case in question with the aid of case specific shares of cutting forms.

C. Model-based and estimated

- modelling; e.g. harvest costs and time use model.
- expert's judgment.

The final procurement of data to indicators for a process, may involve a combination of cluster categories.

6.4 Stand and tree specific input parameters for harvesting work in the Case (regional) studies.

In order to deliver indicator values to ToSIA in a similar way there has been recommended conforming description of logging operations. This conformity is expressed as a defined set of input parameters that at least should be satisfied in all cases. The input parameters are on stand and single tree level. They are demonstrated in Table 6.1 below.

The stand characteristics are described in detail in Chapter 5 and 6.7 and onwards. In order to have an input to models for calculation of costs, time and productivity, in harvesting and forwarding is needed data concerning average arithmetic stem volume for each process. This volume is derived with the aid of standing volume per hectare and number of stems per ha. The Scandinavian chain contains five chains for forest management that consist of varying degree of pine (together with quantities of lodge pole pine), spruce, birch and mixtures thereof. Four of the chains (cases) in even-aged single-storey stands are treated with processes as thinnings and final harvest (Table 6.3). One chain that involves single tree selection in uneven-aged multi-storey stands are treated with just thinning, i.e. only one kind of felling operation.

Table 6.1 *Input parameters for harvesting in regional case studies*

Cost parameters (stand level)	Revenue parameters (single tree level)
Area	
Ownership (optional)	
District (optional)	
Treatment regime	
Stand ID (optional)	
Site size, ha	
Tree species (P S B …), %	Tree species (P S B …), %
DBH	DBH
m3 / ha harvested	
Height	Height
No. trees/ha	Height of live crown
- pre-treatment	Latitude (optional)
- post treatment	Latitude (optional)
m3/tree	Age BH
Terrain transport distance	Decay %
Undergrowth (stems/ha) (optional)	Crooked, %
Terrain factors (surface, slope)	Other damage, %, Simulation proposed
Km road/ha	
No. assortments	No. assortments.
Distance to industry (optional)	

A general view of stand characteristics is presented in table 6.3. This average contains all kind of forests and is based on input data from Module 2 (presented in this paper, SKA 99 and NFI (27.9 2006).

Table 6.2 *General average of cuttings in Västerbotten* 2005.
Typical values for even-aged management.

Variable	Final	Thinning
Arithmetic mean stem, m^3sub^x	0.34-0.40	0.10-0.20
DBH, cm	20-23	15-18
Volume/ha, m^3sub^x	150-200	100-200
Stems/ha	500	320

^{x}Sub=solid under bark

Stands for single tree selections in uneven aged forests have a larger volume per hectare than a typical stand for final felling in even aged forest management, 200 cubic metres.

6.5 Operations in the Cases

For each case there is a defined set of operations developed (Table 6.3). The detailed appearance of these chains is developed during project work. The sets of operations in the Scandinavian Regional Case chain demonstrated in Table 6.4. Question mark indicates that scenarios or reference futures might include this measurement.

Table 6.3. *Silvicultural measures in different development phases for pine, spruce, and birch forests in Västerbotten. The silvicultural management regimes and this table shows the operational interpretation of processes in those management regimes*

stage	pine			spruce		birch		mixed
silvicultural treatment	even-aged	even-aged	even-aged	even-aged	uneven-aged	even-aged	even-aged	even-aged
regeneration	planting pest control	seeding	nat. reg.	planting pest control	nat. reg.	planting cleaning 1	nat. reg. cleaning 1	planting
young stand	cleaning 1	cleaning 1	cleaning 1	cleaning 1		cleaning 2	cleaning 2	cleaning 1
medium	cleaning 2 fertilization ?	cleaning 2 fertilization ?	cleaning 2 fertilization ?	fertilization ? thinning 1				thinning 1
adult	thinning 1 fertilization ? drainage ? final harvest	thinning 1 fertilization ? drainage ? final harvest	thinning 1 thinning 2 fertilization ? drainage ? final harvest	thinning 2 drainage? final harvest	thinning(s)	thinning 1 final harvest	thinning 1 final harvest	thinning 2 drainage? final harvest

Table 6.4 *A sketch over logging operations and deployment of machine units*

Chain No x									
Activity	Transports equipment	Transports personell	Vehicles	Personell	Power saw	Harvester	Forwarder	Other Products	Comments
Clearance before felling	x	x	x	x	x				
Planning of operation, striproads, boundaries		x	x	x					
Thinning 1	x	x	x	x		x	x		
Thinning 2	x	x	x	x		x	x		
Final felling	x	x	x	x		x	x		
Single tree felling	x	x	x	x		x	x		
Collecting biofuel tops and branches,	x	x	x	x			x		
chipping at roadside									

x operation present

6.5.1 Specifications of different forest machine types

Machinery is specified accordingly as in tables 6.5 - 6.9.

Theses tables are developed for all processes in M3 also for other case studies and are presented in M3 Working document.

Table 6.5 *Specification of harvesters*

	Small harvester	Medium harvester	Large harvester
Examples of machines	JD 770 D SAMPO 1046X SIFOR 414 SOGEDEP SH 10	HSM 405 H1, Valmet 911; JD 1070; Rottne H 14	HSM 405 H2, Valmet 941, JD 1470, Rottne H 20
Engine energy, kW	70-100	101-170	171-250
Fuel consumption, l/h	10-12	12-14	14-18
Size, ton	8-11	12-20	21-25
Cutting diameter, mm	400-550	500	700

Note: Classification of harvesters is mainly based on the weight of the machines. Classification of forwarders is based on the loading capacity of the machine.

Table 6.6 *Specification of forwarders*

	Medium forwarder	Large forwarder
Examples of machines	HSM 208 F 12to Valmet 840; JD 1110, Ponsse Wisent, Gazelle	Valmet 860, JD 1410, Ponsse Elk
Engine energy, kW	120-140	141-150
Fuel consumption, l/h	9-11	12-14
Size, ton	14-15	16-17
Loading size, ton	10-13	>13

Table 6.7 *Specification of Skidders*

	Small skidder	Medium skidder	Large skidder
Examples of machines	HSM 704, W110T	HSM 805, JD 548 G-III, W150, CAT 515	HSM 904, JD 648 G-III, W180, CAT 525
Engine energy, kW	<90	91-120	>120
Fuel consumption, l/h	7-8	9-10	11-12
Size, ton	<10	10-12	>12
Winch , kN	<80	80-150	>150
Zangenöffnung mm	1500	2000	>2500

Note: Skidder with double winch wheel and crane

Table 6.8 *Processor tower yarder*

Examples of machines	Mounty 4000, Koller K500, MM Syncrofalke 3t
Engine energy, kW	250-300
Fuel consumption, l/h	8-9
Loading capacity, t	3-4
Max. skidding distance, m	500-800

Note: Processor tower yarders integrate the drums, a steel spar, power supply, a boom and a processor head on one carrier.

Table 6.9 *Bioenergy harvesting machines*

	bundler	Small chipper (cutting site / roadside landing)	Large chipper (bioenergy platform)	Excavator base for stump extraction
Examples of machines	John Deere Fiberpac Pinox Bundling unit Valmet Woodpac	Biber + tractor	Jenz HEM 560	Volvo 988+ Pallari
Engine energy, kW	70	80-100	200-300	110-130
Fuel consumption, l/h	14	10-12	20	18-22
Size, ton	18-22	8-10	12	18
Product	Top/branches bundles	chips	chips	Pieces of stump

In addition to this Brush saws are used for pre commercial thinning and cutover clearance. For scarification a scarifier is used that is towed behind a prime mover, usually the same forwarder also is used for forwarding in logging.

In short

Forest operations in Scandinavians Västerbotten case has the following general traits:

- Logging is performed by o dual machine system with harvester and forwarder.
- Pre commercial thinning is made by brush saw in motor manual operation.
- In addition to this special equipment is used for digging road building and biofuel harvest.

6.6 Transport

The general situation for secondary transportation of Wood is described in PD3.3.2 In this raw material driven case transports are made with road vehicles (Inside and out of case study area) and railways, mostly out of area. Total volumes of industrial wood, means and distances shipped to individual industries for primary industrial use has been identified for 2005 with the aid of statistics from 2004 and 2005. The shipping to industry is predominantly done according to two methods, a transport by timber lorry directly to saw or pulp mill or (for longer distances) by rail transport. In the latter case the wood is in any case loaded on timber lorries (60 t trucks) for transport from roadside to terminal. The quantities of biofuel are identified through statistics, procured from Svebio, the Swedish biofuel organization.

In short

The secondary road transport from Västerbotten has the following general traits:

- The dominating mean of transportation are made with road vehicles (60 ton trucks with crane) for transport inside and out of case study area and railways, mostly out of area. Switches between road transport and rail are made at terminals. The wood is delivered to industries in Västerbotten and to industries outside - raw material driven case.
- Total volumes of wood and biofuel, means and distances shipped to individual industries for primary industrial use has been identified for 2005.

6.7 Wood characteristics for reference forests

Within this chapter, examples of the wood characteristics after bucking simulation of properties that can be used in the following work within the Scandinavian case study are presented. The characteristics have been calculated for Sots pine dominated sites (Figures 6.1-6.7). The models used were from Skogforsk, STFI and SLU.

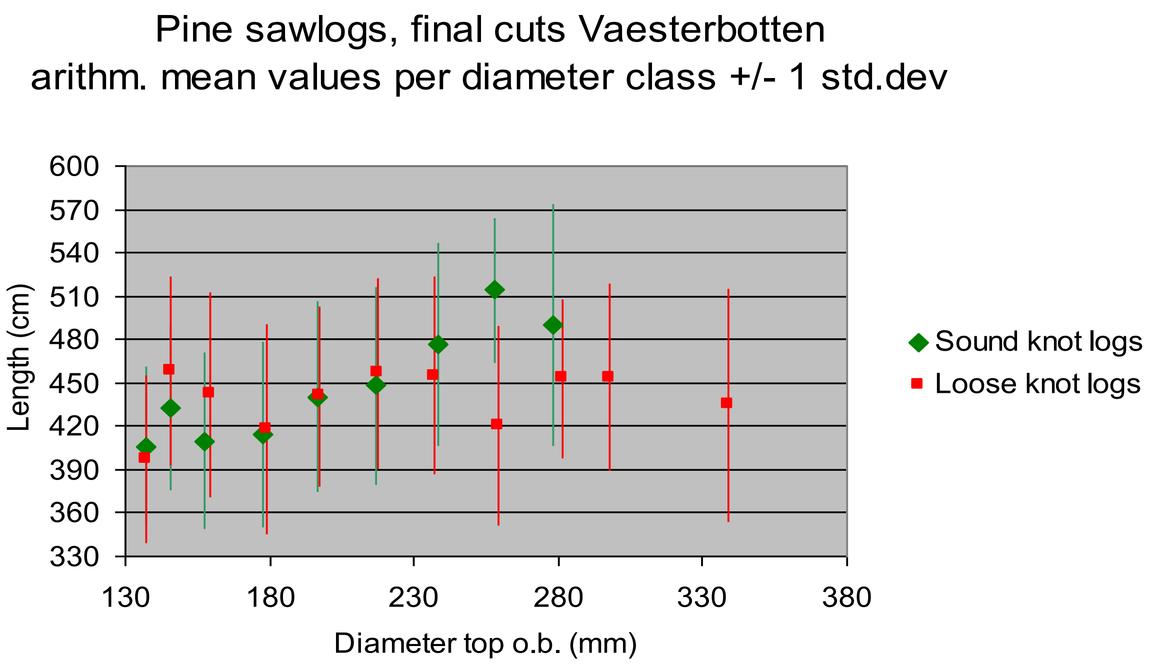


Figure 6.1 Length of pine sawlogs at final cutting.

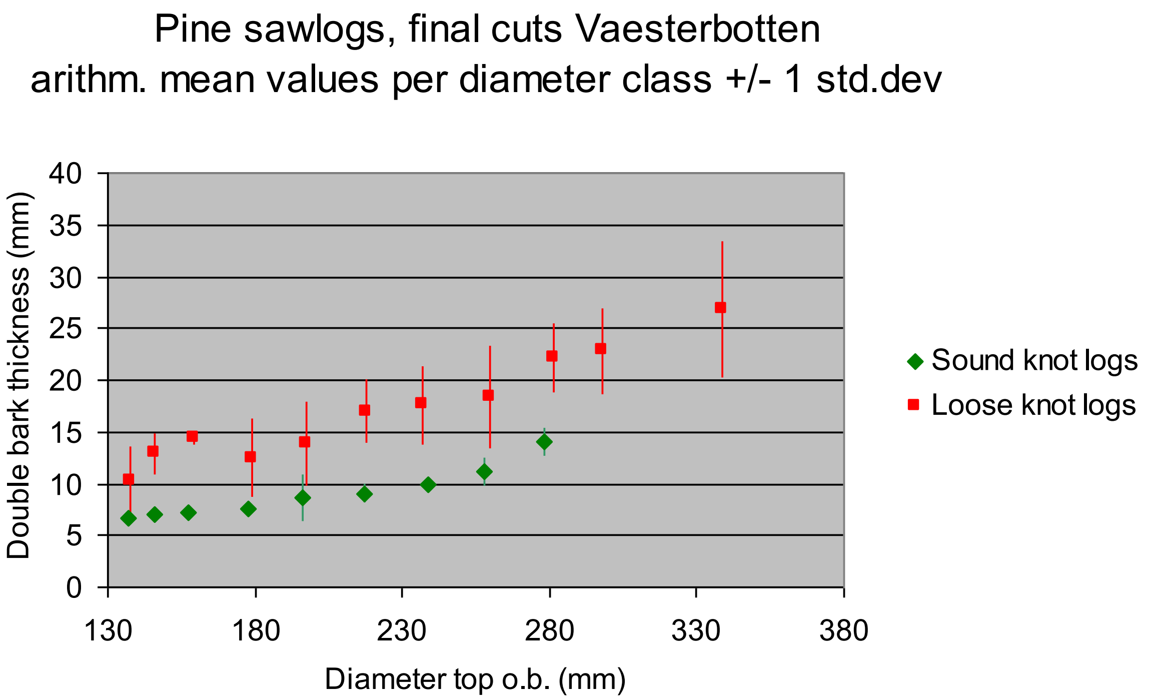


Figure 6.2 Double bark thicknesses of pine sawlogs at final cutting.

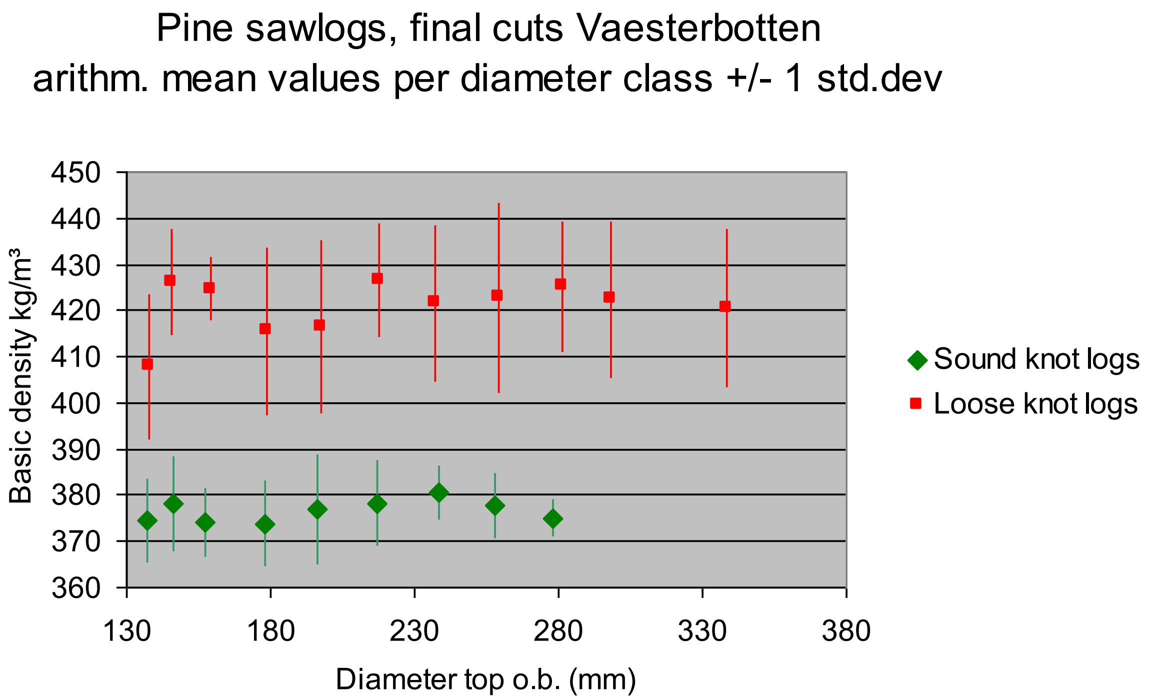


Figure 6.3 Basic densities of pine sawlogs at final cutting.

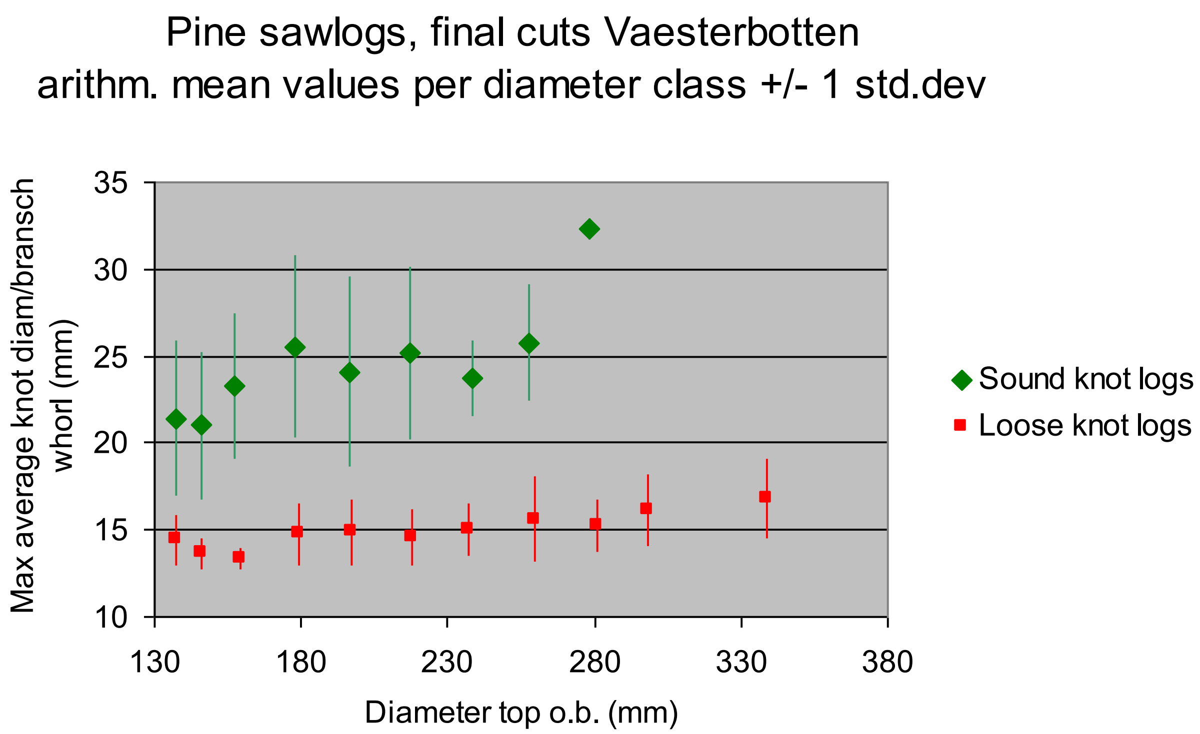


Figure 6.4 Maximum average diameter/branch whorls of pine sawlogs at final cutting.

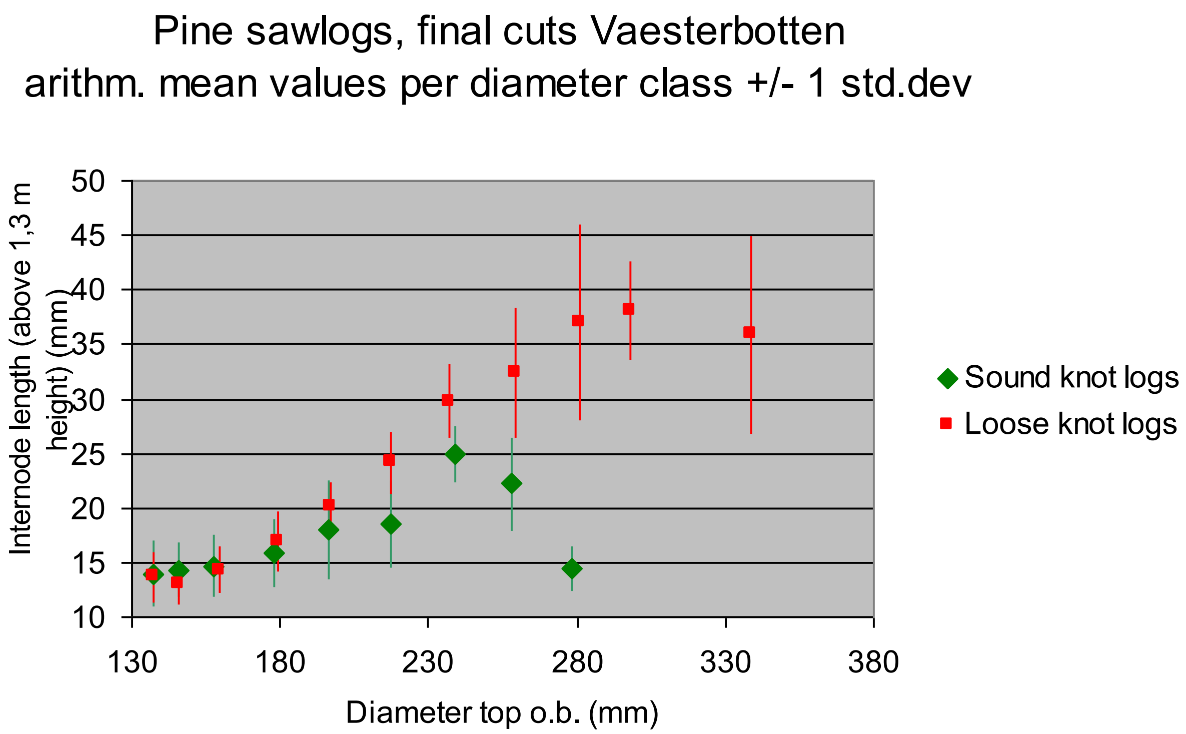


Figure 6.5 *Internode lengths above 1.3 m height of pine sawlogs at final cutting.*

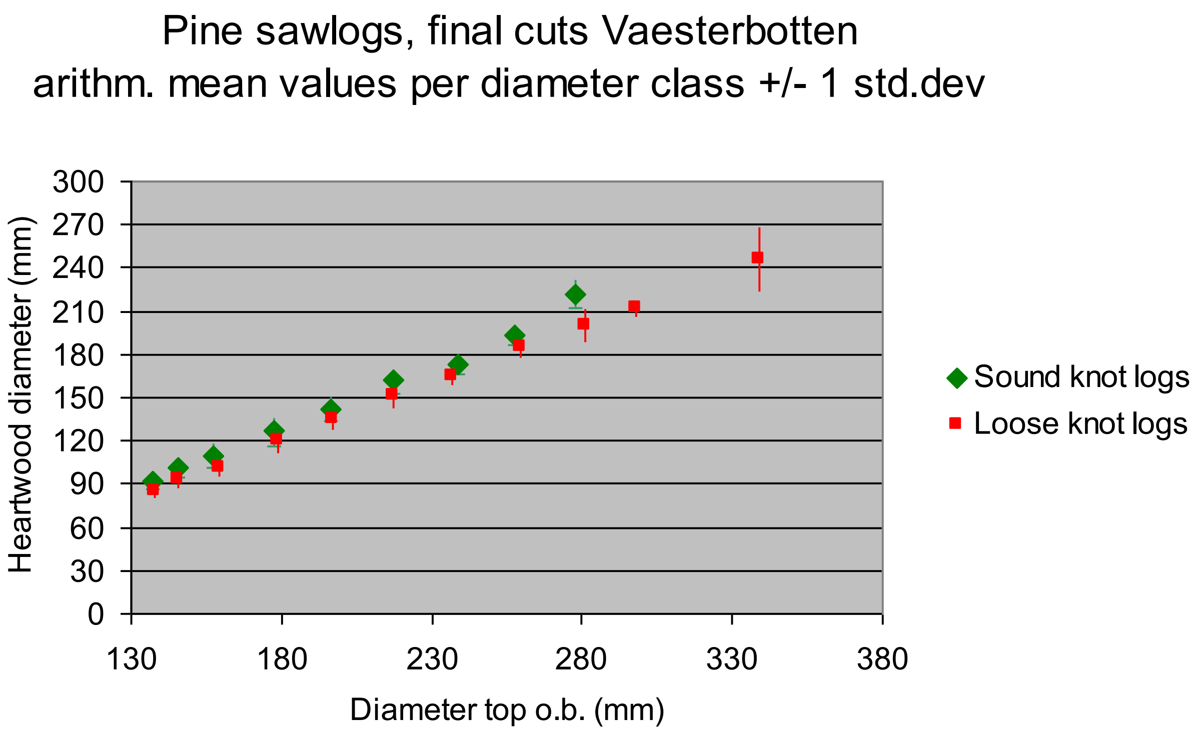


Figure 6.6 *Heartwood diameters of pine sawlogs at final cutting.*

Table 6.11 *Pine pulpwood from final cuts, Case study Västerbotten*
Arithmetic means. Total volume of pulpwood was predicted to be 22% of harvested volume

	Vol m3s ob	Bark Proc ob	Top Dia_ ob	Bolt Length	Dens	Heart-Diam	Heartw cont	Mean_Dbl_ Barkthickn	Late-wood
average	0,04876	12%	96	425	383	64	27%	8	24%
Stdev	0,02707	0,0	37	60	23	26	7,8%	3	3

	AnnGrRing	Fibre Length	Fib. Wall	KD Max	Green DensUb	Green Bark Dens	Defect Log	Mass kg	Inter-node
average	0,7	2,42	2,23	17,8	873	813	7,5%	47	12
Stdev	0,2	0,17	0,08	4,5	23	31		24	4

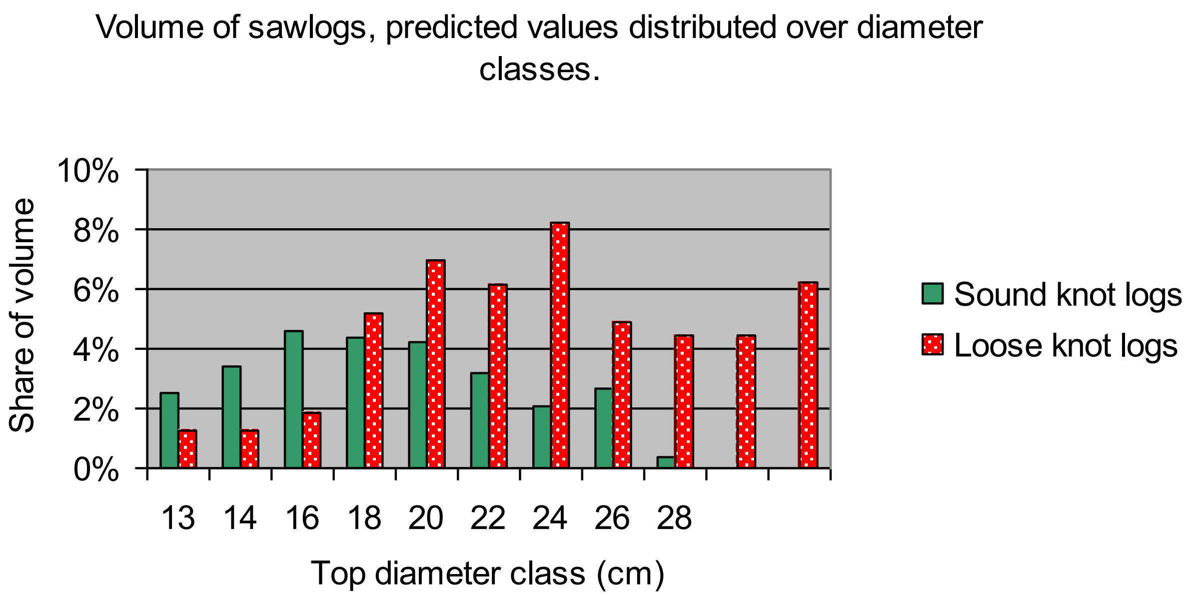


Figure 6.7 *Share of pine sawlogs over diameter classes at final cutting.*

6.8 Examples of bucking simulation including prediction of properties

Results from bucking simulation (Skogforsk-TimAn and Pri-analyses) using a standard length-neutral price list applied on 9715 samples trees from 951 plots originating from five years inventories made by the Swedish NFI (SLU Sweden). The regarded area consisted of the coastland of the two northernmost counties of Sweden according to Figure 3.1. The simulation included altogether 30384 logs of Pinus sylvestris (sawlogs, pulpwood and fuelwood).

Two alternatives have been simulated to characterise the possible yield from final cutting:

1) Cutting including a high proportion of saw logs, 70% of the total volume, including a high number of small dimension logs
2) Cutting including a lower proportion of saw logs, 55% of the total volume, emphasizing conversion from saw logs to pulpwood especially in the lower diameter classes.

Predicted properties described in the following tables are all based on models (functions) referred in the list of references.

Table 6.12a *Predicted properties at felling*

Eforwood Nordic test chain, Pine (Selections, all stands)		
Pine, Final cut [1]	Arithmetic averages	Tree Volume weighted
DBH (o.b.), cm	21.0	26.4
Tot height, cm	1525	1762
DBH (u.b) cm	19.2	24.8
Volume (o.b) m³solid ([2]Brandels func.)	0.314	0.518
of which bark (log volume weighted)	11,4%	11,4%
Thinning		
DBH (o.b.), cm	14.5	18.1
Tot height, cm	1165	1352
DBH (u.b) cm	13.3	16.6
Volume (o.b) m³solid (Näslunds func)	0.119	0.207
of which bark (log volume weighted)	13.0%	13.0%

Table 6.12b *Predicted properties at felling*

Eforwood Nordic test chain, All species and types of forests (Selections final cut Granslut, Tallslut,.Blandslut,.nf (Valingeret al.)

Final cut, all species [1]	Arithmetic averages	Tree Volume weighted
DBH (o.b.), cm	18.6	25.0
Tot height, cm	1402	1698
DBH (u.b) cm	17.5	23.4
Volume (o.b) m³solid ([2]Brandels func. pine, spruce, birch)	0.236	0.456
of which bark (log volume weighted)	11.2%	11.2%
Thinning[3]		
DBH (o.b.), cm	14.3	18.1
Tot height, cm	1179	1380
DBH (u.b) cm	13.3	16.9
Volume (o.b) m³solid ([2]Brandels func. pine, spruce, birch)	0.116	0.209
of which bark (log volume weighted)	12.2%	12.2%

[1]DBH>9 cm

[2]Brandel, G. 1990. Volymfunktioner för enskilda träd. Tall, gran och björk. SLU, Inst f skogsproduktion, Rapport 26, 72 s., Garpenberg.

[3] DBH thinned trees=0.9*DBH of average trees before thinning, Totheight thinned trees=0.95*Totheight of average trees before thinning

Log sizes see Table 6.13.

The volume figures are based on a simple function applied on the average tree (Arithmetic only)

Table 6.13 *Volume weighted log averages. 55% of volume saw logs from final cut. Analyses are based on bucking simulation applied on all sample plots (National Forest Inventory) (Material described in Wilhelmsson et al. Examples of bucking simulation including prediction of properties 2006-09-15 Internal document)*

	Pulp wood final cut	Saw logs final cut	Fuelwood	Pulpwood thinning	Sawlogs thinning	Fuel wood
Pulpwood with top diam (o.b) < 13 cm						
Length, cm	405	470		420	465	
Top diam (o.b.) average	8.1	22		8.5	18	
Share of total volume within assortment	18%			24%		
Pulpwood with top diam (o.b) >= 13 cm						
Length, cm	420			420		
Top diam (o.b.) average	17,5			15,6		
Share of total volume within assortment	82%			76%		
All pulpwood (55% sawlog alternative)						
Volume weighted top diam o.b (cm)	14,6			12,9		
Volume weighted length, cm	417			420		
Share of total volume of wood (all assortments)	40%	55%	5%	21%	74%	5%

Table 6.14 *Volumes and shares*

	Volumes and shares			
Overall volume and share statistics	Saw-logs	Pulpwood	Fuelwood	Total
Sum final cutting	6339138	4586087	578325	11503550
Final cut	55%	40%	5%	100%
Sum thinning	480526	1712367	117404	2310296
Thinning	21%	74%	5%	100%
Total sum	6819664	6298454	695728	13813846
% of total sum	49%	46%	5%	100%
Final cut % of tot volume	93%	73%	83%	83%
Thinning % of tot volume	7%	27%	17%	17%

7 M4/M5 – Processing, manufacturing, distribution and consumption (Anna von Schenck, Arto Usenius Margareta Wihersaari, Cathrine Löfgren, Gus Verhaeghe)

The Model Mills to be included in the Scandinavian case study:
BSKP = Bleached Softwood Kraft Pulp
BHKP= Bleached Hardwood Kraft Pulp

Fine paper mill_ (85 000 tonnes/year),100% kraft pulp (BSKP:BHKP = app. 1:2) Note: uncoated, 20% minerals

Kraftliner mill (290 000 tonnes/year), 100% kraft pulp Note: Kraftliner, 16 % minerals

7.1 Fine paper

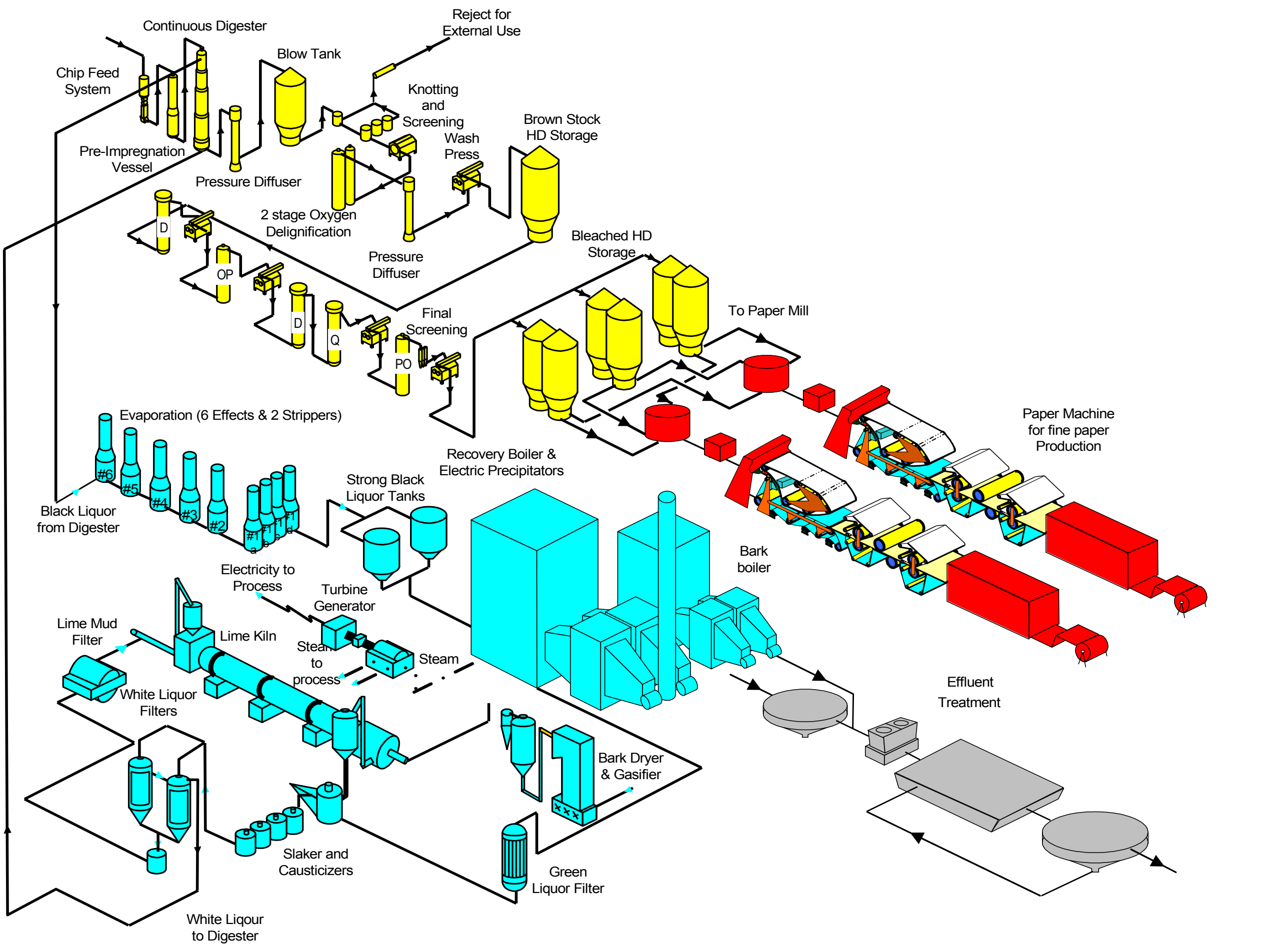


Figure 7.1 *A fine paper model mill including the fibre line, recovery area, steam generation, bleach plant and the fine paper machines.*

7.1.1 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.

7.1.2 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*.

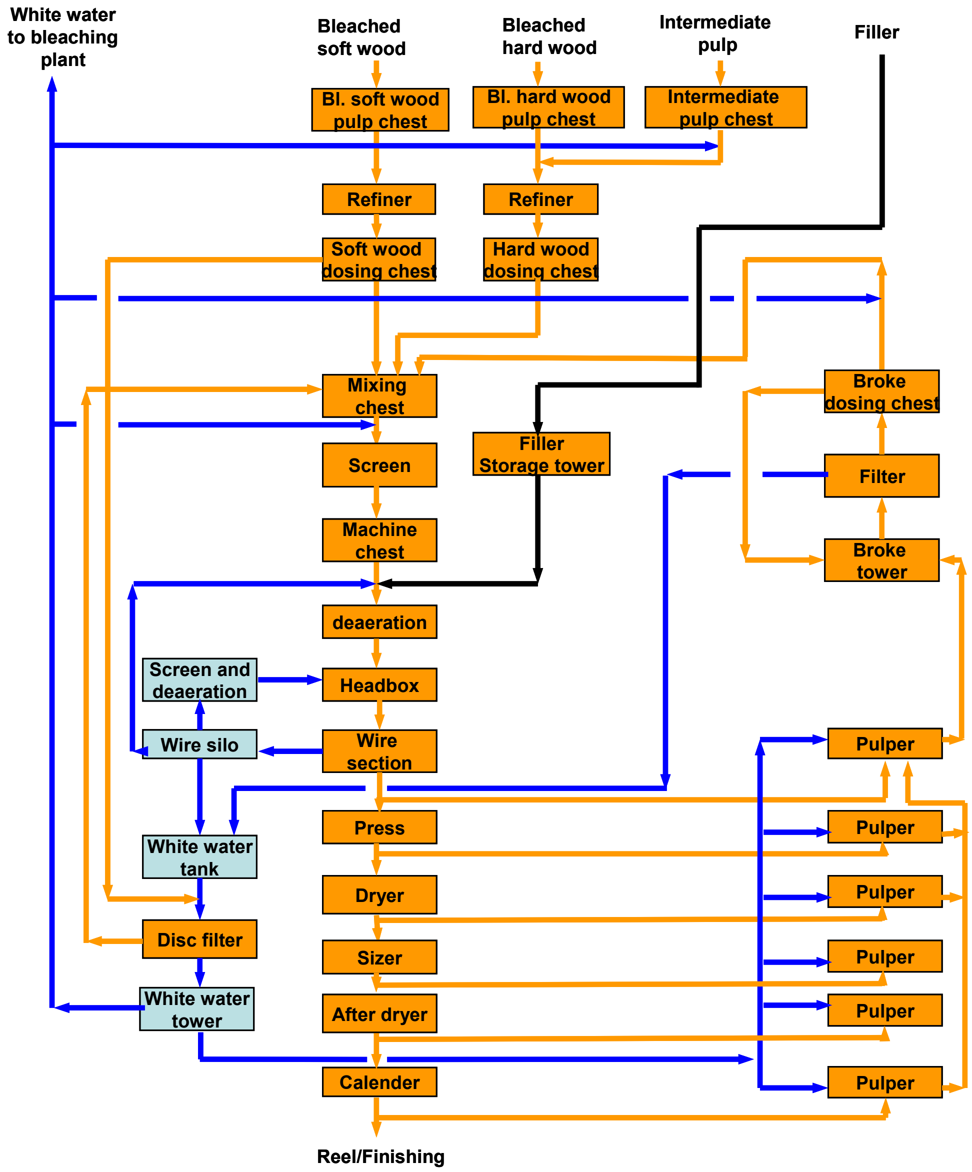


Figure 7.2 *Block diagram showing the process concept of the fine paper machines.*

7.1.3 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.

7.1.4 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.

7.1.5 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.

7.1.6 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.

7.1.7 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.

7.1.8 Effluent Treatment

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

7.1.9 The Fine paper product chain structure

The Fine paper product chain structure will be divided in two chains. One cover the distribution of Fine paper to production and use of magazines and the other one cover the distribution of Fine paper to production and use of office paper. Waste management is also included.

Based on the current information data for each chain will be collected for 2 Fine paper regions. One for the Central + Northern region of Europe (where the consumption patterns are similar for fiber products) and one for the Southern part of Europe

Field of application of Fine paper products from one Fine paper producer in the Northern part of Sweden.

	(tonne)	
Fine paper production	*680000*	
Uncoated	430000	63%
Coated	250000	37%
Uncoated - products	430000	
office paper	240000	56%
Statement of account, letter paper, etc	190000	44%
Coated - products	250000	
Magazine, journals	225000	90%
Brochure	25000	10%

7.1.10 Fine paper production and finepaper deliveries from northern part of Sweden, year 2004 and 2005.

(Information from The Swedish Forest Industries Federation – Skogsindustrierna.)

Fine paper production	**Production Fine paper (tonne)**	
	2004	**2005**
	925 772	960 506

Fine paper deliveries

Region	**Country**	**2004 (%)**	**2005 (%)**	
Europe	UK	16,54	16,27	
Europe	Germany	16,11	17,91	
Europe	Sweden	12,88	11,30	
Europe	France	5,90	4,53	
Europe	Denmark	3,86	4,08	
Europe	The Netherlands	3,35	3,76	
Europe	Turkey	3,23	2,16	
Europe	Spain	2,62	2,78	
Europe	Norway	2,59	2,68	
Europe	Finland	2,55	3,18	
Europe	Italy	2,36	1,56	70,20
Europe	Polen	1,97	2,68	
Europe	Latvija	1,83	0,76	
Europe	Belgium/Luxembourg	1,65	1,73	
Europe	Schweiz	1,38	1,45	

Europe	Austria	1,33	1,48
Europe	Russia	0,83	2,08
Europe	Hungary	0,67	1,23
Europe	Czech Republic	0,64	0,81
Europe	Ireland	0,58	0,57
Europe	Greece	0,53	0,48
Europe	Slovenia	0,32	0,43
Europe	Rumania	0,31	0,45
Europe	Ukraine	0,25	0,48
Europe	Estonia	0,23	0,25
Europe	Lithuania	0,23	0,25
Europe	Portugal	0,13	0,24
Europe	Iceland	0,13	0,09
Europe	Slovakia	0,12	0,29
Europe	Cyprus	0,09	0,09
Europe	Yugoslavia	0,06	0,04
Europe	Bulgaria	0,06	0,14
Europe	Croatia	0,05	0,06
Europe	Macedonia	0,02	0,04
Europe	Serbia Montenegro	0,02	0,02
Europe	Gibraltar	0,003	0,00
Europe	Malta	0,000	0,01
Europe	**TOT**	**85,42**	**86,35**
N. America		1,12	0,59
Latin America		1,63	0,87
Africa		3,69	3,77
Asia		7,81	8,23
Oceania		0,33	0,20
TOT	**TOT**	**100,00**	**100,00**

7.1.11 Fine paper products from Northern part of Sweden.

(Information from a Fine paper producer in the Northern part of Sweden.)

Finepaper

(information from a fine paper producer in the Northern part of Sweden)

	(tonne)	
Finepaper production	*680000*	
Uncoated	430000	63%
Coated	250000	37%
Uncoated - products	430000	
office paper	240000	56%
Statement of account, letter paper, etc	190000	44%
Coated - products	250000	
Magazine, journals	225000	90%
Brochure	25000	10%

7.1.12 Transports of finepaper to different Countries from from Northern part of Sweden.

(Information from a Fine paper producer in the Northern part of Sweden.)

Transports of Fine paper

1. Great Britain – boat toTillbury then truck to final destination
2. Germany - boat to Lübeck then truck to final destination
3. Sweden - truck to final destination
4. France - boat to Lübeck then truck or railroad to final destination
5. Denmark - truck to final destination bil
6. Holland - boat to Lübeck, then truck to Holland
7. Turkey – boat to final destination
8. Spain – boat to Lübeck then rail road, then it might be a short truck transport to final destination
9. Norway - truck to final destination
10. Finland - truck to final destination
11. Italy - boat to Lübeck then truck or railroad due to final destination

7.1.13 Fine paper production in from Northern part of Sweden.

(Information from Fine paper producer in the Northern part of Sweden.)

Average annual production about 680000 tonne.

7.1.14 Fine paper in summary

The different M5 Regions chosen in Eforwood are:

1. Western/ Northern Europe:

Austria, Belgium, Denmark, Finland, Germany, Ireland, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom (12)

2. Latin/Southern Europe:

Cyprus, France, Greece, Italy, Malta, Portugal, Spain (7)

3. East Europe:

Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic, Slovenia (8)

The data collection in M5 on volume flows will be based on country wise data. Common indicator values will be collected for indicator data.

Deliveries of Fine paper from northern part of Sweden to the different M5 regions in Europe and chosen Countries

1. Western/ Northern Europe:
Total part of deliveries of Fine paper to Western/ Northern Europe is 64 %
Chosen Country for data collection: Germany (18%).

2. Latin/Southern Europe:
Total part of deliveries of Fine paper to Latin/Southern Europe is 10%
Chosen Country for data collection: Spain (3%).

3. East Europe:
No Country Chosen in this group due to so small deliveries. (5%)

Chosen segments for the Fine paper products in M5
The Fine paper product chain structure will be divided in two chains. One cover the distribution of Fine paper to production and use of magazines and the other one cover the distribution of Fine paper to production and use of office paper. Waste management is also included.

1. Uncoated fine paper (office paper used at office)
2. Coated fine paper (magazines to store and to household)

Fine paper products from one Fine paper producer in the Northern part of Sweden are divided into uncoated (63%) and coated products (37%).

The part of the produced uncoated fine paper that is used as office paper is 56%.
The part of the produced coated fine paper that is used as magazines is 90%

Transports of fine paper from Sweden to the chosen Countries Germany and Spain

Germany: Boat to Lübeck then truck to final destination.
Spain: Boat to Lübeck then rail road, then a short truck transport to final destination.

7.2 Kraft paper

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.

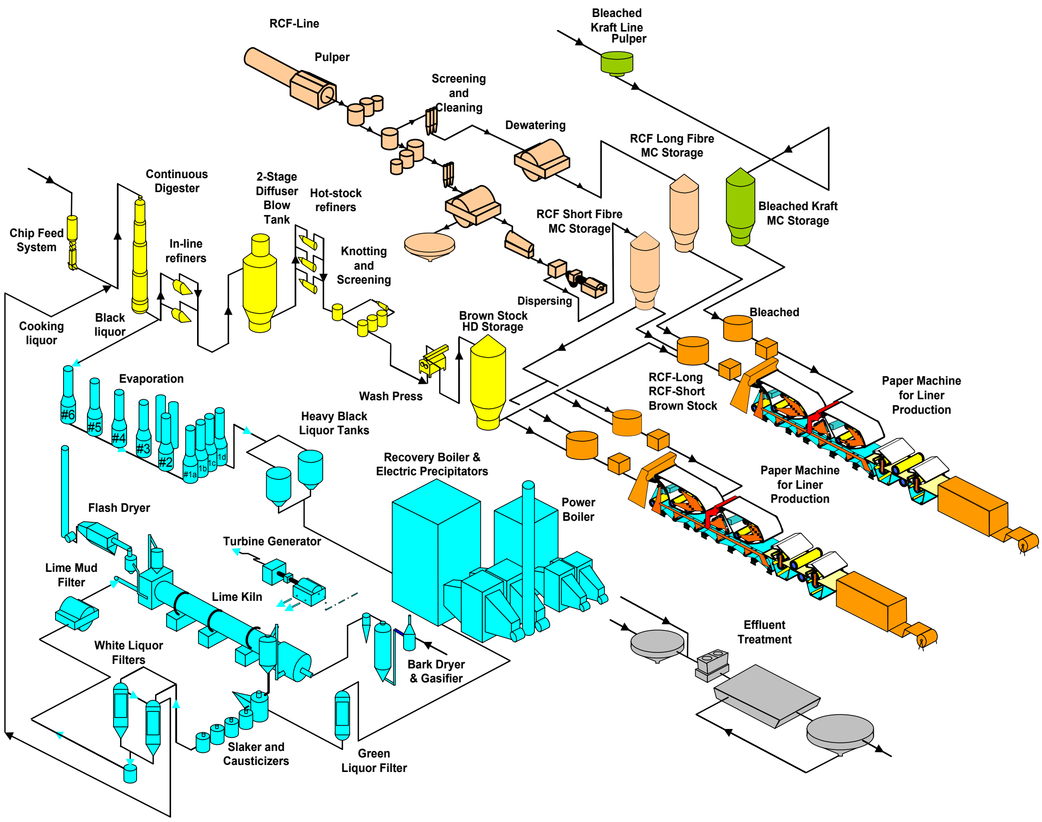


***Figure** 7.3 The kraftliner model mill including the fibre line, chemical recovery, steam and power generation, liner machines, and effluent treatment.*

7.2.1 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.

7.2.2 Cooking

Cooking and delignification is performed in a continuous digester.

7.2.3 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.

7.2.4 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 kraft liner mill. A power boiler burning bark is therefore used to produce the required additional steam.

7.2.5 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 hot melts, stickies and other contaminants are dispersed.
The reject handling separates the various types of rejects and thickens 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.

7.2.6 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.

7.2.7 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.

7.2.8 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 head box 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 run ability 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 run ability 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.

7.2.9 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 are the same as in the integrated fine paper mill.

7.2.10 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.

7.2.11 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.

7.2.12 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.

7.2.13 The Kraftliner product chain structure

The Kraftliner product chain structure will cover the distribution of Kraftliner to production of corrugated boxes, to retail user and to industry user and then to waste management.

Based on the current information data will be collected for 2 Kraftliner regions. One for the Central + Northern region of Europe (where the consumption patterns are similar for fiber products) and one for the Southern part of Europe

Field of application of Kraftliner products (corrugated boxes).

Segment	Central and Northern	Southern
Food and drinks	33%	42%
Industrial	37%	25%
% of total	70%	67%

7.2.14 Kraftliner production and kraftliner deliveries from northern part of Sweden, year 2004 and 2005.

(Information from The Swedish Forest Industries Federation – Skogsindustrierna.)

Kraftliner production from 3 mills, northern Sweden	Production Kraftliner (tonne)	
	2004	2005
	1 267 069	1 265 363

Kraftliner deliveries
(average value from 3 mills)

Region	Country	2004 (%)	2005 (%)	
Europe	Germany	19,36	20,12	
Europe	UK	17,03	16,75	
Europe	The Netherlands	8,74	9,14	
Europe	Spain	8,04	7,82	
Europe	Sweden	7,14	6,92	
Europe	Denmark	6,10	5,33	
Europe	France	5,10	4,04	70,11
Europe	Finland	4,00	3,04	
Europe	Italy	3,62	5,31	
Europe	Ireland	2,60	2,34	
Europe	Belgium	2,13	1,99	
Europe	Austria	1,90	2,06	
Europe	Schweiz	1,62	2,32	
Europe	Norway	1,24	1,20	
Europe	Portugal	0,62	0,56	
Europe	Polen	0,61	0,54	
Europe	Czech Republic	0,30	0,65	
Europe	Greece	0,28	0,53	
Europe	Hungary	0,21	0,31	
Europe	Iceland	0,19	0,16	
Europe	Turkey	0,16	0,53	
Europe	Lithuania	0,08	0,06	
Europe	Cyprus	0,05	0,06	
Europe	Rumania	0,02	0,03	
Europe	Slovakia	0,01	0,02	

Europe	Coatia	0,01	0,00
Europe	Russia	0,003	0,00
Europe	Estonia	0,0004	0,08
Europe	Malta	0,00	0,05
Europe	/Luxembourg	0,00	0,02
Europe	Macedonia	0,00	0,01
Europe	Bulgaria	0,00	0,01
TOT		**91,14**	**91,98**
N. America		0,13	0,04
Latin Amerika		0,27	0,20
Africa		1,49	2,18
Asia		6,73	5,59
Oceania		0,23	0,00
TOT		**100,00**	**100,00**

7.2.15 Kraftliner products from Västerbotten to Germany, the Nordic countries and to Italy.

(Information from kraftliner producer in Västerbotten, Sweden.)

GERMANY	
Segment	Andel
Processed foods	14%
Drinks	7%
Short shelf life foods	12%
Non food Cons.	5%
Consumer durables	15%
Industrial	41%
Other	6%
NORDIC Countries	
Processed foods	16%
Drinks	6%
Short shelf life foods	11%
Non food Cons.	5%
Consumer durables	20%
Industrial	32%
Other	10%
ITALY	
Processed foods	21%
Drinks	9%
Short shelf life foods	12%
Non food Cons.	7%
Consumer durables	17%
Industrial	25%
Other	9%

Average value for Germany and the Nordic countries that will represent the consumtion of kraftliner products central and northern Europe

Segment	
Processed foods	15%
Drinks	6%
Short shelf life foods	11%
Non food Cons.	5%
Consumer durables	17%
Industrial	37%
Other	8%

The information about Italy that will represent the consumtion of Kraftliner products in southern Europé.

ITALY	
Processed foods	21%
Drinks	9%
Short shelf life foods	12%
Non food Cons.	7%
Consumer durables	17%
Industrial	25%
Other	9%

7.2.16 Transports of Kraftliner to different Countries from västerbotten, Sweden.

(Information from kraftliner producer in Västerbotten, Sweden.)

Transports of kraftliner to different Countries from Västerbotten	
Sweden	Railroad to main storage in Skövde, then truck to final destination.
Denmark	"
Finland	Ferry from Holmsund to Vasa, then truck to final destination
Germany	Boat to Lübeck, then truck to final destination
Holland	Boat to Rotterdam, then truck to final destination
England	Boat to Tilbury (London), then truck to final destination
France	Boat to Rotterdam, then truck to final destination
Spain,	Boat to Gandia, then truck to final destination

7.2.17 Kraftliner production in Västerbotten.

(Information from kraftliner producer in Västerbotten, Sweden.)

Average annual production about 400000 tonne.

7.2.18 Kraftliner in summary

The different M5 Regions chosen in Eforwood are:
1. Western/ Northern Europe:
Austria, Belgium, Denmark, Finland, Germany, Ireland, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom (12)
2. Latin/Southern Europe:
Cyprus, France, Greece, Italy, Malta, Portugal, Spain (7)
3. East Europe:
Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic, Slovenia (8)

The data collection in M5 on volume flows will be based on country wise data. Common indicator values will be collected for indicator data.

Deliveries of Kraftliner from northern part of Sweden to the different M5 regions in Europe and chosen Countries

1. Western/ Northern Europe:
Total part of deliveries of Kraftliner to Western/ Northern Europe is 71%
Chosen Country for data collection: Germany (20%).

2. Latin/Southern Europe:
Total part of deliveries of Kraftliner to Latin/Southern Europe is 18%
Chosen Country for data collection: Spain (8%).

3. East Europe:
No Country is chosen in this group due to so small deliveries.

Chosen segments for the Kraftliner products in M5
The Kraftliner product chain structure will cover the distribution of Kraftliner to production of corrugated boxes, to retail user and to industry user and then to waste management.

1. Industry
2. Retailer

Field of application of Kraftliner products in Germany: Industrial 37 % and
Retailer 32%.

Field of application of Kraftliner products in Spain: Industrial 25 % and Retailer 42%.

Transports of Kraftliner from northern part of Sweden to the chosen Countries Germany and Spain.
Germany: Boat from Holmsund to Lubeck, then truck to final destination.
Spain: Boat to Gandia, then truck to final destination.

7.3 Solid wood chain

<u>Model Mills to be included in Scandinavian case study</u>
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

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

7.3.1.1 Saw milling

Timber Production Processes - Today and Future Processes

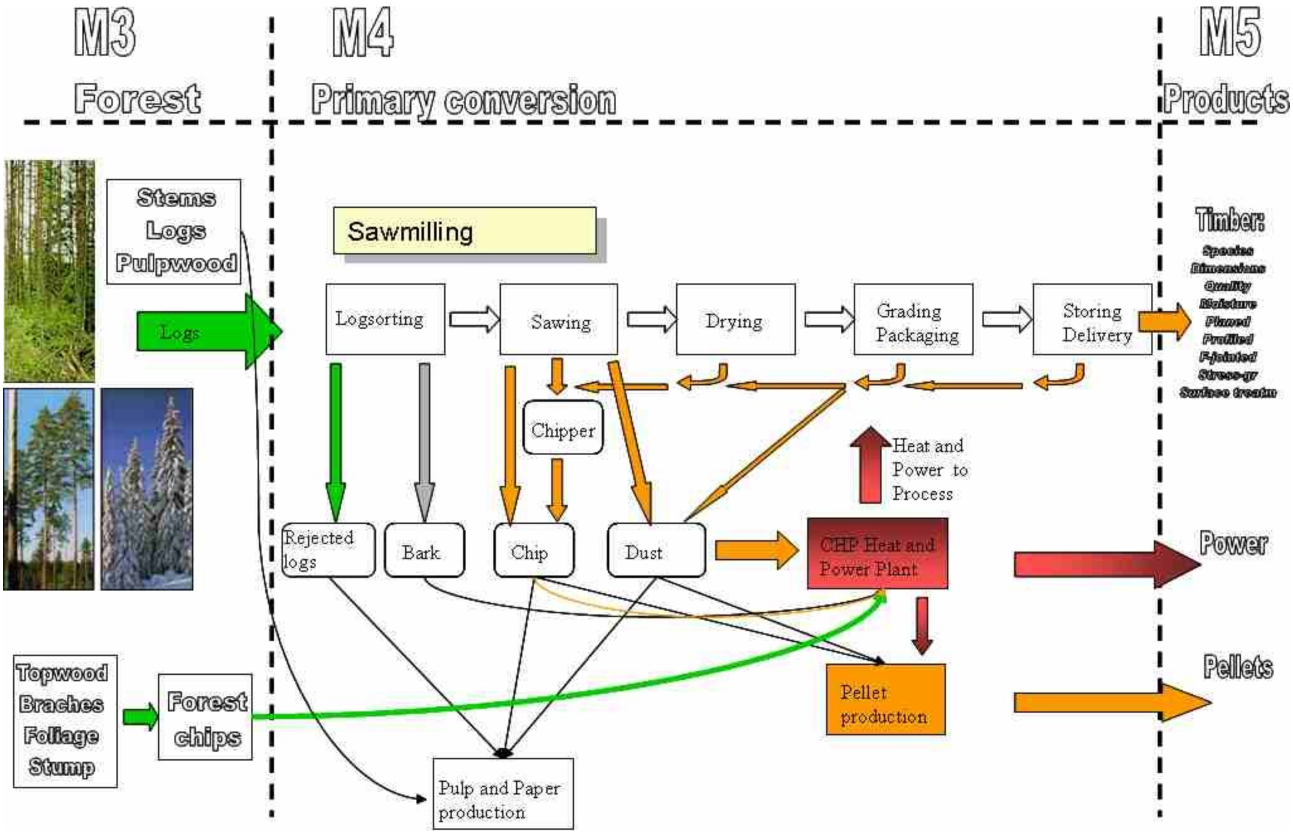


***Figure** 7.4 Phases in the sawmill converting stems to sawn timber.*

7.3.1.2 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.

7.3.1.3 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.

7.3.1.4 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.

7.3.1.5 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.

7.3.1.6 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 in information for “collecting” right pieces into right bins and further to drying.

7.3.1.7 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 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.

7.3.1.8 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.

7.3.1.9 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.

7.3.2 Wood-based panels

7.3.2.1 Plywood

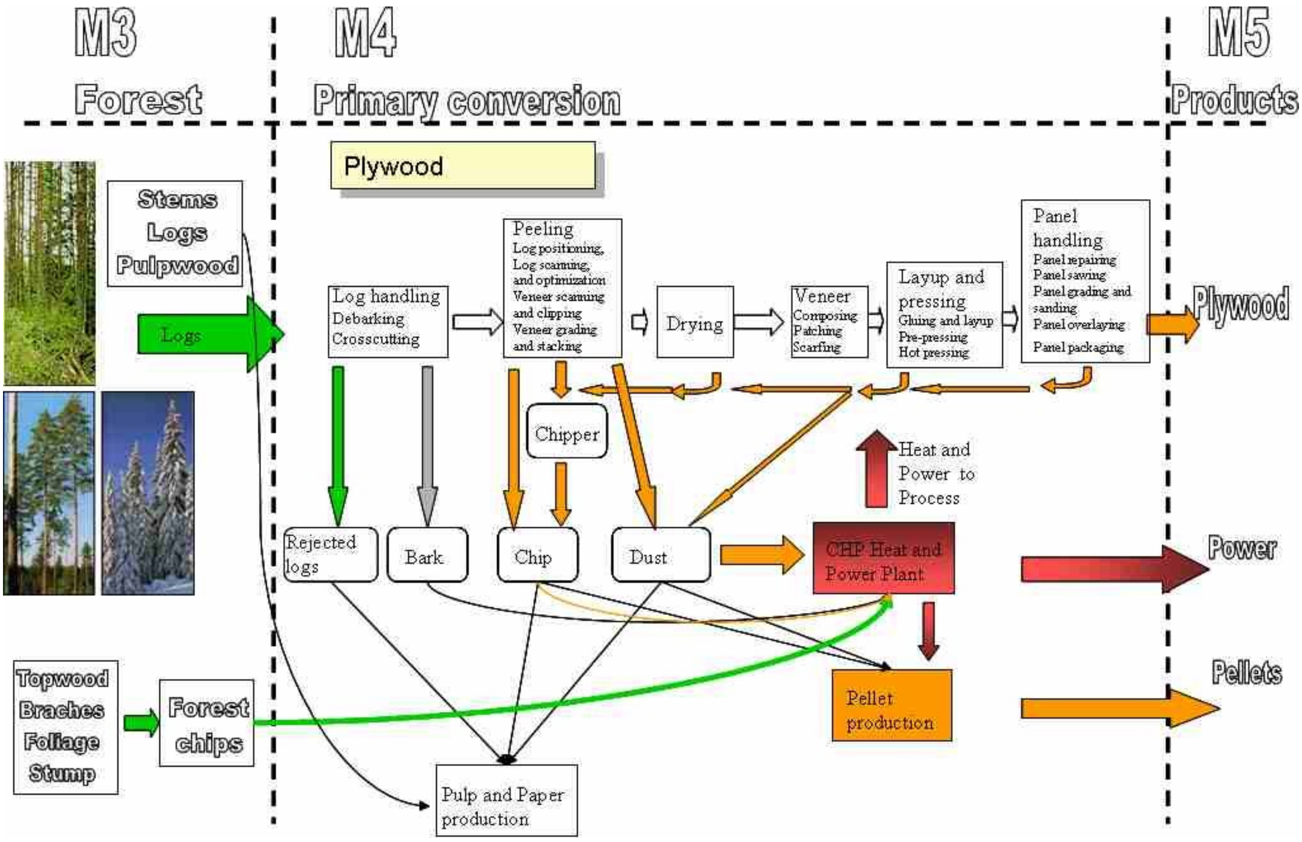


Figure 7.5 Phases in the manufacturing process of plywood.

7.3.2.2 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.

7.3.2.3 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.

7.3.2.4 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.

7.3.2.5 Veneer drying

Veneer is dried 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 re-drying. 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 fibreboard or energy. Exhaust air from dryer is led into scrubber for washing and for heat recovery.

7.3.2.6 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.

7.3.2.7 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.

7.3.2.8 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.

7.3.2.9 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.

7.3.2.10 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.

7.3.3 Particleboard and OSB

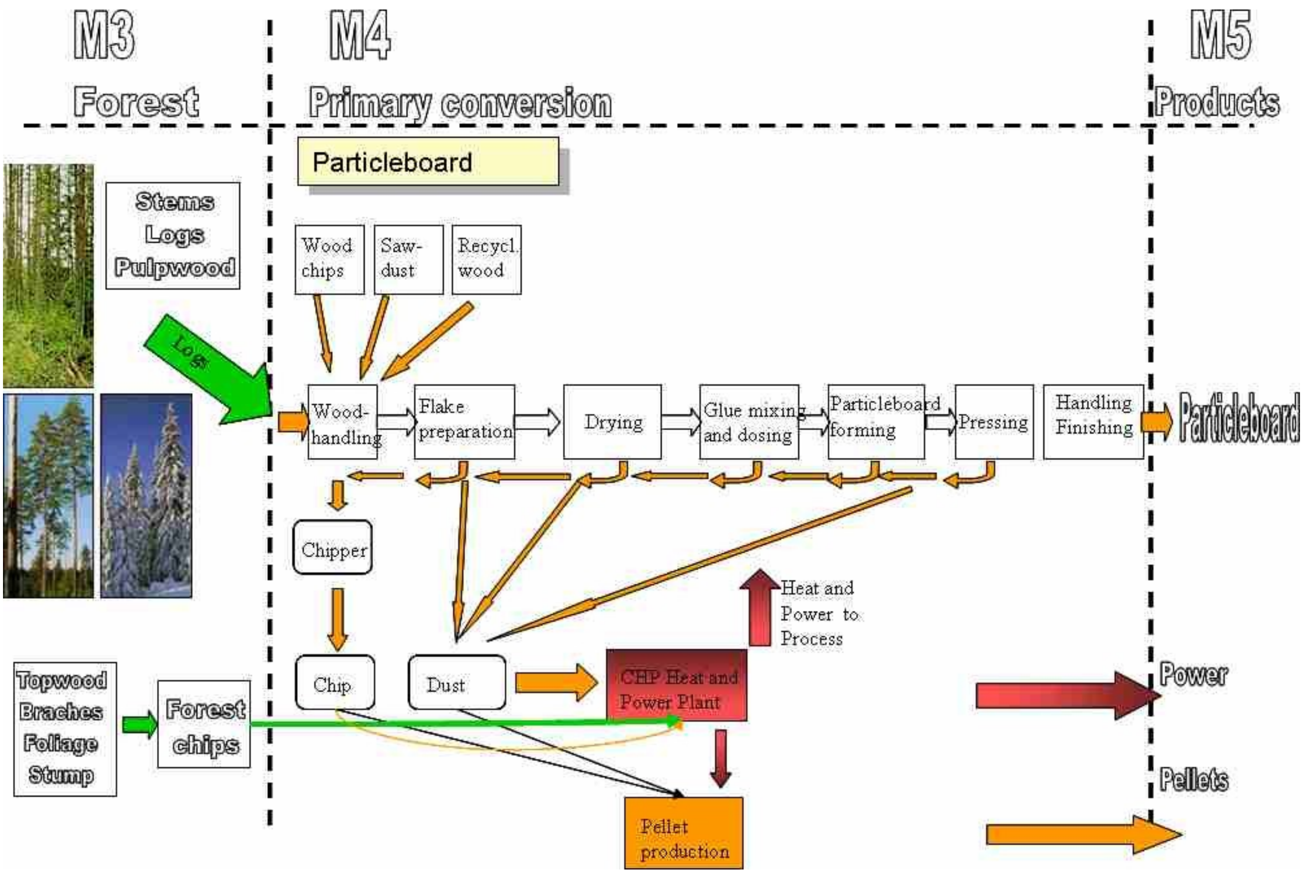


Figure 7.6 Phases in the production of particleboard.

7.3.3.1 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.

7.3.3.2 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.

7.3.3.3 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.

7.3.3.4 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.

7.3.3.5 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.

7.3.3.6 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.

7.3.3.7 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

7.3.3.8 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.

7.3.4 Prefabricated buildings

7.3.4.1 Gluelam production

Glulam manufacture is carried out in much the same way regardless of manufacturer or country. Figure 7.7 shows, schematically, a sketch of the manufacture.

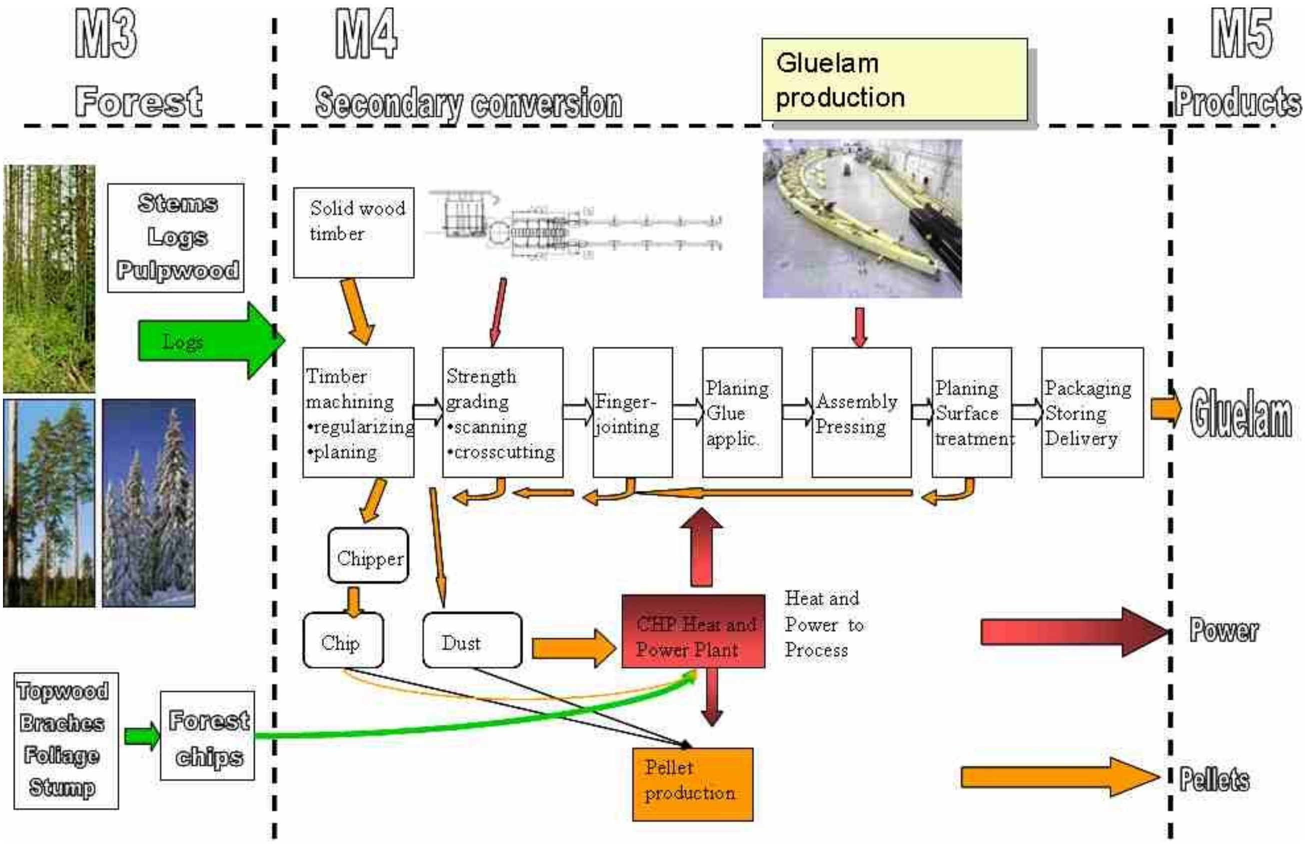


Figure 7.7 Phases in the production of gluelam.

7.3.4.2 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 directly 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 negative effects on the load bearing capacity of the construction.

7.3.4.3 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.

7.3.4.4 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.

7.3.4.5 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 **planer** where the sides are planed to the required degree of finish.
Then follows the **final work** of the components, e.g. fine sawing, drilling of holes, 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.

7.3.4.6 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”.

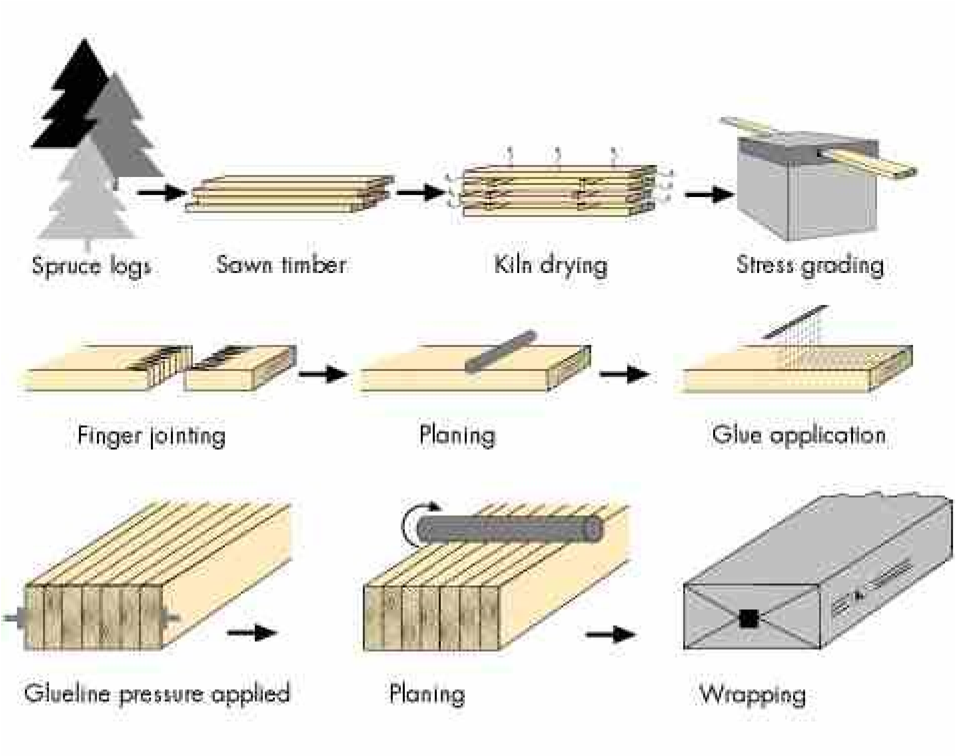


Figure 7.8 *GlueLam manufacturing.*

7.3.5 Edge Glued Panel/Board Production

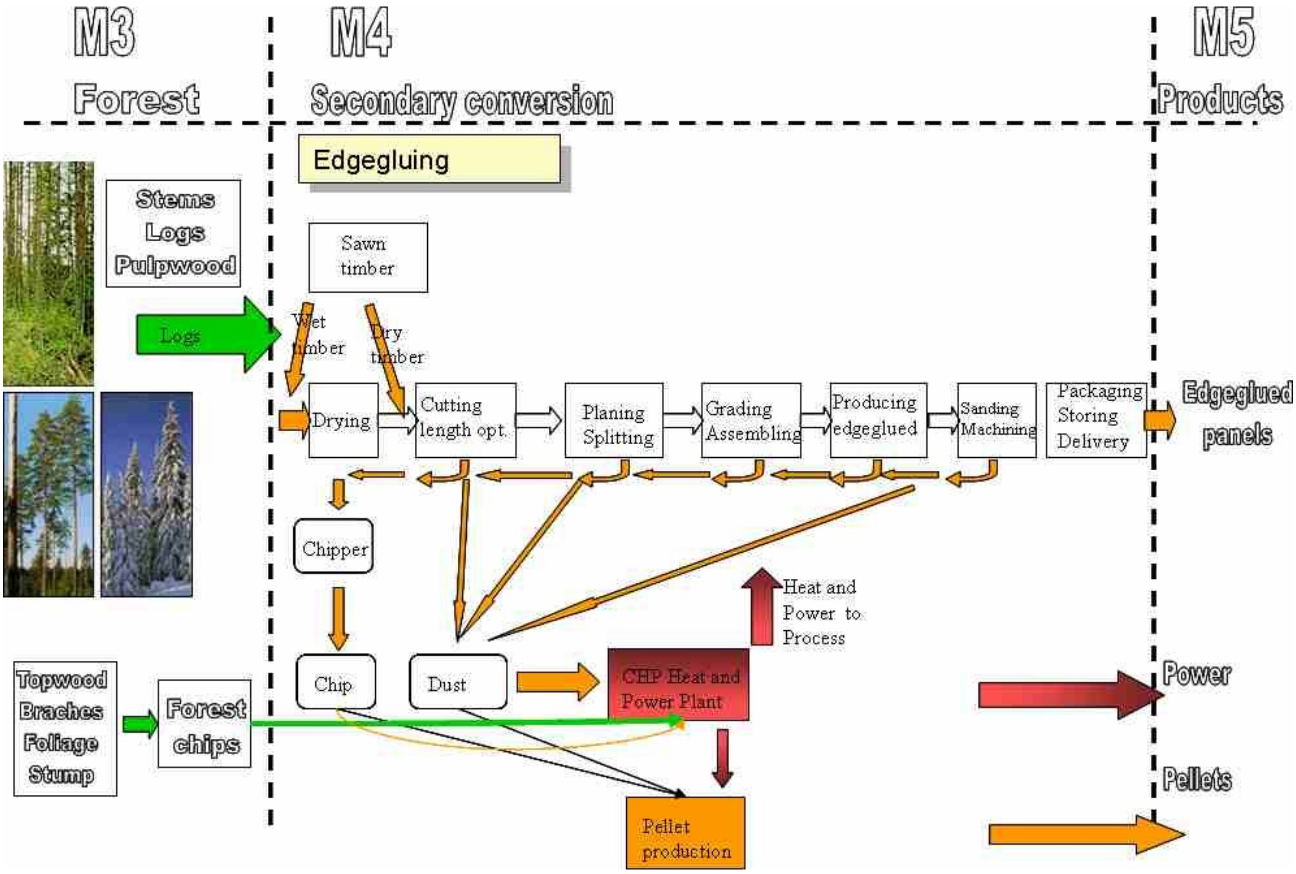


Figure 7.9 General edge glued panel/boards production process steps.

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.

7.3.5.1 Drying (option)

Procedure of wood drying is given in 7.3.1.7 "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.

7.3.5.2 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.

7.3.5.3 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.

7.3.5.4 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.

7.3.6 Window production

7.3.6.1 Raw material (wood)

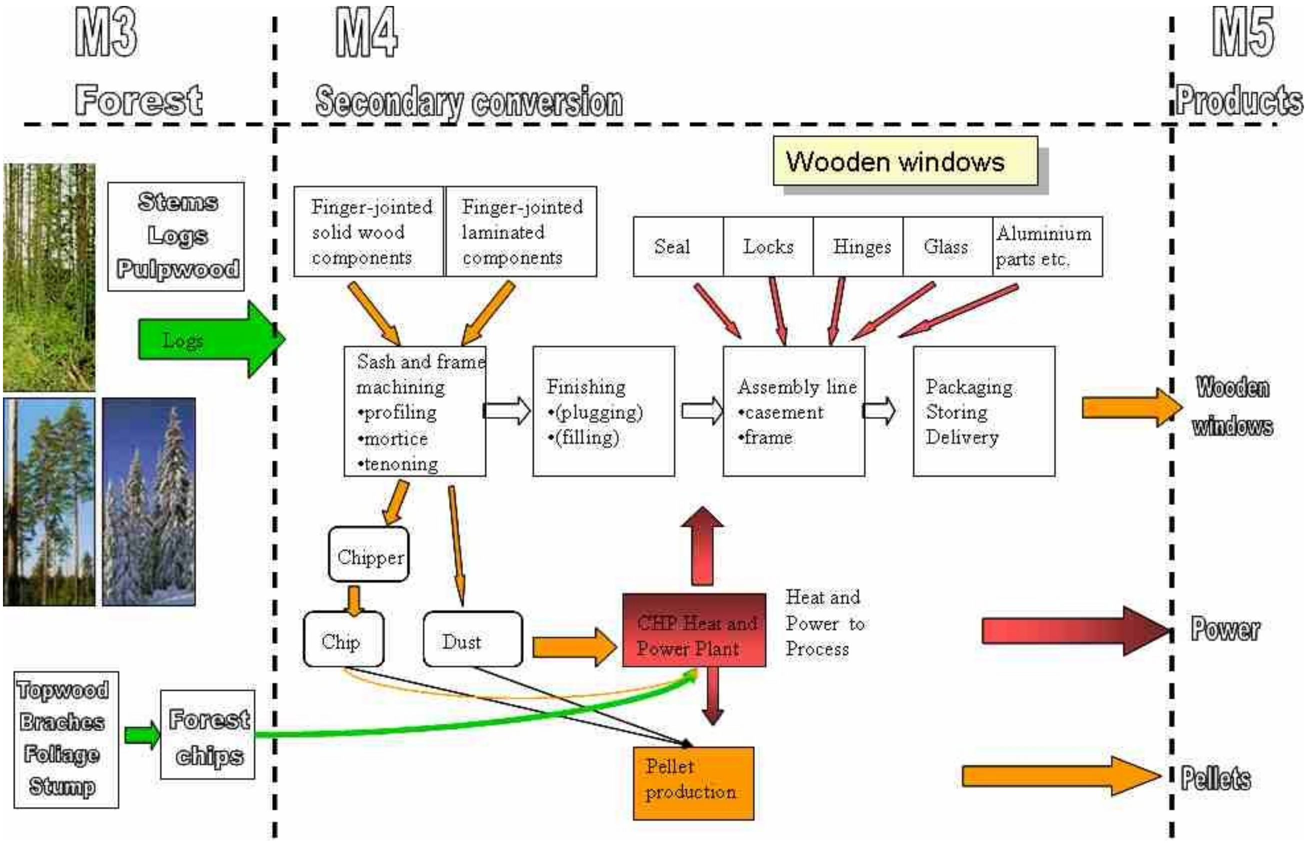


Figure 7.10 Manufacturing of wooden windows.

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)

7.3.6.2 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.

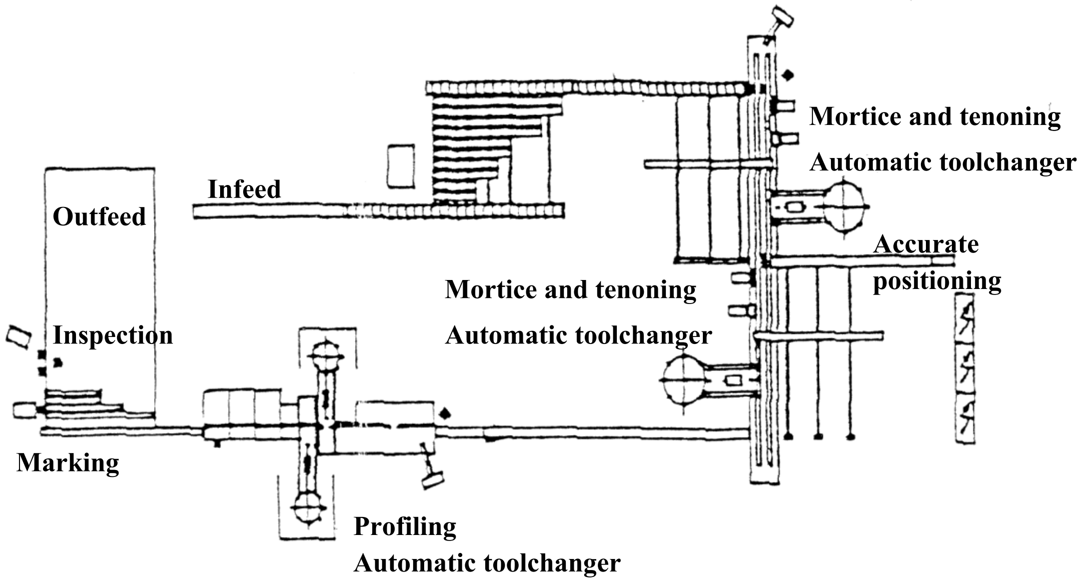


Figure 7.11 *Sash and frame machining (example).*

7.3.6.3 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.

7.3.6.4 Assembly

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

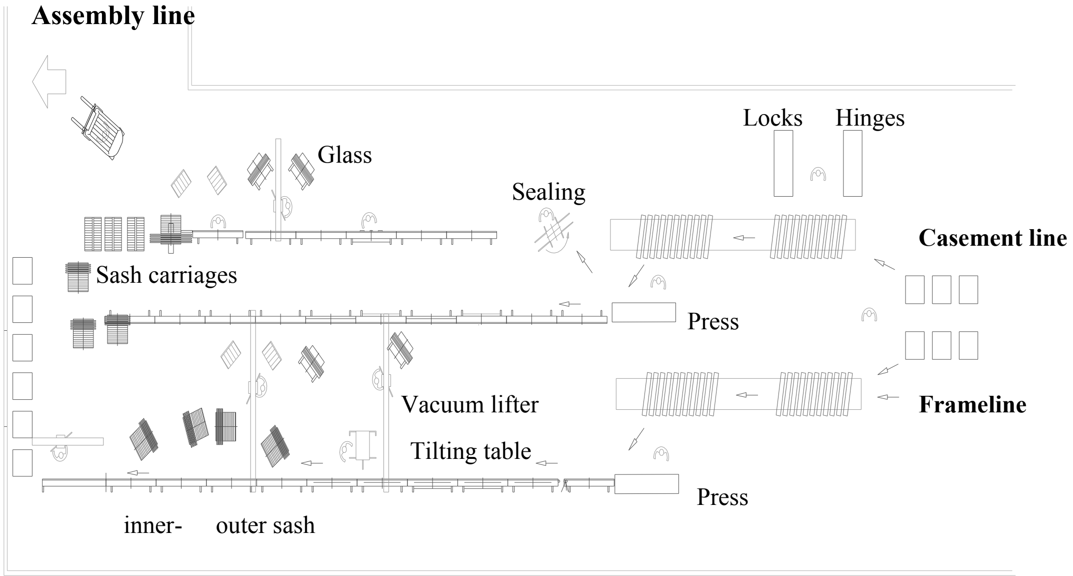


Figure 7.12 *Wood window assembly line (example).*

7.3.6.5 Packaging, storing and delivery

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

7.3.7 Production of wooden houses

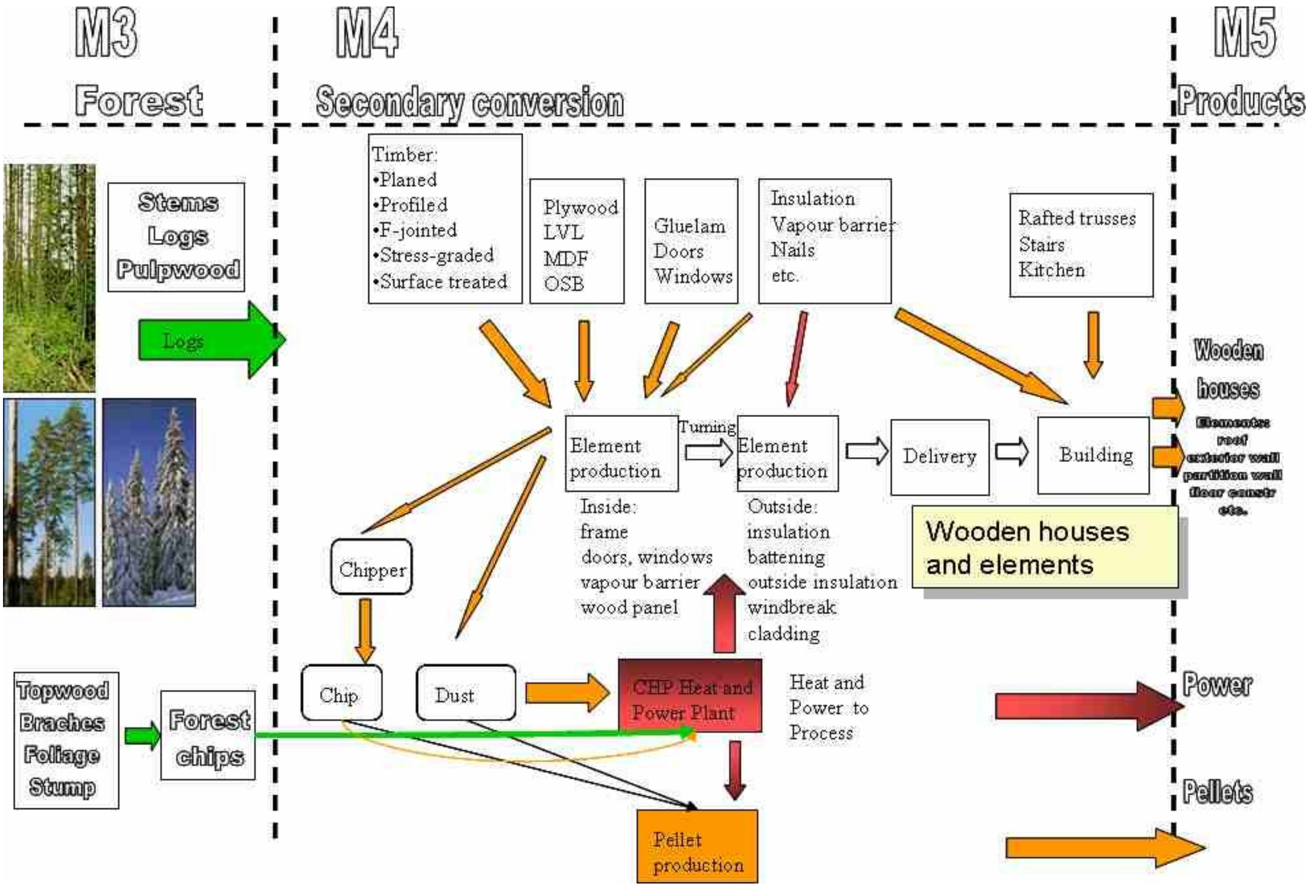


Figure 7.13 *Production principle of wood houses and wooden elements.*

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.

7.3.8 Furniture

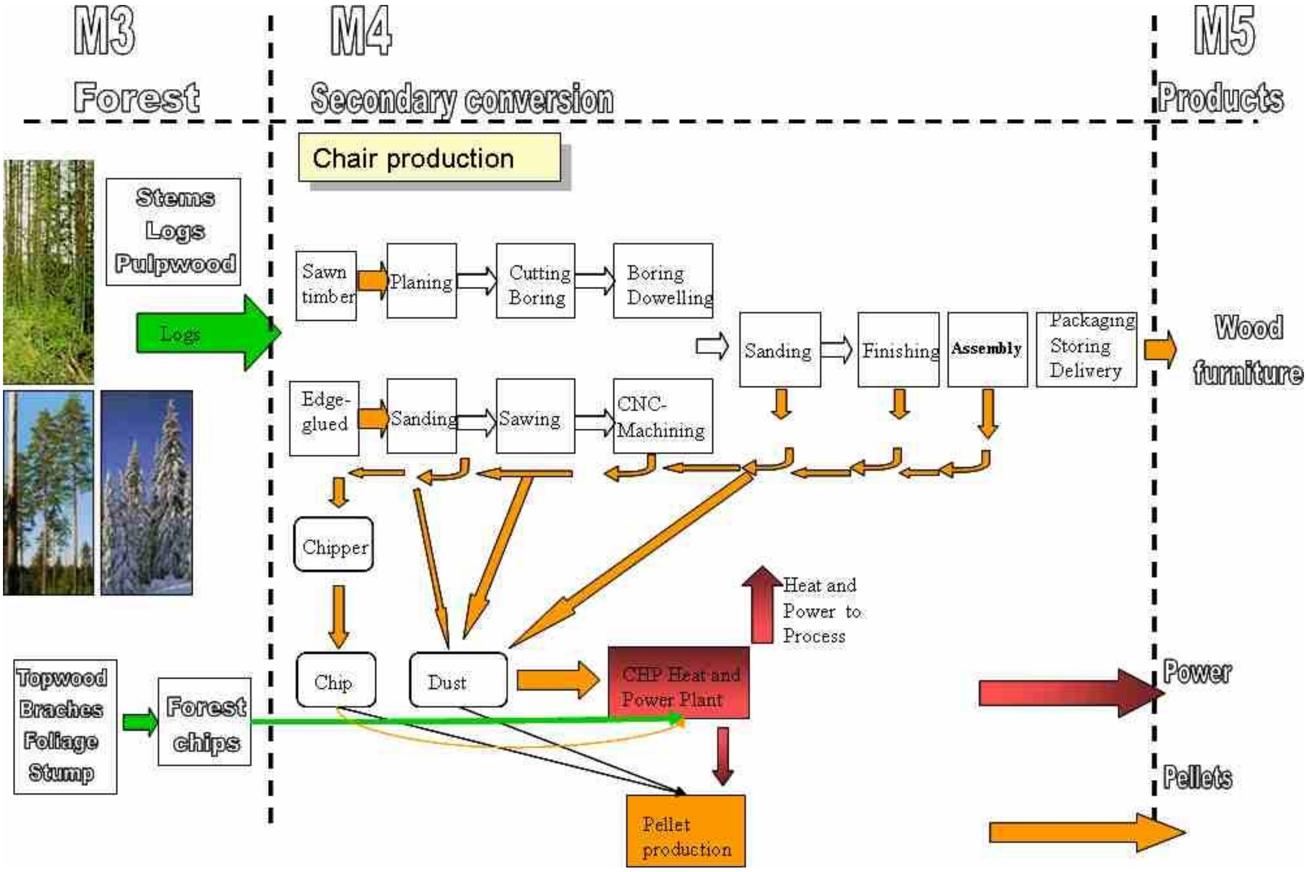


Figure 7.14 *Phases in solid wood chair production.*

7.3.9 Solid wood in summary

The wood chain in the Scandinavian case ends with the consumption of the products produced along the chain of processes beginning with the forest production in the Västerbotten region. The processes in M5 producer-consumer interaction are basically divided into 3 groups:

- Distribution of the finished product from the producer to the end user
- Use of the wooden products
- Recovery and the end of life routes for the wooden products

The end products in the case study have been defined by M4 and are the following:

- Wooden houses
- Gluelam
- Windows
- Furniture
- Planed goods
- Particleboards
- Plywood
- Sawn wood

7.3.9.1 Wooden houses

Wooden houses as end product are the result of assembly of the outcomes of different other solid wood chains. The installation of the wooden house can be done in different ways, depending on the type of house. Wooden houses can be constructed at the residential site, or can be prefabricated at the manufacturer's site and transported to residential site where they get assembled.

The process chain for the wooden houses in the Scandinavian case in M5 is presented in Appendix 2.

7.3.9.2 Gluelam

Gluelam has been developed in order to be able to use wood for construction and load bearing applications where the traditional dimensions of solid wood does not meet the requirements (too small). Gluelam can be used for very big roof beams or bridge building, but also for traditional building. According to the application the gluelam beam is tailored made or has a standarad size. Depending on the size the first M5 process (transport to the end user) can differ quite a lot, going from normal transport with a lorry to special long vehicle transport for big dimension gluelam beams.
The process mapping of gluelam in the Scandinavian case in M5 is presented in Appendix 2.

7.3.9.3 Windows

Depending of the type of building the wooden window gets installed at a different place in the material chain. If the window is used in a prefabricated wooden house, the windows get installed at the manufacturer's production site and no transport of the windows as such in M5 is occurring. When the windows get installed at the building site of the house, there is a transport of the window to the construction site. The M5 chain in the Scandinavian case foresees the second option (Appendix 2)

7.3.9.4 Furniture

In the Scandinavian chain it is assumed that the wooden furniture exists out of solid wood together with other wood-based material as plywood and particleboard. Depending on the purpose of the furniture the distribution will happen on a different way for example public furniture for schools, hospitals or hotels (business to business distribution models) has another distribution chains as furniture for household use (business to consumer distribution). In the M5 of the Scandinavian chain, the second group is choses. Appendix 2 reflects the process chain for furniture in M5 for the Scandinavian case.

7.3.9.5 Planed goods

To be completed.

7.3.9.6 Particleboard

Particleboard gets a lot of purposes, both as an end product towards the final users and as an intermediate raw material for the production of other wood-based products. The main application of particleboard is the furniture production and the use in construction. By replacing solid wood in a variety of applications, particleboard makes wood furniture more affordable for the consumer. Particleboard supports all the variations in design and style which have become the basis for modern living. To chose particleboard for furniture means supporting both tradition and style.

Particleboard for structural applications is easy to handle and to process. Different types of speciality boards can be produced according to individual building application requirements. Moisture resistance, fire retardance or acoustic insulation are all proporties which can be achieved by using specific types of particleboard. Particleboard can also be used for construction purposes in combination with other materials, for example in parquet or insulation materials.

For the Scandinavian case, the M5 processes mapping for particleboards are focussed on the use in construction (Appendix 2).

7.3.9.7 Plywood

Just as particleboard, plywood is in various cases only an intermediated raw material for the production of a final wooden or wood-containing end product. The most important uses of plywood are the construction sector, the furniture sector and the transport and packaging sector.

The most important uses of plywood in the building sector are:
- Concrete formwork and shuttering
Plywood is used for technically demanding formwork systems, as it withstand many castings. It is exceptionally hard wear. Plywood can be coated by phenolic film coating, which is hot pressed on the plywood surface. Other types of shuttering panels are available for less demanding formwork projects, where the form is not used many times, but the casting finish still needs to be good.
- Wood based construction and Facades
Plywood is an important element in wood based construction. Moreover, plywood industry has developed special plywood for balconies and other demanding outdoor applications. Plywood can also be used for facades in buildings, which will be painted.

For furniture production plywood is also very import:
The use of plywood is highly recommended for furniture components and quality furniture, due to its good technical characteristics, its lightness, its high dimension stability, as well as its good surface finishing properties. The plywood used for furniture is often covered with solid wood veneer or laminated wood, for which it is a good support. The finished furniture product will benefit from the finest qualities of plywood.

In the M5 Scandinavian chain the plywood final use has been chosen to be construction and do it yourself purposes, as presented in Appendix 2.

7.3.9.8 Sawn wood

The sawn wood process chain fo M5 in the scandinavian case is reflected in Appendix 2. Although sawn wood is in the major of the occasions only a intermediate product in M4, it can also be a final product provided in M5. In this case the sawn wood is used for construction and building purposes and do it yourself applications.

7.4 The Bioenergy Flows

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, fig 7.15. 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. However, at a meeting in Freiburg it was decided that it should be excluded from the case study.

The third group of biomass-to energy within Eforwood is forest residue from clear cuttings, thinning, 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 sells and buys 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 has 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 sells 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 Bio energy 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. Bio energy 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.

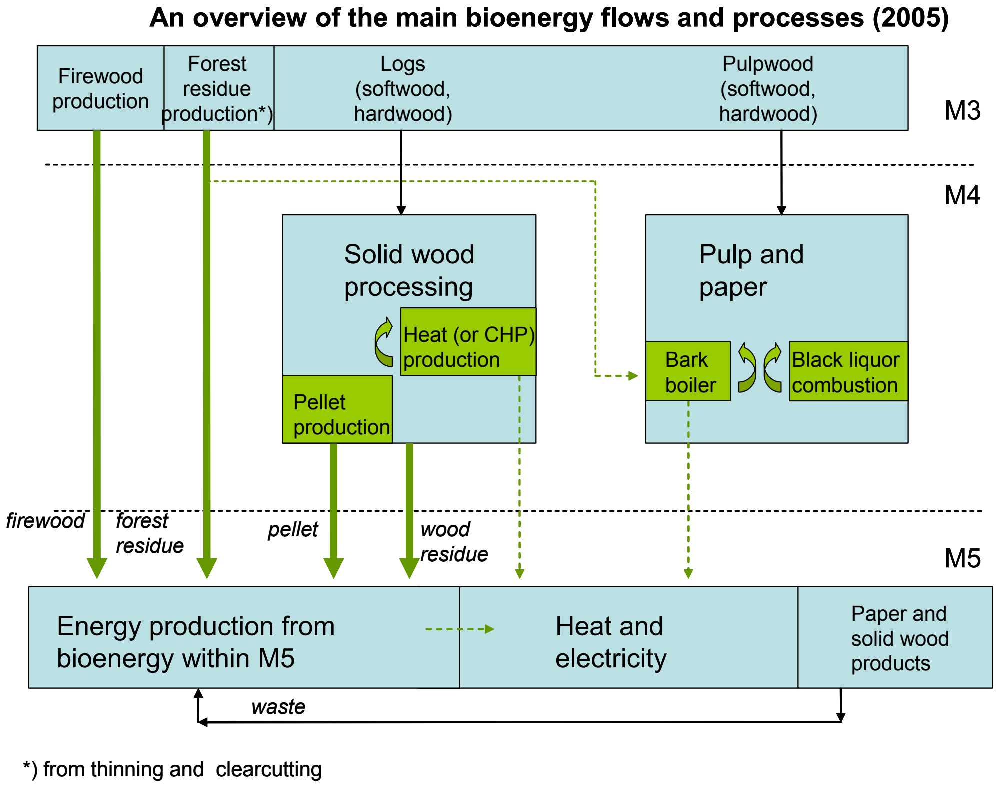


Figure 7.15 Main bioenergy flows and processes

7.4.1 Bioenergy in case study countries

In this chapter some data about bioenergy utilisation in case study countries is represented that could be updated an used within the introduction of case studies. 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. As previously stated (Chapter 7.4) it was decided at a meeting in Freiburg that as its social and economic impact cannot be modelled it should be excluded from the case study.

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:

Residential firewood: flowing from M3 to M5, not part of M4. The residential firewood flow is a small part of the of wood-to-energy flow in the Scandinavian case studies.

Wood residue (construction and demolition wood, packing and paper waste, not paper re-circulated to M4): this flow is born when wood and paper products end up as waste. Parts of this flow end up at landfills and parts are used in wood-based combined heat and power production plants and municipal solid waste incineration plants within M5.

Figure 7.16 shows the wood biomass resources used for covering energy consumption in the countries where the case studies are performed.

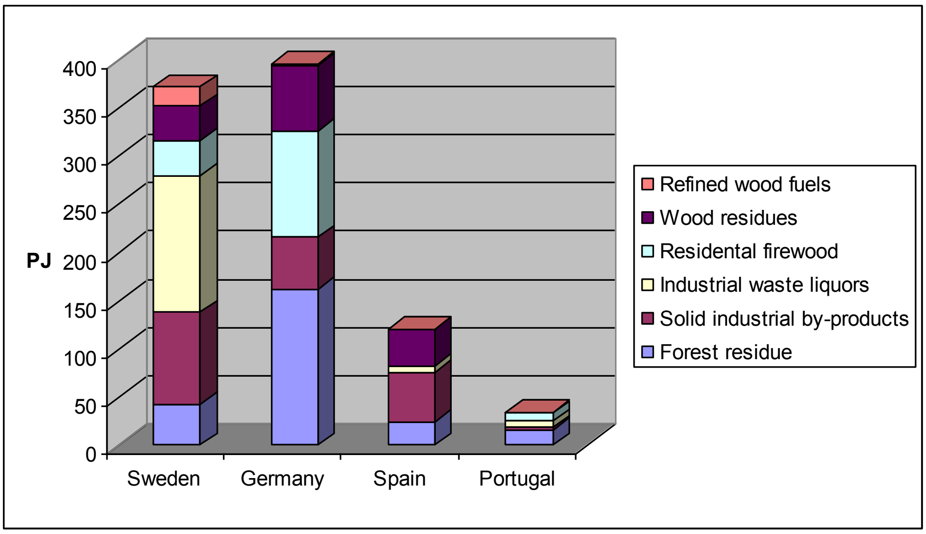


Figure 7.16 *The magnitude of wood biomass resources used for energy (2004) in Eforwood case study countries (Information source: EUBIONET).*

7.4.2 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. In Fig. 7.17 the bioenergy use within P&P industry in case study countries is presented.

Table 7.1 *Bioenergy use 2004 within pulp and paper industry in case study countries (source: EUBIONET)*

Country	PJ
Sweden	187,8
Germany	26,5
Spain	36,3
Portugal	33,9

Table 7.2 *Industrial biomass users Bioenergy in case study countries (source: EUBIONET)*

Industrial biomass users

	Pulp and Paper solid biomass			Pulp and Paper recovery boilers black liquor)		Sawmills			Other industries		
	MW_{th}	MW_e	plants	MW_{th}	plants	MW_{th}	MW_e	plants	MW_{th}	MW_e	plants
Sweden	na	na	na	na	na	na	na	na	na	na	na
Germany	na	na	160	na	na	na	na	2 200	na	na	na
Spain	na	25	1	na	3	na	4	1	na	72	8
Portugal	500	332	7	na	na	44	8	2	318	119	5

Table 7.3 *Municipal biomass users in case study countries (source: EUBIONET)*

Municipal biomass users

Municipal biomass users in case study countries (source: EUBIONET)

	District heating		Combined heat and power production (CHP)			Separate power production	
	MW_h	plants	MW_h	MW_p	plants	MW_p	plants
Sweden	n.a.	169	n.a.	1442	31	n.a.	n.a.
Germany	n.a.	350	2000	1464	3000	n.a.	40
Spain	0	0	0	0	0	344	10
Portugal			1400	371	9	119	5

Pellet production and consumption 2005 in some countries (source:VTT)

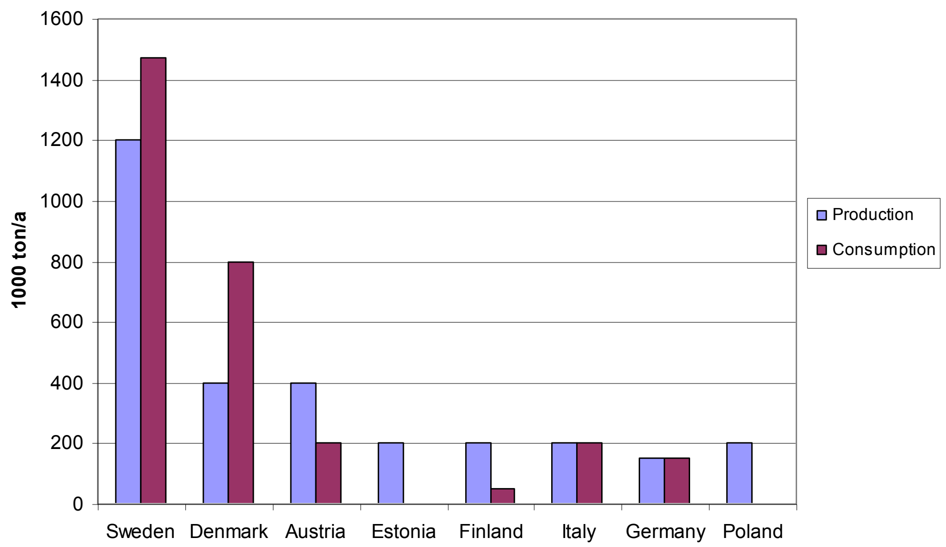


Figure 7.17 *Pellet production and comsumption 2005 in some countries (source: VTT).*

7.4.3 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. 7.18. 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 originate from dried timber.

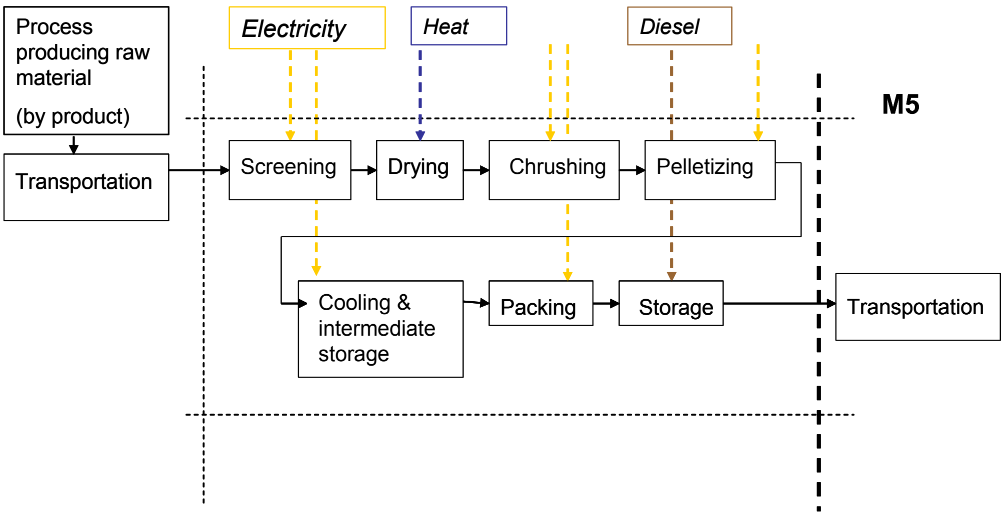


Figure 7.18 *General process description of pellet production*

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.

7.4.3.1 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. 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 describes 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 price for pellets in different countries is quite well known.

7.4.3.2 Social aspects

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

7.4.3.3 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 e.g. drying)(Figure 7.19). 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 e.g. primary 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. For example, 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 simplest 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 <u>net energy</u> use (electricity, heat, steam and diesel) for average pellet production processes.

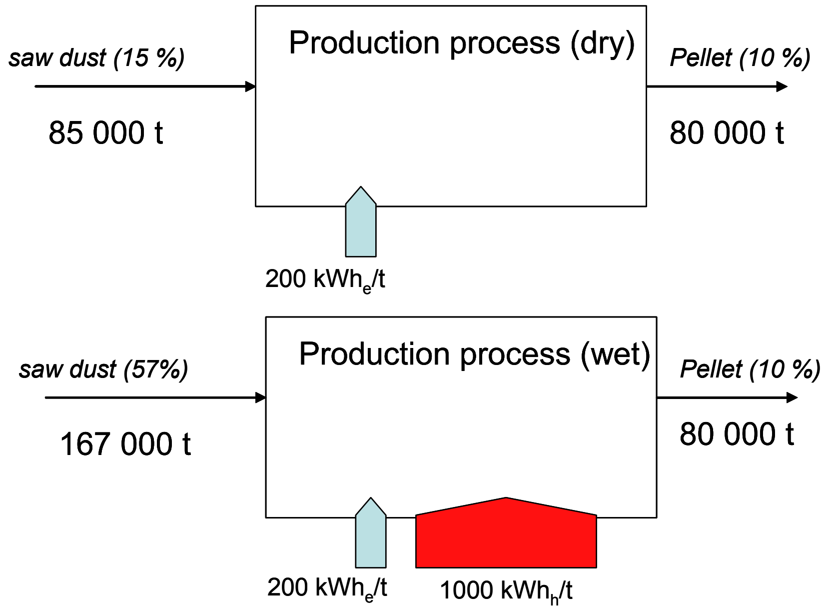


Figure. 7.19 *Very general energy and material flows for pellet production (80 000 t/yr)*

7.4.4 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 e.g. 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 e.g. veneer production or pellet production) are sometimes integrated with other units (e.g. power production and district heating) which mean 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 7.20).

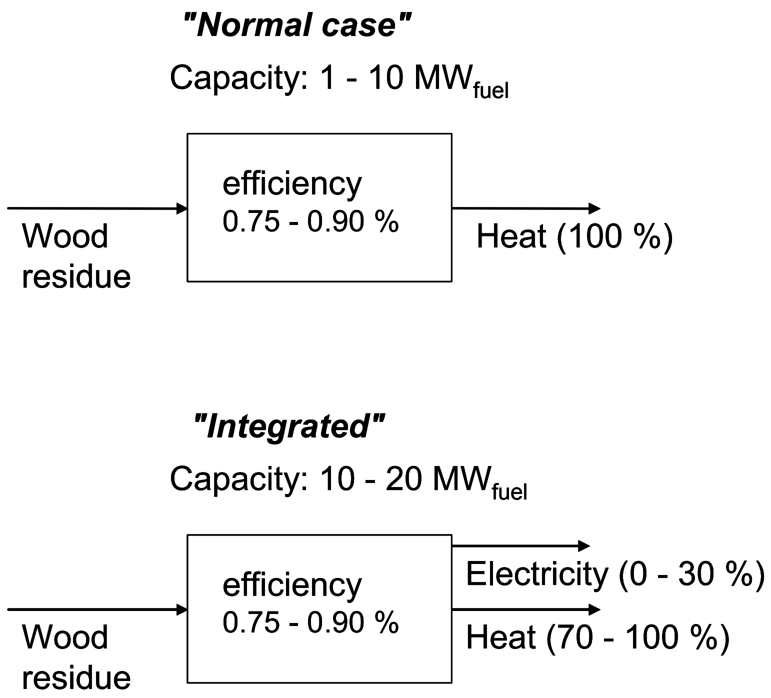


Figure 7.20 *Simplified process boxes that might be used for explaining wood-to energy flows within saw mill industry. The upper process "normal case" should be used if no more exact data is available.*

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).

7.4.5 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 7.21. 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 combust able by-products itself and is most often integrated to pulp production.

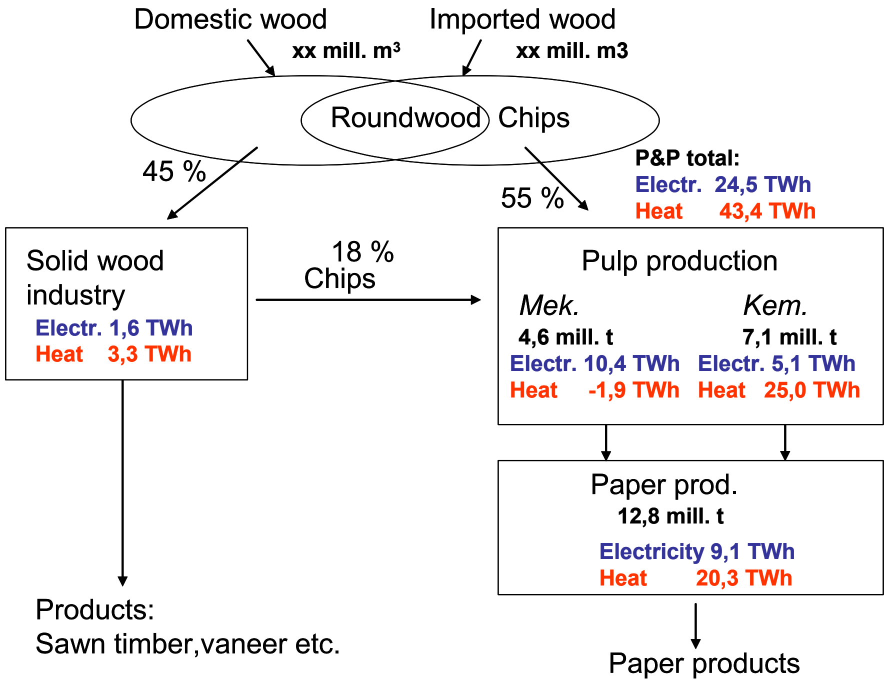


Figure 7.21 *Principle picture of material flow distribution and structure of energy consumption within Finnish forest industry.*

8 Management of the case study

The "Scandinavian case study" is coordinated by Module 2. Partner 21 (SLU) will act as the coordinator and will ensure that the agreed terms of references and all deadlines are met. Modules 3, 4 and 5 will be presented in the task force group by the nominated participants.

Nominated participants / contact persons

	M2	M3	M4	M5
Scandinavian regional case	**E. Valinger** (SLU)	S. Berg (Skogforsk) L.Wilhelmsson (Skogforsk)	A. von Schenk (STFI) [fibres] M. Wihersaari (VTT)[bioenergy]	G. Verhaege (AIDIMA) [wood] B. Szirmay (AIDIMA) [wood] H. Lehtinen (Pöyry) [bioenergy] C. Löfgren (STFI) [fibre]

Communications:

- day-to-day communication will be ensured by email, a contact list will be provided by the CS coordinator
- regular telephone conferences of the task force group will be held to ensure agreement on decisions taken and continuous up-date on work progress
- meetings of the task force group will be held during the up-coming EFORWOOD weeks to allow presentations of results and discussion on the approach agreed to date
- on the EFORWOOD portal, a section will be reserved for the case study to upload information and data and allow access to information required for all partners to follow the progress of the work

9 Time schedule

The following time schedule has been agreed in the Implementation plan for month 13 to 30. The task force needs to ensure that these deadlines are met.

Major milestone	Short description	Targeted Time of delivery (month)
Case study	Definition of regional cases studies completed	18
FWC data-base	Information related to regional cases completed	24
ToSIA – FWC	The basic version of ToSIA, tested at regional cases' level	24

To meet the given deadlines the following steps were followed:

M2 meeting in Barcelona During week 7. The collected preliminary forest data was discussed	February 2007 - M 2 meeting in Barcelona
M2 reported back from the Barcelona meeting on decisions taken on forest resource/stand identification to M3-M5.	Within a week after Barcelona meeting
M3 allocation meeting in Uppsala week 10. M3 identified the most relevant harvesting and logistic systems to "transfer" the wood from the forest suitable for the identified forest stands	after Uppsala meeting
M4 and M5 started a review on wood industry, and wood consumption, volumes produced and consumed with the origin of Västerbotten	
M4 and M5 identified the most relevant partial chains for each sector (wood, fibres, bioenergy)	end of March 2007
Telephone meeting to discuss proposed chains	Week 12 March 23 2007
M2, M3, M4, M5 refined definition of case study Scandinavia, agreed on data and information structure and transfer	March to April 2007
Telephone meeting to discuss proposed chains	Week 18 May 4 2007
Final definition of case study (boundaries, chains and processes identified, data structure and interfaces agreed)	May 2007, Eforwood week
Report describing the forest-based Scadinavian case study	June 2007 PD 2.0.3 - month 20
Updated report on Scandinavian case study	December 2007 PD 2.0.5 – month 26
Telephone meetings	December 7 2007, January 9 2008, January 15 2008, January 29 2008, April 1 2008
PD2.0.5 submitted for reviewing	April 30 2008
Discussion about case study outline	May 2008, Eforwood week

10 References

Anon 2006. Deliverable D3.2.3. SI data for Harvesting operations based on 3.2.1 and 3.2.2.

Anon 2007. PD 3.4.2 Collection and aggregation of single chain data from WP 3.1 –WP 3.4 in order to derive ToSIA inputs in commonly agreed units and formats and deliver those to M1.

Anon 2007. Minutes from the M2-M3 "Scandinavian case study" meeting in Uppsala March 5-6, 2007

Berg, S., Brunberg, Bölle, V. and Villette, A. 2007. Manual for description of harvest operations in case studies - WP 3.2 Harvesting System

Le Net , E., Baric, F., Vötter, D. Berg, S., Andersson, G., Roux, S. 2007
Project Deliverable PD3.3.2 Identification of existing transport methods and alternative methods or new approaches with data about costs, labour input and energy consumption.

NFI - Swedish National Forest Inventory. 2006.
www.skogsvardsstyrelsen.se/dokument/sks/Statistik/dokumenten/Natur%20o%20miljo/ovrigt/5-10%20Tab.%20Total... 27.9

Skogsstyrelsen. 2000. Skogliga konsekvensanalyser Skogens möjligheter på 2000-talet/SKA99. http://www.svo.se/ska99/2008-04-09.

Toet, H., Fridman, J. & Holm, S. 2007. Precisionen i Riksskogstaxeringens skattningar 1998-2002. Sveriges lantbruksuniversitet, Institutionen för skoglig resurshushållning. Arbetsrapport 167.

11 Appendix 1

M3 processes within the Scandinavian case study and their linkage to M2:

Overview over silvicultural regimes within the case study:

Stands/Silvicultural regimes	**Unmanaged forest nature reserve**	**Close-to-nature forestry**	**Combined objective forestry**	**Intensive even-aged forestry**	**Dendro-biomass production**
Pine stand		2005	Included in "Mixed pine-spruce-birch stand"	Included in "Mixed pine-spruce-birch stand"	
Spruce stand		2005	Included in "Mixed pine-spruce-birch stand"	Included in "Mixed pine-spruce-birch stand"	
Birch stand			2005		
Mixed pine-spruce stand			Included in "Mixed pine-spruce-birch stand"	Included in "Mixed pine-spruce-birch stand"	
Mixed pine-spruce-birch stand			2005	2005	

For 2005, five stand types will form the start-off point for M3 and thus the connection between M2 (green) and M3 (blue).In detail this will look like this:

Stands/ Silvi-cultural regimes	**Close-to-nature forestry**		**Combined objective forestry**		**Intensive even-aged forestry**	
Pine stand	Regen.		Regen.		Regen.	
	Young	1 pre-com. thinning	Young	1 pre-com. thinning	Young	1 pre-com. thinning
	Medium	1st + 2nd thinning	Medium	1st thinning	Medium	
	Adult	3rd thinning clear-cut	Adult	2nd thinning Clear-cut	Adult	1st + 2nd thinning Clear-cut Harvest res. removal Stump removal
Spruce stand	Regen.		Regen.		Regen.	
	Young		Young	1 pre-com. thinning	Young	1 pre-com. thinning
	Medium		Medium		Medium	
	Adult	Single tree selection harvesting	Adult	1 thinning Clear-cut	Adult	1st + 2nd thinning Clear-cut Harvest res. removal Stump removal
Birch stand			Regen.			
			Young	1 pre-com. thinning		
			Medium	1st thinning		
			Adult	2nd thinning Clear-cut		
Mixed pine-spruce-birch stand stand			Regen.		Regen.	
			Young	1 pre-com. thinning	Young	1 pre-com. thinning
			Medium	1st thinning	Medium	
			Adult	2nd thinning Clear-cut	Adult	1st + 2nd thinning Clear-cut Harvest res. removal Stump removal

Consequently, the files for M3 processes will be named according to these stands:

- Close-to-nature Pine stand
- Close-to-nature Spruce stand
- Combined objective Birch stand
- Combined objective Mixed Pine-Spruce-Birch stand
- Intensive Even-aged Mixed Pine-Spruce-Birch stand

And therefore the respective M3-processes will be thus:

Close-to-nature Pine stand:

	Harvesting	**Forwarding**	**Transport**	**Millgate operation**	**Link to M4 (products)**
Regen.					-
Young	1 pre-com. thinning				-
Medium	1st thinning by medium harvester	Forwarding with medium forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood
	2nd thinning by medium harvester	Forwarding with medium forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood
Adult	3rd thinning by medium harvester	Forwarding with large forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood
	clear-cut by large harvester	Forwarding with large forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood

Close-to-nature Spruce stand: - uneven-aged

	Harvesting	**Forwarding**	**Transport**	**Millgate operation**	**Link to M4 (products)**
Regen.					
Young					
Medium					
Adult	Single tree selection harvesting by medium harvester	Forwarding with large forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Spruce sawlogs Downgraded spruce sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at integrated finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood
			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood

As it is an uneven-aged stand the selectively cut trees at each cutting are approximately of the same size and quality; and so are their products.

Combined objective Birch stand:

	Harvesting	**Forwarding**	**Transport**	**Millgate operation**	**Link to M4 (products)**
Regen.					-
Young	1 pre-com. thinning				-
Medium					-
Adult	1st thinning by medium harvester	Forwarding with medium forwarder	Alt.1: Transport by 60t truck with crane to mill	Final measuring and sorting at pulpmill	Birch pulpwood Downgraded birch pulpwood to fuelwood
				Downgraded fuelwood at CHP	Fuelwood
	clear-cut by large harvester	Forwarding with large forwarder	Alt.1: Transport by 60t truck with crane to mill	Final measuring and sorting at sawmill	
				Final measuring and sorting at pulpmill	Birch pulpwood Downgraded birch pulpwood
				Downgraded fuelwood at CHP	Fuelwood

Appr. 70% of pulpwood is transported by truck only. For fuelwood truck-only transport is 100%.

Combined objective Mixed Pine-Spruce-Birch stand:

	Harvesting	Forwarding	Transport	Millgate operation	Link to M4 (products)
Regen.					-
Young	1 pre-com. thinning				-
Medium	1st thinning by medium harvester	Forwarding with medium forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs Spruce sawlogs Downgraded spruce sawlogs Birch sawlogs Downgraded birch sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
Adult	2nd thinning by medium harvester	Forwarding with medium forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs Spruce sawlogs Downgraded spruce sawlogs Birch sawlogs Downgraded birch sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood
	clear-cut by large harvester	Forwarding with large forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs Spruce sawlogs Downgraded spruce sawlogs Birch sawlogs Downgraded birch sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood

			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood

This one summarizes the following stand types into one model:

- *Combined objective Mixed Pine-Spruce-Birch stand*
- *Combined objective Mixed Pine-Spruce stand*
- *Combined objective Even-aged Pine stand*
- *Combined objective Even-aged Spruce stand*

Intensive Even-aged Mixed Pine-Spruce-Birch stand:

	Harvesting	**Forwarding**	**Transport**	**Millgate operation**	**Link to M4 (products)**
Regen.					-
Young	1 pre-com. thinning				-
Medium	1st thinning by medium harvester	Forwarding with medium forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs Spruce sawlogs Downgraded spruce sawlogs Birch sawlogs Downgraded birch sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood
Adult	2nd thinning by medium harvester	Forwarding with medium forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs Spruce sawlogs Downgraded spruce sawlogs Birch sawlogs Downgraded birch sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood
	(1) clear-cut by large harvester (3) chipping of harvest residues by chipper (4) removal of stumps	(2) Forwarding with large forwarder	Alt.1a: Transport by 60t truck with crane to sawmill	Final measuring and sorting at sawmill	Pine sawlogs Downgraded pine sawlogs Spruce sawlogs Downgraded spruce sawlogs Birch sawlogs Downgraded birch sawlogs
			Alt.1b: Transport by 60t truck with crane to pulpmill	Final measuring and sorting at pulpmill (Kraftliner or integrated finepaper)	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.2: Transport by 60t truck with crane to terminal Transport by train to mill	Final measuring and sorting at finepaper pulpmill	Kraft pulpwood Downgraded Kraft pulpwood Birch pulpwood Downgraded birch pulpwood
			Alt.1c: Transport by 60t truck with crane to CHP plant	Downgraded fuelwood at CHP	Fuelwood
Obs!	(3) chipping of harvest residues by	(2) Forwarding with large forwarder	Transport by 60t container truck to CHP plant	Weighting at CHP	Forest wood chips

	chipper				
Obs!	(4) removal of stumps	(2) Forwarding with large forwarder	Transport by 60t truck with crane to CHP plant	Weighting at CHP	stumps

This one summarizes the following stand types into one model:

- *Intensive Even-aged Mixed Pine-Spruce-Birch stand*
- *Intensive Even-aged Mixed Pine-Spruce stand*
- *Intensive Even-aged Pine stand*
- *Intensive Even-aged Spruce stand*

Current work on M3 to M4/M5 links:

Pulpwood:
There are two pulpmills in the region of Västerbotten with the following specification in their linkage to M3:

1 Kraftliner mill: which accepts purely softwood Kraft pulp
by truck-only
distance: xx?
amount of wood: SW 1 313 004 m3

1 finepaper mill: which accepts softwood and hardwood in the ratio of 1:2
transport of raw material there by truck-train and truck-only
distance: xx?
amount of wood: SW 132 147 m3
HW 194 480 m3

Sawlogs:
For pine and spruce sawlogs only truck transport exist. Truck-train combinations would only be used for imports, e.g. from Russia, which are excluded from the Scandinavian case study, as well as long-distance exports.
Mill types: xxxx
Assortments: xxxxx

Fuelwood, stumps, forest wood chips:
Fuelwood usually just is for short distance transport to CHP plants, heat plants or power plants (has to be defined by M5 more precisely, as well as their situation), and thus truck-only is used for forest wood chips and stumps and fuelwood. In some cases it might, however, be that birch fuelwood is transported over longer distances where a truck-train combination could be considered. Will be checked by Hannele Lehtinen, Pöyry, tel. +358 10 3311, 10/01/2008.

Birchwood:
sawlogs: are not cut
pulpwood: Appr. 70% of pulpwood is transported by truck only.
Fuelwood: truck-only transport is 100%.
Info by Lars Wilhelmsson and Mikael Frisk, 09/01/2008

Destination M3 end products to M4/M5 mills: - M4 and M5 please check!!!

Pine sawlogs		Saw mill (different types of mills?)
Spruce sawlogs		
Kraft pulpwood		Kraftliner mill
Birch pulpwood		Finepaper mill
Pine fuelwood		CHP (in various forms – to be defined)
Spruce fuelwood		Household heating? (– to be defined)
Birch fuelwood		
Forest wood chips		
Stumps		
Downgraded Kraft pulpwood		
Downgraded birch pulpwood		
Downgraded pine sawlogs		
Downgraded spruce sawlogs		

Further information:

- use 2004 data for wood flow

- no private household use of firewood

Used documents:

Ph. Duncker, H. Spiecker, K. Tojic, N.N. …: „D2.1.3: Definition of forest management alternative"; 01.06.2007

E. Valinger, S. Berg, A. von Schenk, G. Verhaege, M. Johansson, H. Lehtinen: "Deliverable PD 2.0.3; Report describing the Forest-based Case Study "Scandinavian regional case""; 19.11.2007

D. Vötter, S. Berg, L. Wilhelmsson, T. Brunberg: "M3 Pine stand", 30.12.2007

D. Vötter, S. Berg, L. Wilhelmsson, T. Brunberg: "M3 Spruce chain", 30.12.2007

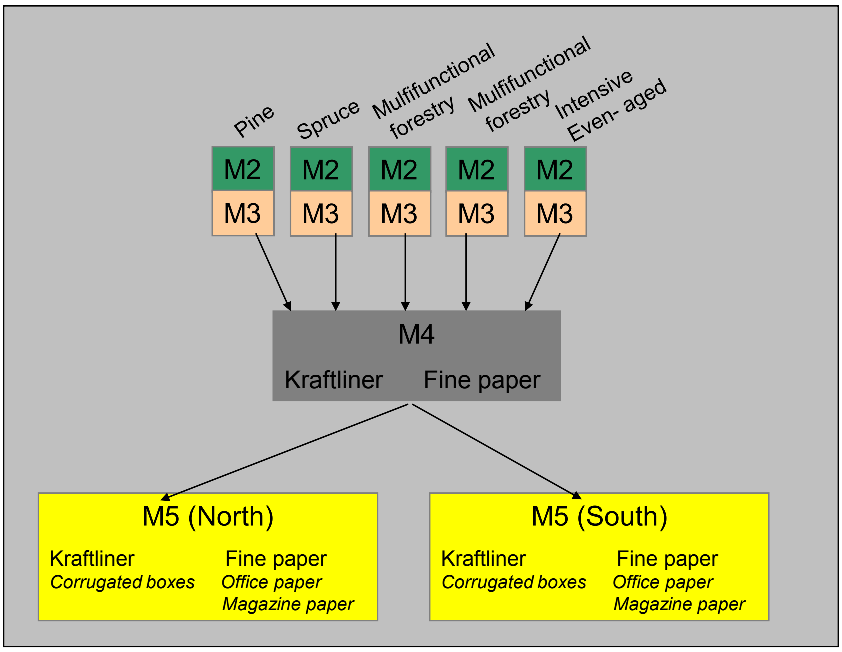
D. Vötter, S. Berg, L. Wilhelmsson, T. Brunberg: "M3 Mixed pine spruce birch stand", 30.12.2007

D. Vötter, S. Berg, L. Wilhelmsson, T. Brunberg: "M3 Mixed pine spruce stand", 30.12.2007

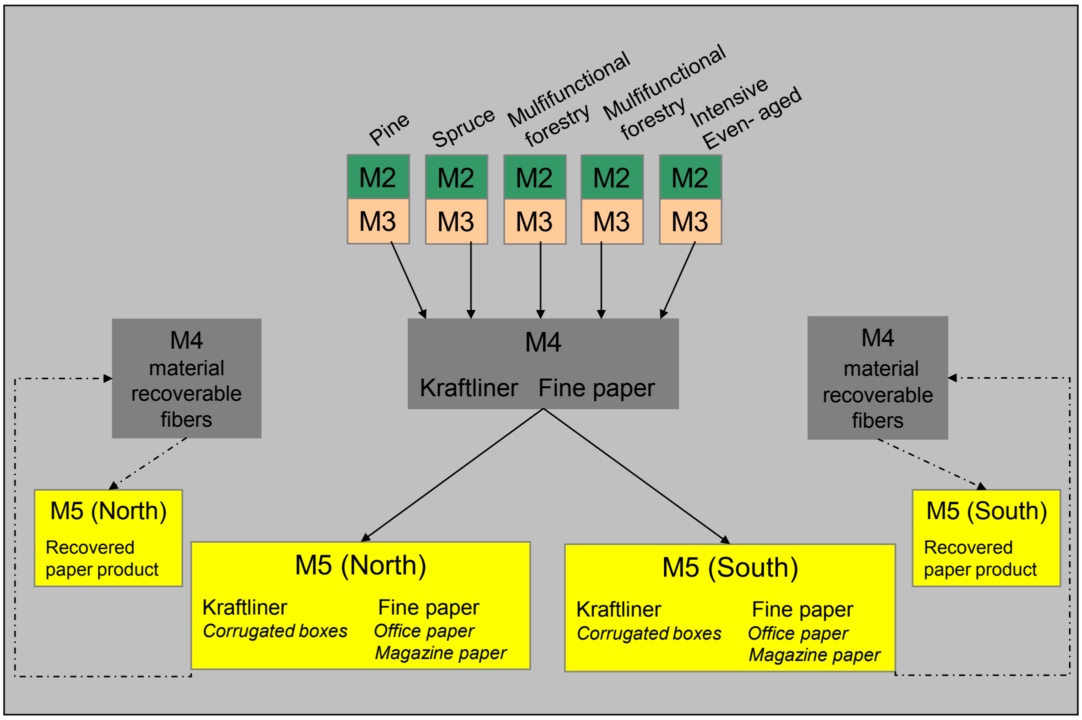
12 Appendix 2

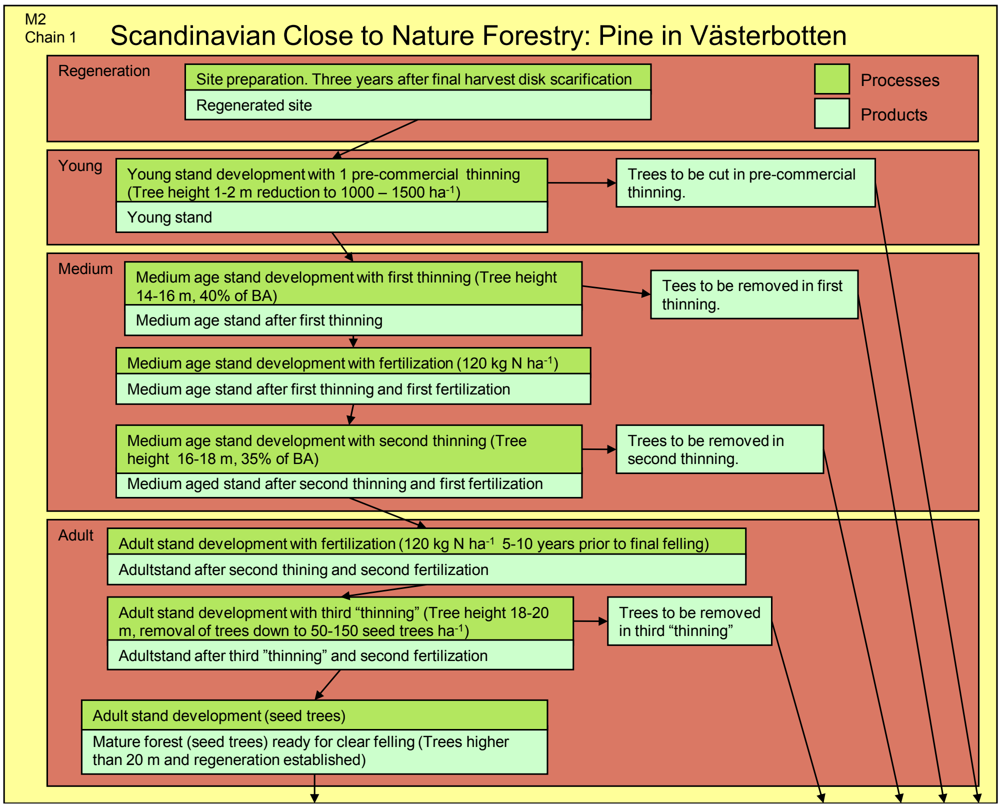
Sic! Please notice that the indicated management regime "Multifunctional forestry" should be corrected to "Combined objective forestry" whenever it is present in the Appendix.

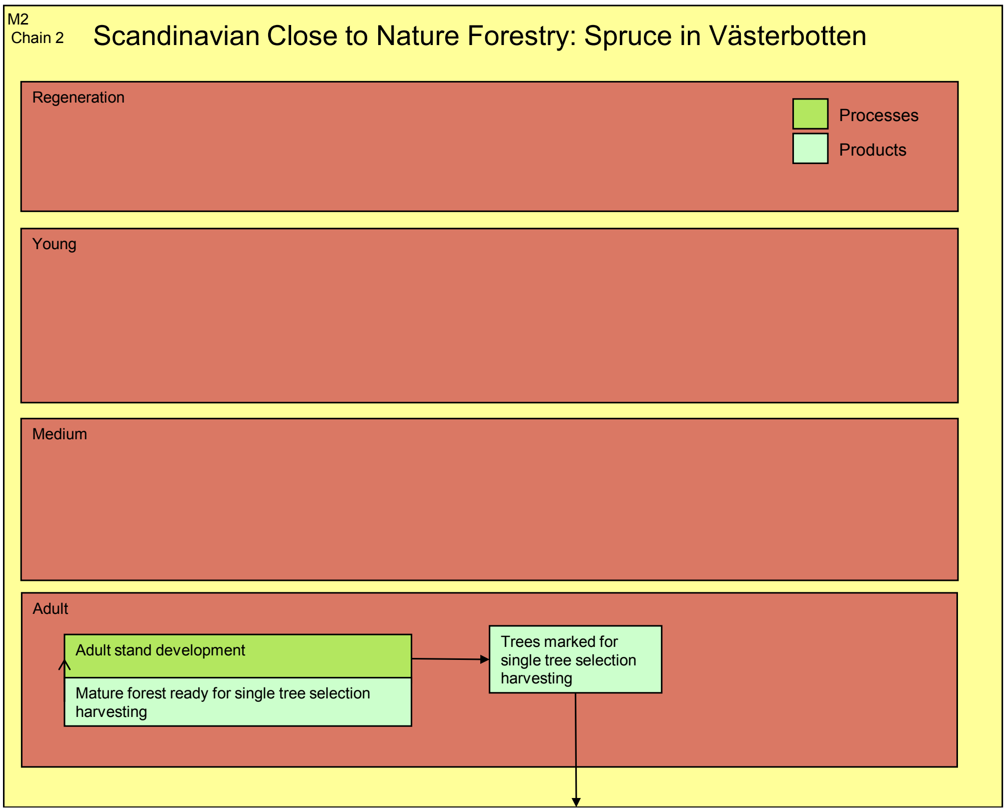
Scandinavian Case

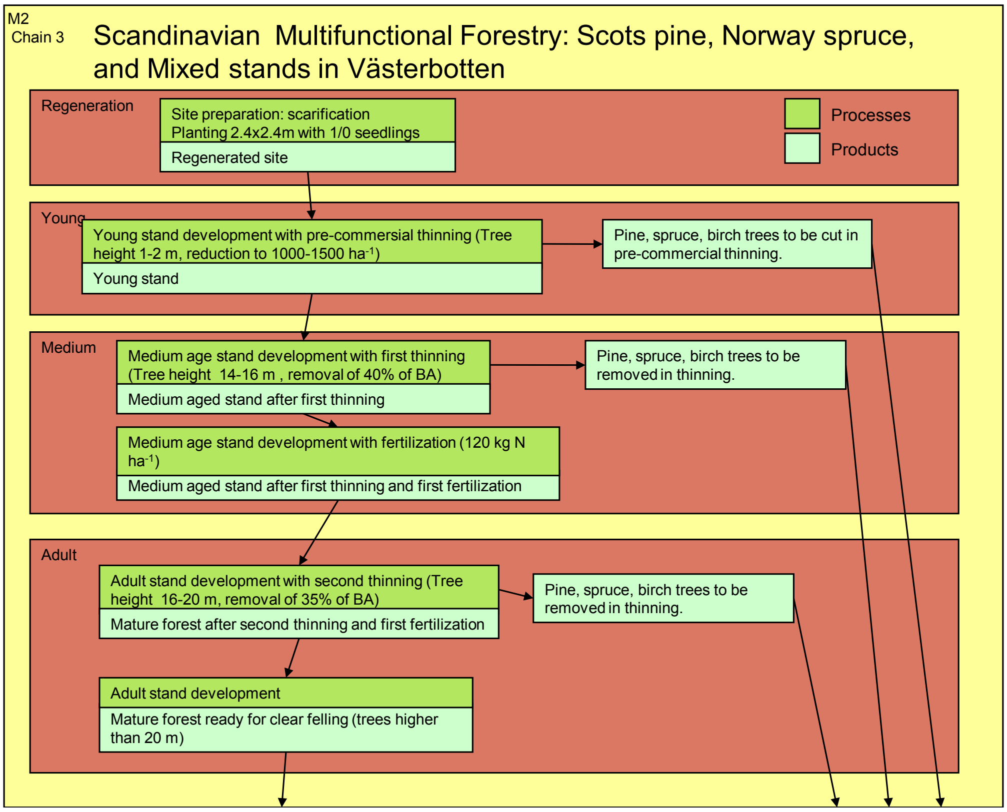


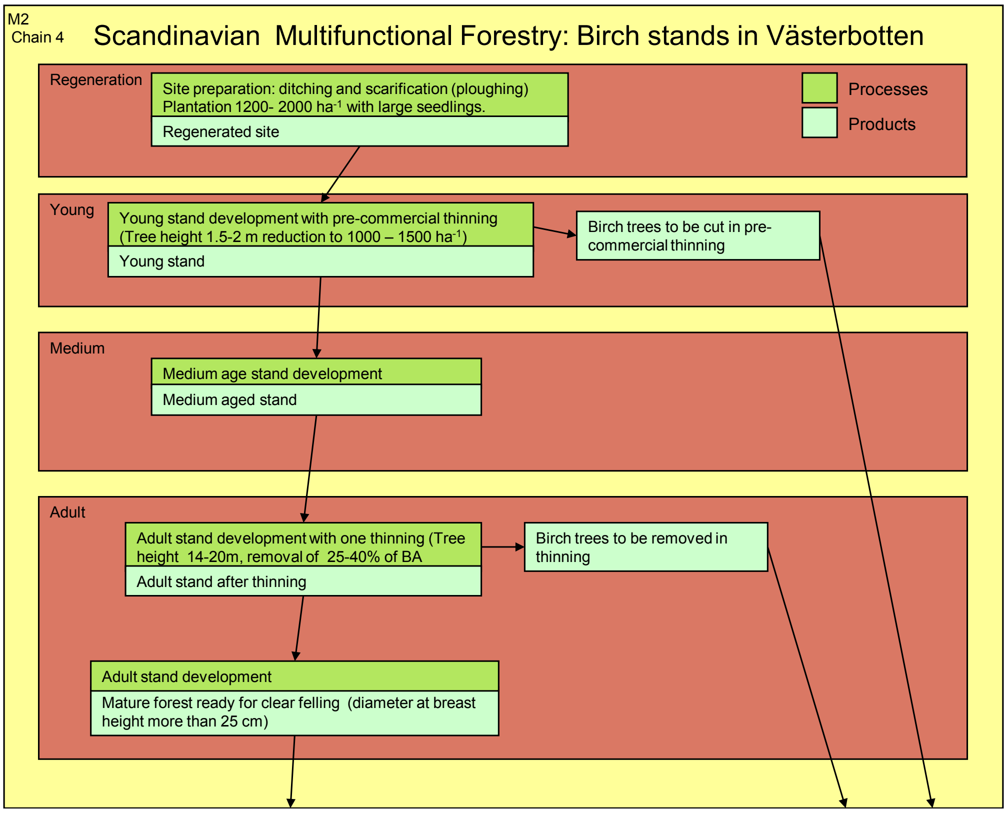
Scandinavian Case (incl. Material recovery)

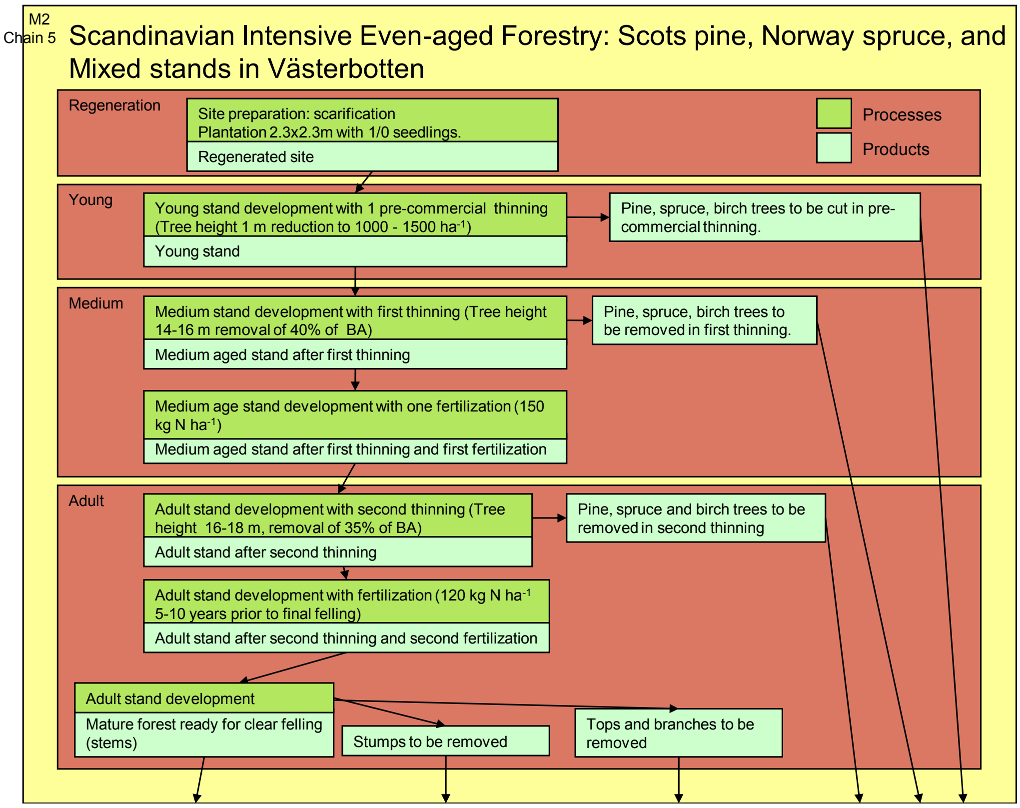


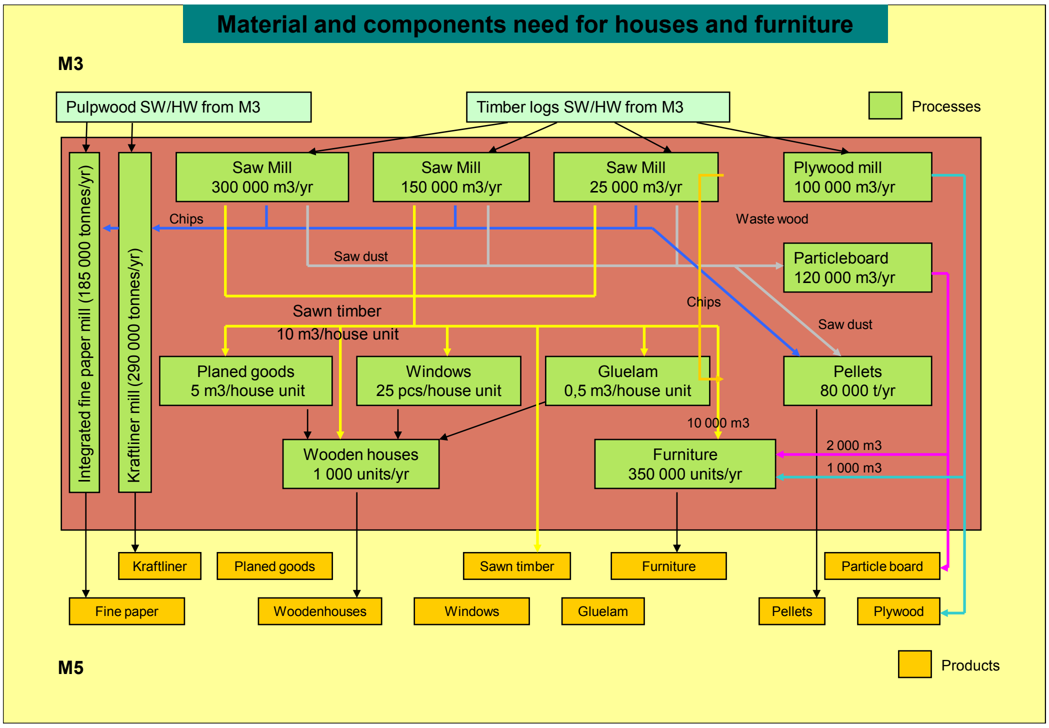

M2
Chain 1
Scandinavian Close to Nature Forestry: Pine in Västerbotten
Regeneration
Site preparation. Three years after final harvest disk scarification
Regenerated site
Processes
Products
Young
Young stand development with 1 pre-commercial thinning (Tree height 1-2 m reduction to 1000 – 1500 ha-1)
Young stand
Trees to be cut in pre-commercial thinning.
Medium
Medium age stand development with first thinning (Tree height 14-16 m, 40% of BA)
Medium age stand after first thinning
Tees to be removed in first thinning.
Medium age stand development with fertilization (120 kg N ha-1)
Medium age stand after first thinning and first fertilization
Medium age stand development with second thinning (Tree height 16-18 m, 35% of BA)
Medium aged stand after second thinning and first fertilization
Trees to be removed in second thinning.
Adult
Adult stand development with fertilization (120 kg N ha-1 5-10 years prior to final felling)
Adultstand after second thining and second fertilization
Adult stand development with third "thinning" (Tree height 18-20 m, removal of trees down to 50-150 seed trees ha-1)
Adultstand after third "thinning" and second fertilization
Trees to be removed in third "thinning"
Adult stand development (seed trees)
Mature forest (seed trees) ready for clear felling (Trees higher than 20 m and regeneration established)

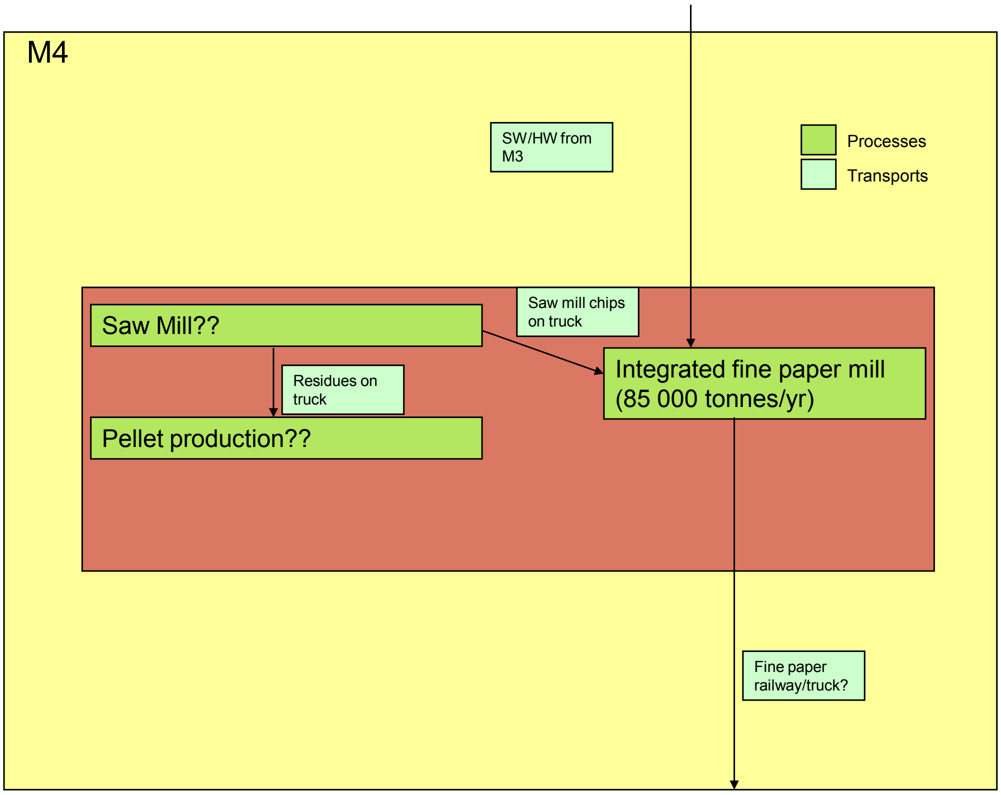

M2
Chain 2
Scandinavian Close to Nature Forestry: Spruce in Västerbotten
Regeneration
Processes
Products
Young
Medium
Adult
Adult stand development
Mature forest ready for single tree selection harvesting
Trees marked for single tree selection harvesting

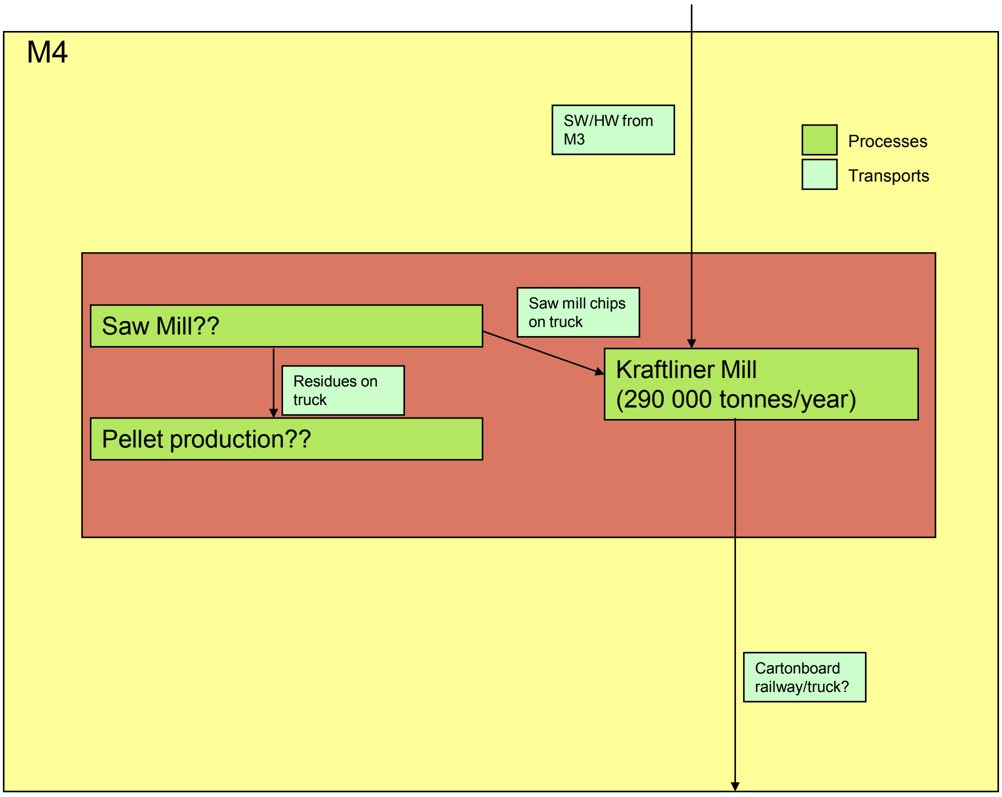

M2
Chain 3
Scandinavian Multifunctional Forestry: Scots pine, Norway spruce, and Mixed stands in Västerbotten
Regeneration
Site preparation: scarification Planting 2.4x2.4m with 1/0 seedlings
Regenerated site
Processes
Products
Young
Young stand development with pre-commersial thinning (Tree height 1-2 m, reduction to 1000-1500 ha-1)
Young stand
Pine, spruce, birch trees to be cut in pre-commercial thinning.
Medium
Medium age stand development with first thinning (Tree height 14-16 m , removal of 40% of BA)
Medium aged stand after first thinning
Pine, spruce, birch trees to be removed in thinning.
Medium age stand development with fertilization (120 kg N ha-1)
Medium aged stand after first thinning and first fertilization
Adult
Adult stand development with second thinning (Tree height 16-20 m, removal of 35% of BA)
Mature forest after second thinning and first fertilization
Pine, spruce, birch trees to be removed in thinning.
Adult stand development
Mature forest ready for clear felling (trees higher than 20 m)

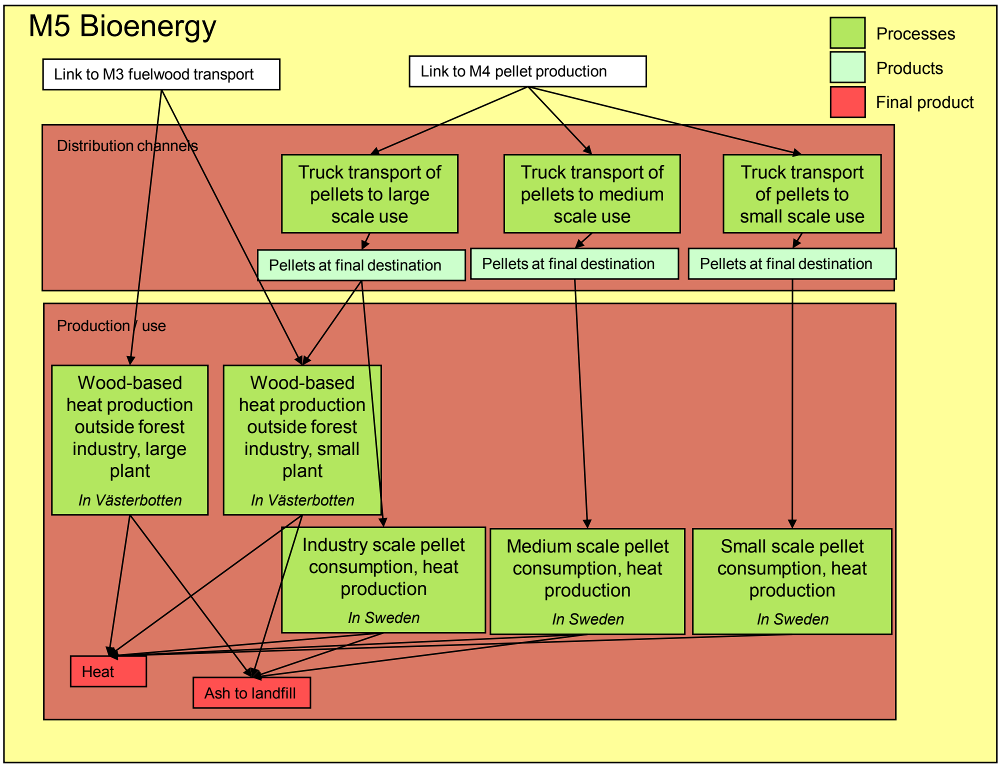

M2
Chain 4
Scandinavian Multifunctional Forestry: Birch stands in Västerbotten
Regeneration
Site preparation: ditching and scarification (ploughing) Plantation 1200- 2000 ha-1 with large seedlings.
Regenerated site
Processes
Products
Young
Young stand development with pre-commercial thinning (Tree height 1.5-2 m reduction to 1000 – 1500 ha-1)
Young stand
Birch trees to be cut in pre-commercial thinning
Medium
Medium age stand development
Medium aged stand
Adult
Adult stand development with one thinning (Tree height 14-20m, removal of 25-40% of BA
Adult stand after thinning
Birch trees to be removed in thinning
Adult stand development
Mature forest ready for clear felling (diameter at breast height more than 25 cm)


M2
Chain 5
Scandinavian Intensive Even-aged Forestry: Scots pine, Norway spruce, and Mixed stands in Västerbotten
Regeneration
Site preparation: scarification
Plantation 2.3x2.3m with 1/0 seedlings.
Regenerated site
Processes
Products
Young
Young stand development with 1 pre-commercial thinning (Tree height 1 m reduction to 1000 - 1500 ha-1)
Young stand
Pine, spruce, birch trees to be cut in pre-commercial thinning.
Medium
Medium stand development with first thinning (Tree height 14-16 m removal of 40% of BA)
Medium aged stand after first thinning
Pine, spruce, birch trees to be removed in first thinning.
Medium age stand development with one fertilization (150 kg N ha-1)
Medium aged stand after first thinning and first fertilization
Adult
Adult stand development with second thinning (Tree height 16-18 m, removal of 35% of BA)
Adult stand after second thinning
Pine, spruce and birch trees to be removed in second thinning
Adult stand development with fertilization (120 kg N ha-1 5-10 years prior to final felling)
Adult stand after second thinning and second fertilization
Adult stand development
Mature forest ready for clear felling (stems)
Stumps to be removed
Tops and branches to be removed

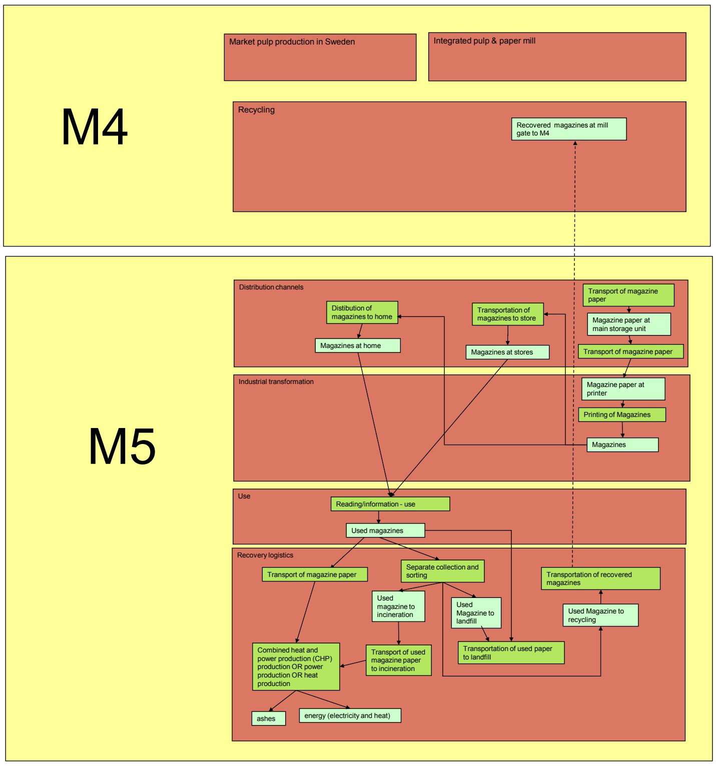

Material and components need for houses and furniture
M3
Pulpwood SW/HW from M3
Timber logs SW/HW from M3
Processes
Integrated fine paper mill (185 000 tonnes/yr)
Kraftliner mill (290 000 tonnes/yr)
Saw Mill
300 000 m3/yr
Saw Mill
150 000 m3/yr
Saw Mill
25 000 m3/yr
Plywood mill
100 000 m3/yr
Chips
Waste wood
Saw dust
Particleboard
120 000 m3/yr
Chips
Sawn timber
10 m3/house unit
Saw dust
Planed goods
5 m3/house unit
Windows
25 pcs/house unit
Gluelam
0,5 m3/house unit
Pellets
80 000 t/yr
10 000 m3
2 000 m3
1 000 m3
Wooden houses
1 000 units/yr
Furniture
350 000 units/yr
Kraftliner
Planed goods
Sawn timber
Furniture
Particle board
Fine paper
Woodenhouses
Windows
Gluelam
Pellets
Plywood
M5
Products


M4
SW/HW from M3
Processes
Transports
Saw mill chips on truck
Saw Mill??
Residues on truck
Integrated fine paper mill (85 000 tonnes/yr)
Pellet production??
Fine paper railway/truck?

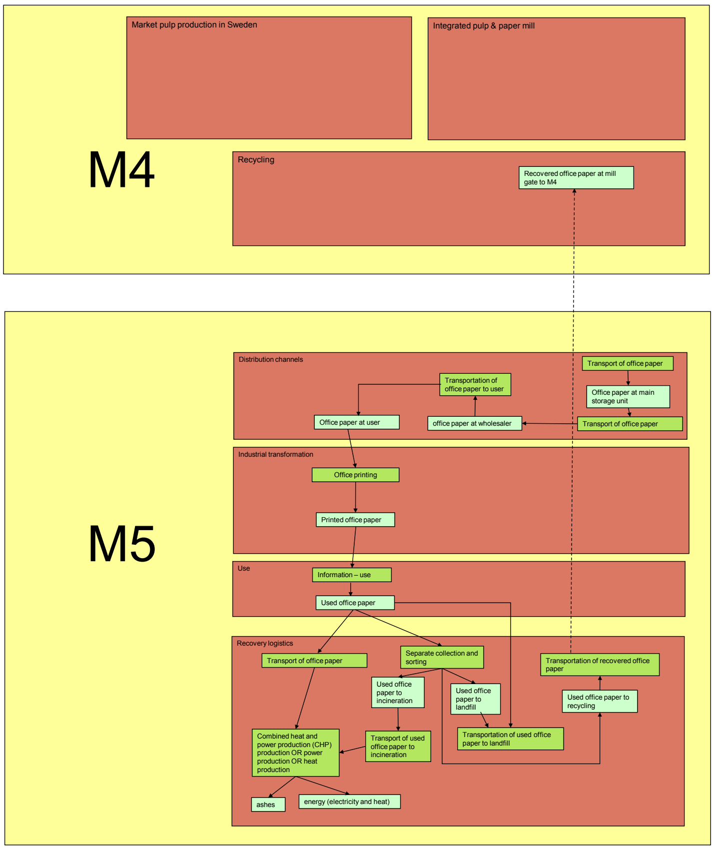

M4
SW/HW from M3
Processes
Transports
Saw mill chips on truck
Saw Mill??
Residues on truck
Kraftliner Mill (290 000 tonnes/year)
Pellet production??
Cartonboard railway/truck?


M5 Bioenergy
Processes
Products
Final product
Link to M3 fuelwood transport
Link to M4 pellet production
Distribution channels
Truck transport of pellets to large scale use
Truck transport of pellets to medium scale use
Truck transport of pellets to small scale use
Pellets at final destination
Pellets at final destination
Pellets at final destination
Production / use
Wood-based heat production outside forest industry, large plant
In Västerbotten
Wood-based heat production outside forest industry, small plant
In Västerbotten
Industry scale pellet consumption, heat production
In Sweden
Medium scale pellet consumption, heat production
In Sweden
Small scale pellet consumption, heat production
In Sweden
Heat
Ash to landfill

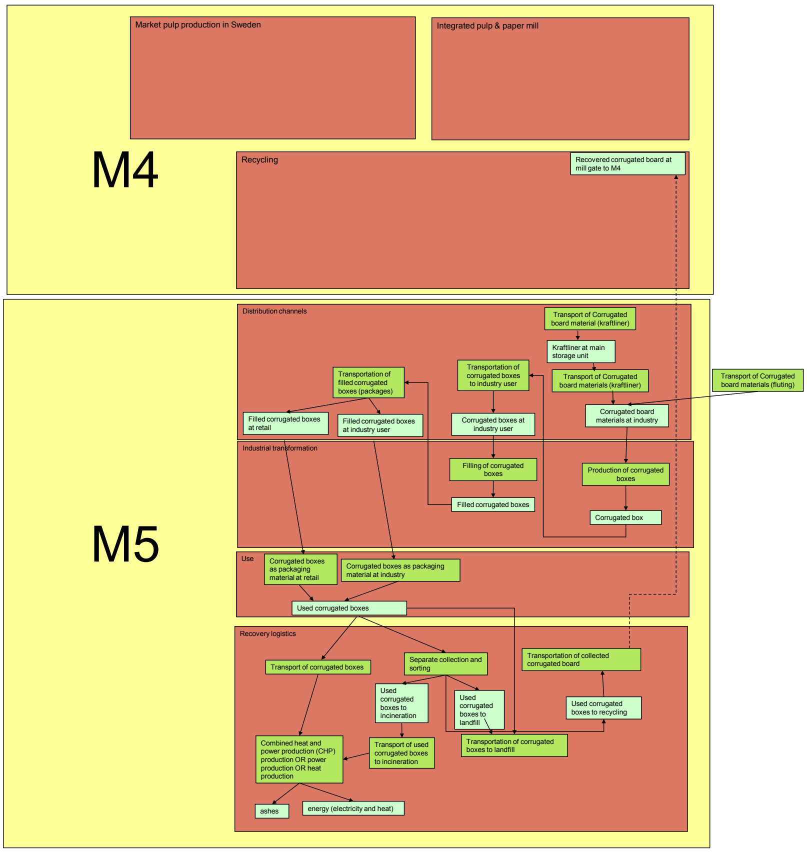
Scandinavian case
A product-defined fine paper / **magazine chain**
including recycling

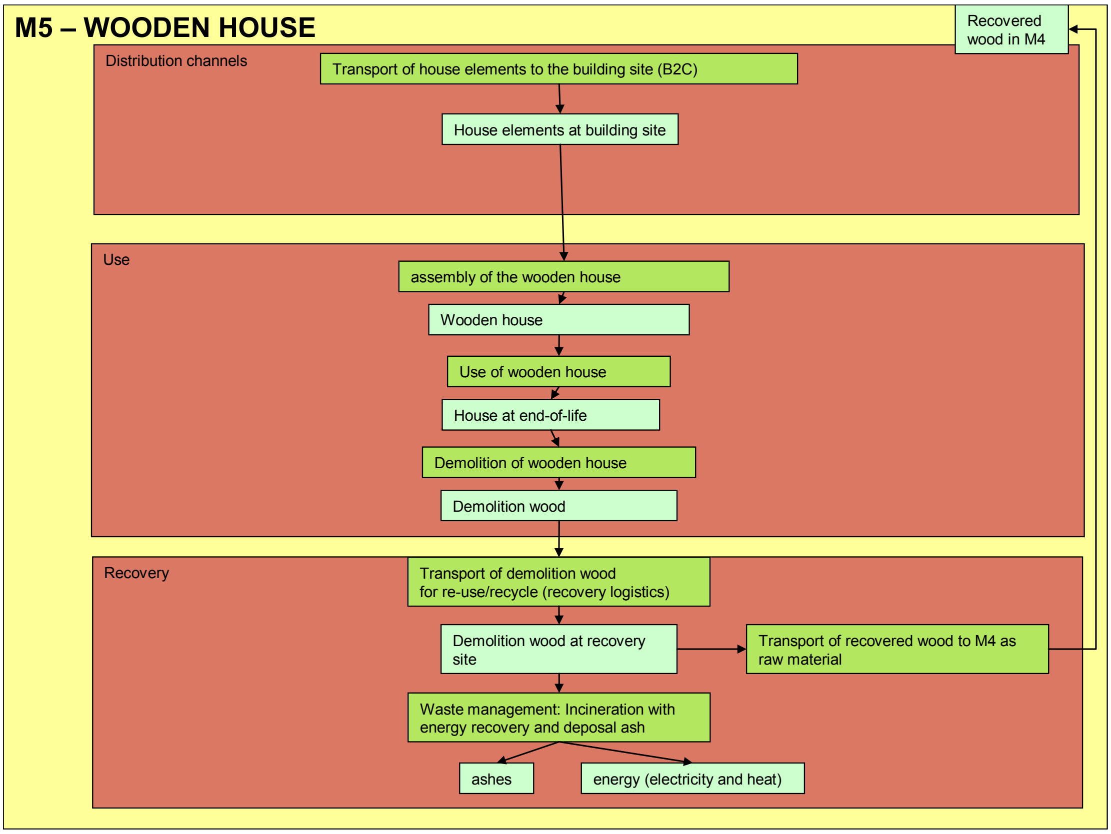


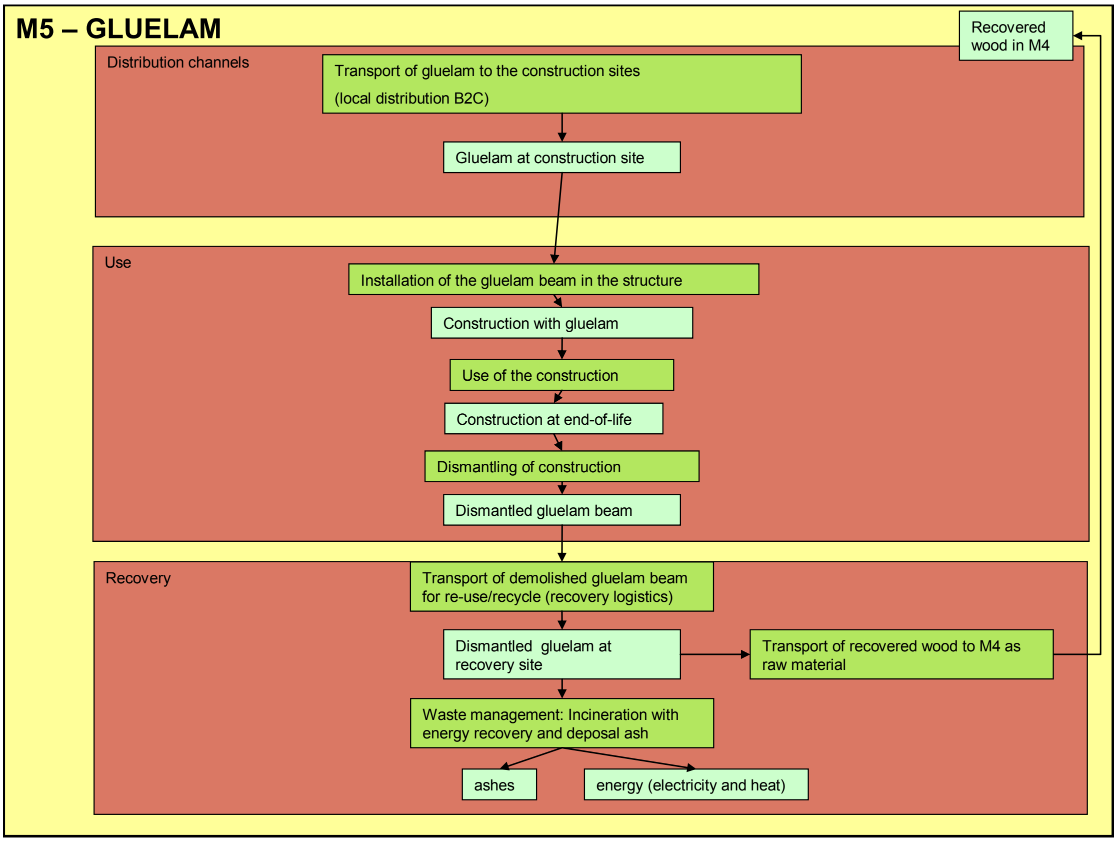
Scandinavian case
A product-defined fine paper / **office paper** chain
including recycling

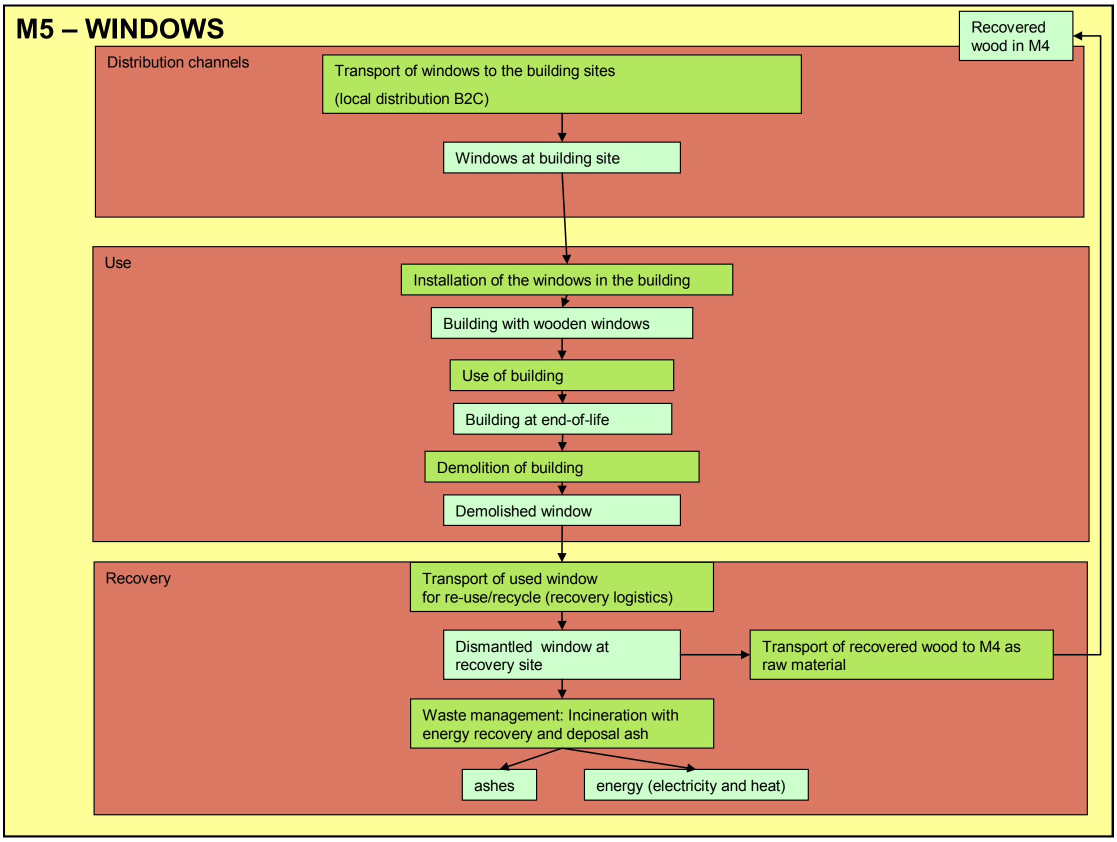


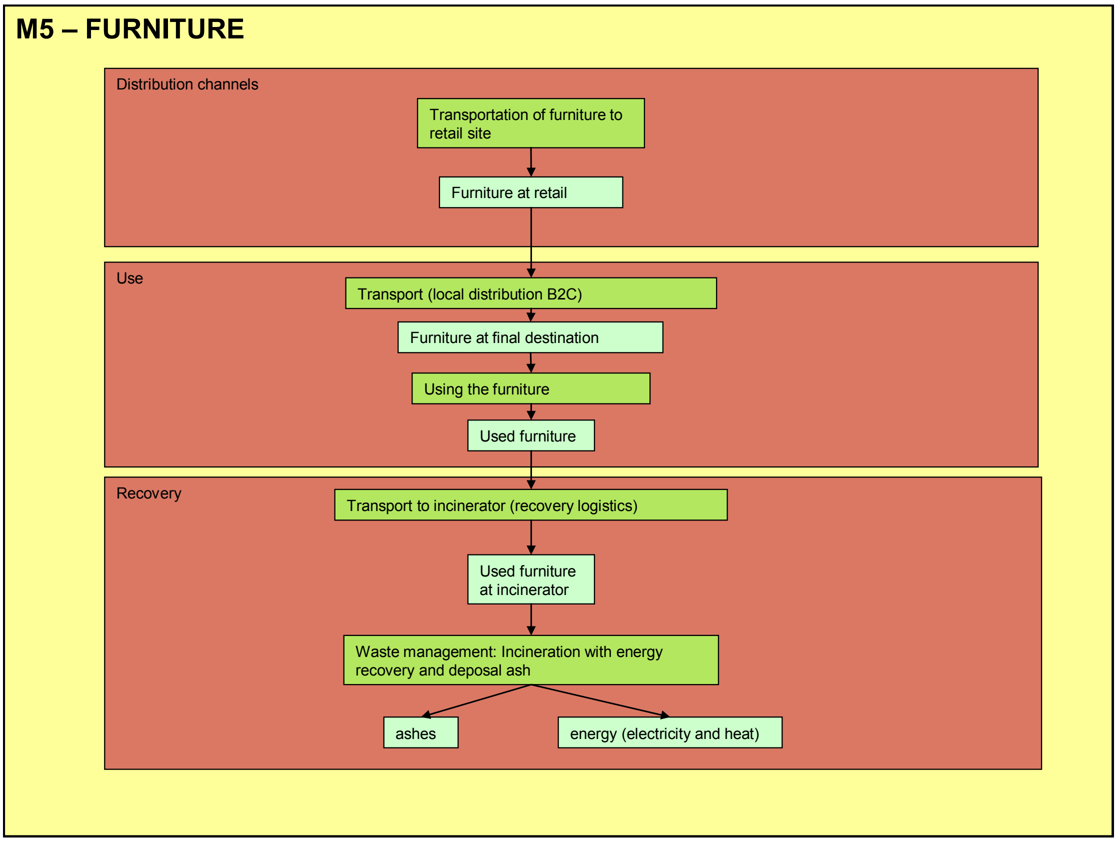
Scandinavian case
A product-defined **kraft liner** chain
including recycling

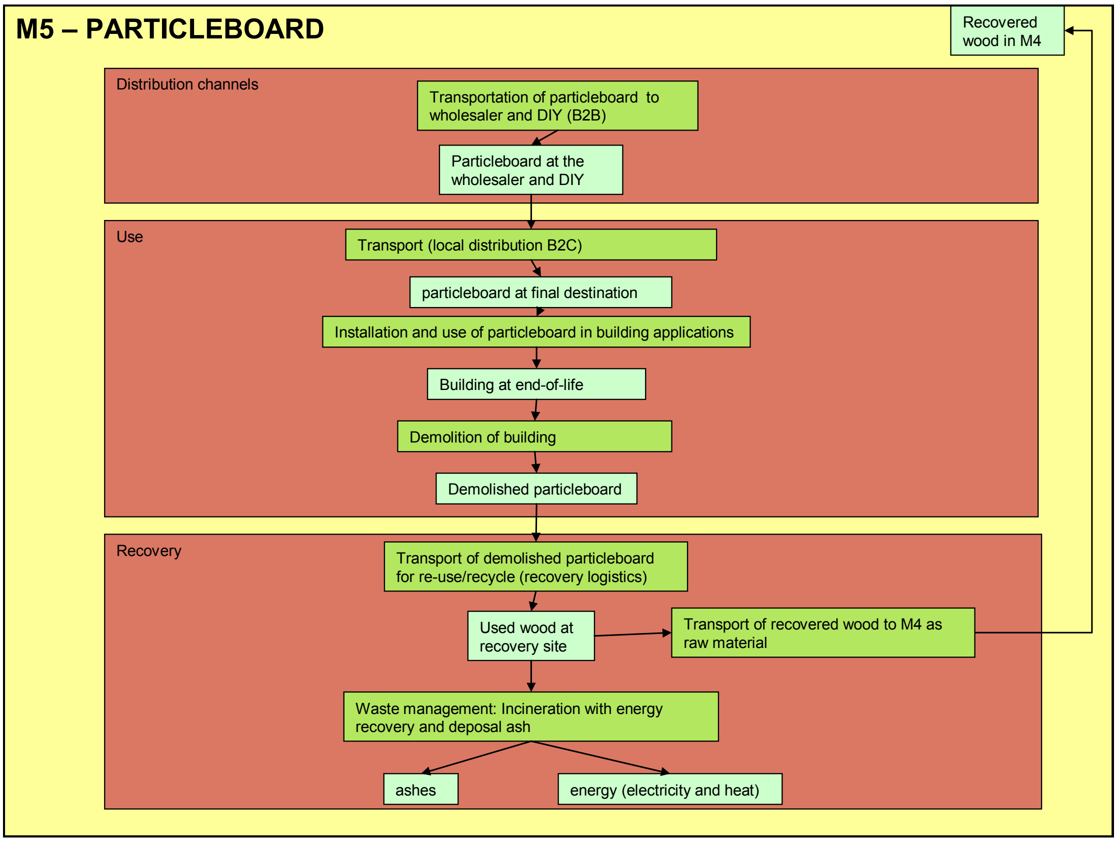


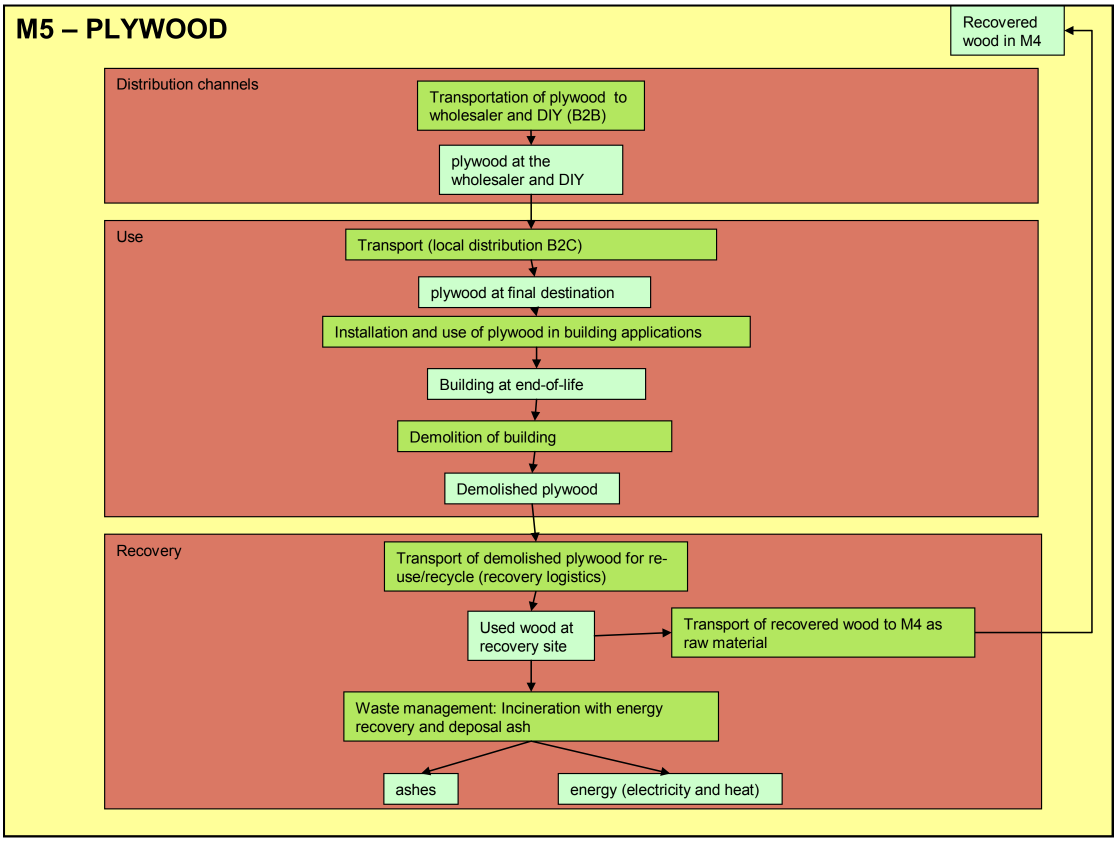

M5 – WOODEN HOUSE
Recovered wood in M4
Distribution channels
Transport of house elements to the building site (B2C)
House elements at building site
Use
assembly of the wooden house
Wooden house
Use of wooden house
House at end-of-life
Demolition of wooden house
Demolition wood
Recovery
Transport of demolition wood for re-use/recycle (recovery logistics)
Demolition wood at recovery site
Transport of recovered wood to M4 as raw material
Waste management: Incineration with energy recovery and deposal ash
ashes
energy (electricity and heat)

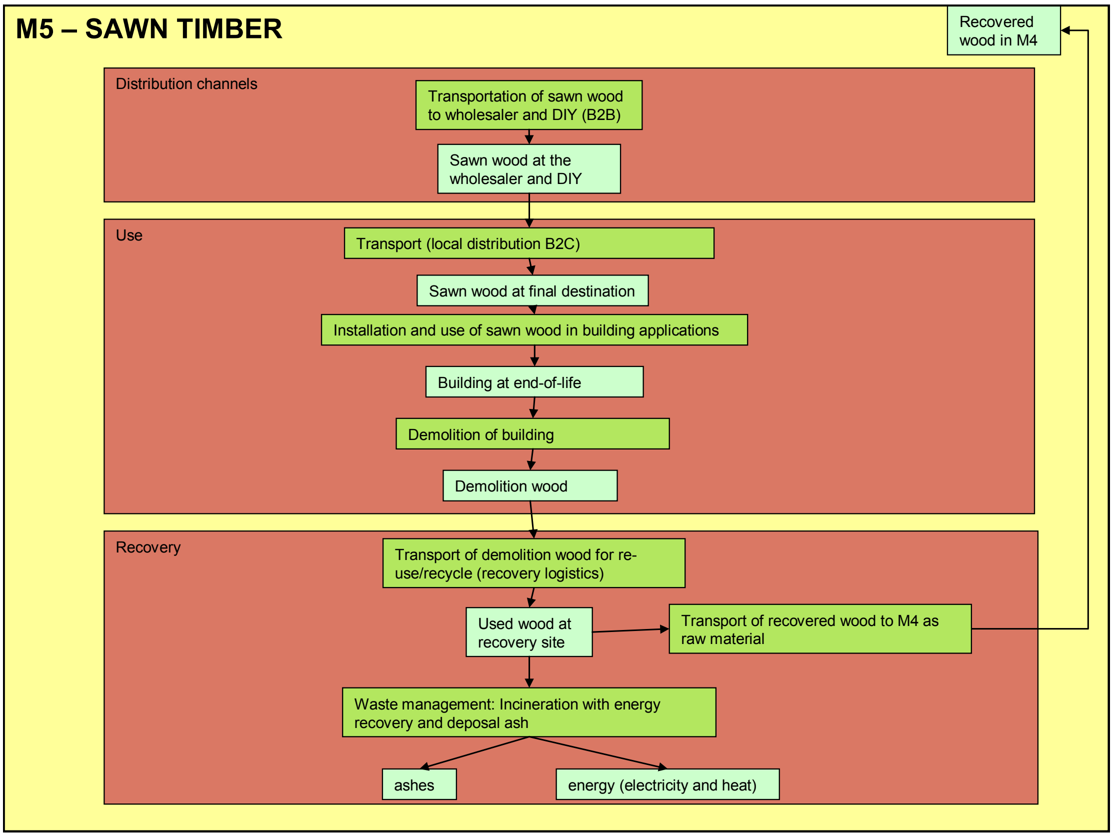

M5 – GLUELAM
Recovered wood in M4
Distribution channels
Transport of gluelam to the construction sites (local distribution B2C)
Gluelam at construction site
Use
Installation of the gluelam beam in the structure
Construction with gluelam
Use of the construction
Construction at end-of-life
Dismantling of construction
Dismantled gluelam beam
Recovery
Transport of demolished gluelam beam for re-use/recycle (recovery logistics)
Dismantled gluelam at recovery site
Transport of recovered wood to M4 as raw material
Waste management: Incineration with energy recovery and deposal ash
ashes
energy (electricity and heat)


M5 – WINDOWS
Recovered wood in M4
Distribution channels
Transport of windows to the building sites (local distribution B2C)
Windows at building site
Use
Installation of the windows in the building
Building with wooden windows
Use of building
Building at end-of-life
Demolition of building
Demolished window
Recovery
Transport of used window for re-use/recycle (recovery logistics)
Dismantled window at recovery site
Transport of recovered wood to M4 as raw material
Waste management: Incineration with energy recovery and deposal ash
ashes
energy (electricity and heat)


M5 – FURNITURE
Distribution channels
Transportation of furniture to retail site
Furniture at retail
Use
Transport (local distribution B2C)
Furniture at final destination
Using the furniture
Used furniture
Recovery
Transport to incinerator (recovery logistics)
Used furniture at incinerator
Waste management: Incineration with energy recovery and deposal ash
ashes
energy (electricity and heat)


M5 – PARTICLEBOARD
Recovered wood in M4
Distribution channels
Transportation of particleboard to wholesaler and DIY (B2B)
Particleboard at the wholesaler and DIY
Use
Transport (local distribution B2C)
particleboard at final destination
Installation and use of particleboard in building applications
Building at end-of-life
Demolition of building
Demolished particleboard
Recovery
Transport of demolished particleboard for re-use/recycle (recovery logistics)
Used wood at recovery site
Transport of recovered wood to M4 as raw material
Waste management: Incineration with energy recovery and deposal ash
ashes
energy (electricity and heat)


M5 – PLYWOOD
Recovered wood in M4
Distribution channels
Transportation of plywood to wholesaler and DIY (B2B)
plywood at the wholesaler and DIY
Use
Transport (local distribution B2C)
plywood at final destination
Installation and use of plywood in building applications
Building at end-of-life
Demolition of building
Demolished plywood
Recovery
Transport of demolished plywood for re-use/recycle (recovery logistics)
Used wood at recovery site
Transport of recovered wood to M4 as raw material
Waste management: Incineration with energy recovery and deposal ash
ashes
energy (electricity and heat)


M5 – SAWN TIMBER
Recovered wood in M4
Distribution channels
Transportation of sawn wood to wholesaler and DIY (B2B)
Sawn wood at the wholesaler and DIY
Use
Transport (local distribution B2C)
Sawn wood at final destination
Installation and use of sawn wood in building applications
Building at end-of-life
Demolition of building
Demolition wood
Recovery
Transport of demolition wood for re-use/recycle (recovery logistics)
Used wood at recovery site
Transport of recovered wood to M4 as raw material
Waste management: Incineration with energy recovery and deposal ash
ashes
energy (electricity and heat)