FlexWood

Flexible Wood Supply Chain

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Industrial requirements, gaps and improvement needs

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SEVENTH FRAMEWORK PROGRAMME

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1. Executive summary

The main objective of deliverable D3.1 is to express and to describe the demands of main industrial sectors within the Wood Supply Chain (WSC) in terms of wood raw material qualities. It covers production of solid wood products (sawmills), pulp and paper (fibre) and bio-energies. It is often observed that industrials of the WSC must produce on any wood materials available and delivered, where wood raw material pushes the manufacturing of certain products. Combining industrial demand with new technologies such as remote sensing, which enable to identify wood properties early in the chain, opens the door for more efficient processes and material uses.

This deliverable identifies the profiles of demand of three sectors on wood raw material properties according to their relative importance. The profiles are strongly related to particularities of each production site. Therefore the results are to be seen as representing the typical, general characteristics of industrial requirements that can be expected in an average situation. The profiles of demand are determined by sector specifications, products made and processes used.

There exist several key quality properties of wood raw material for each industrial sector. The requirements are characterised by wood properties at stand level and at individual tree (log) level. Sometimes these properties are shared among sectors (e.g. species), but most of time their relative importance vary (e.g. age). Typical requirements of sawmills are higher than those of bio-energy producers. In pulping, the basic, unconditional requirements vary depending on the type of pulping process (i.e. mechanical vs. chemical pulping). In general requirements are more difficult for mechanical than for chemical pulping. The importance of quality properties is expected to increase in future.

Beside the native wood properties, there are several activities along the supply chain affecting the quality of wood (e.g. harvesting, forwarding, stocking). In general for bio-energies their impacts may be more important than the native properties (e.g. grades, contamination with other materials …). Industrials expect suppliers to improve their efficiency. For a supplier this includes the ability to solve a puzzle of several parallel harvesting objects to serve several customers in time and quantity under variable harvesting and transportation conditions. It can be achieved i.e. by improvements of harvesting and transport techniques, of information systems and logistic planning.

Regarding the quantities of wood, the major consumption of round wood is realised by sawmills, although the level vary among countries. It is reasonable to expect that productions of sawmills and bio-energies will increase at the horizon 2020. Therefore the more the demand of sawmills (having the highest requirements of wood qualities) increases in the future, the more identification of wood quality properties at the beginning of supply chain is relevant, and make the use of remote sensing technologies attractive. Similarly, the more the demand of bio-energies (representing high requirements on activities of supply chain) increases in the future the more efficiency of logistics and material supply is relevant.

Finally, the industrial sectors are not operating isolated in the WSC. Interactions are numerous, and other actors intervene. A stakeholder analyses reveals that there is a potential conflict between material and energy use of wood. The support for Renewable Energy Sources (RES) may lead to shortage of wood and increase in competition within the supply chain. Here also the remote sensing technologies, and logistics, can improve the efficiency of the wood use and as such improve the visibility of the forest based sectors in the sustainable development of Europe.

2. Introduction

2.1 Objectives of the deliverable

The main objective of this deliverable is to express and to describe the demands of main industrial sectors within the Wood Supply Chain (WSC) in terms of raw material qualities. The main industrial sectors, covered in this deliverable, are production of solid wood products (sawmills), of pulp and paper (fibre) and of bio-energies. The ultimate aim is to assess the capacity of the WSC of being demand driven, where demand of industries pulls the activity in the rest of supply chain (and forest exploitation). This is the opposite to the very often observed situation in the WSC where industrials have to produce on any wood materials available and delivered, where wood raw material pushes the manufacturing of certain products. Combining industrial demand with new technologies like remote sensing, which enable to identify wood properties early in the WSC (at stand, at road), opens the door for more efficient processes and material uses.

Requirements on quality properties are enumerated by industrial sector, and ranked according to their importance. When possible, quantitative values are provided. Future evolution of industrial sectors is foreseen, through the identification of future requirements with perspective of 5 to 10 years.

Beside demands on wood qualities, industrial requirements on wood quantities, which exist today and forecasted at the medium term (5 to 10 years), are illustrated.

Additionally, the industrial sectors are not operating isolated in the WSC. There are numerous interconnections, as well as other actors influencing the situation. Focusing only on industrial requirements, without considering demands and positions of other stakeholders, would produce only a partial picture. Therefore, requirements of stakeholders of the WSC are also assessed, to draw up measures of success for meeting industrial requirements within the multiple stakeholders environment.

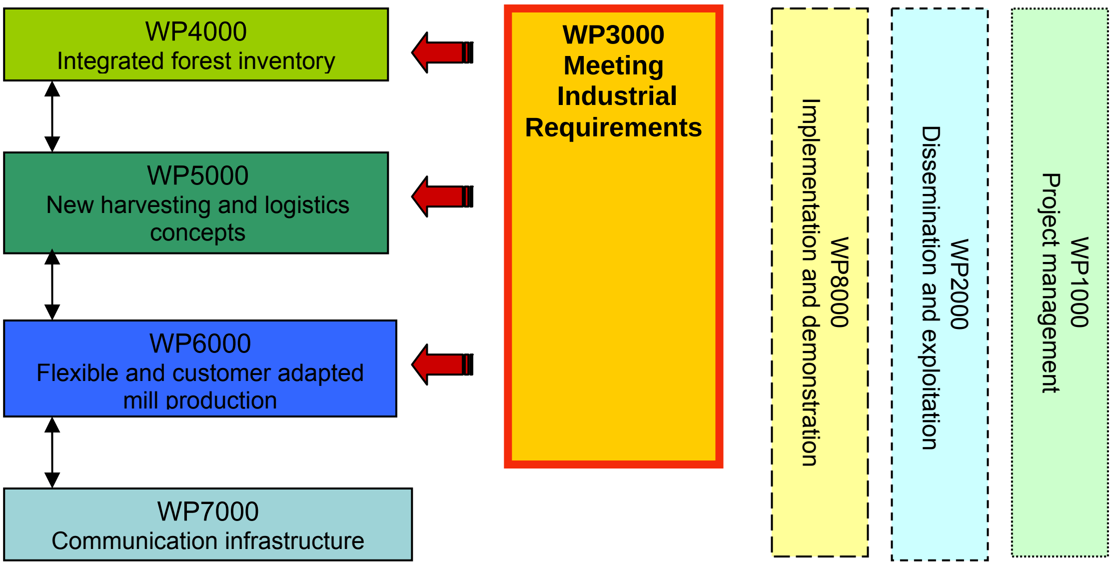
The deliverable focuses on six European countries: Austria, Finland, France, Germany, Poland and Sweden. The geographical coverage can embody large differences among industries of the same sector; when estimated relevant and possible, the national specificities are reported.

2.2 Organisation and structure

The deliverable is a common result of five tasks, belonging to the WP3000. It is the only deliverable of the WP3000; it is also the first milestone of the project.

The results of the deliverable will be further used in WP4000, WP5000 and WP6000 of the project (Figure 1).

Figure 1. WP3000 as a source of information to other WPs



The deliverable is structured as follows. Once the general approach of work for identifying profiles of industrial demand presented (Chapter 3), the requirements of industrials in terms of wood quality properties are identified per industrial sectors (Chapters 4, 5 and 6) and summarised according to their relative importance (Chapter 7). The trends of future industrial demands in terms of quantities are estimated in the chapter 8. The demands of stakeholders, within the WSC, are assessed in the Chapter 9.

3. The approach

3.1 The rationale

In order to generate a comparable and consistent picture among tasks and aims of the WP3000, the partners decided to elaborate and share a common approach of work.

The deliverable D3.1 is a common result of tasks 3100, 3200, 3300, 3400 and 3500. The tasks gather seven partners in the FlexWood project from six countries.

The tasks consider three industrial sectors (sawing, pulp/paper and bio energy productions) and stakeholders within the WSC. The tasks 3100, 3200 and 3300 share common objectives related to industrial requirements (and needs) regarding the wood raw material, while the task 3400 assesses these requirements within a broader context of WSC (actors and their behaviours).

The common approach defines the manner to achieve the objectives, shared among tasks and partners, although some specificities (e.g. content of questionnaires, targeted population) should remain.

3.2 A common focus on industrial requirements

The tasks of WP3000 share a common focus on industrial requirements related to the wood raw material. The requirements are defined as properties of wood which are demanded (wished or needed) by industries.

At the lowest scale, the industrial demands are specific to each production site, according to its needs and context of the wood supply chain (e.g. local prices of wood, relations with suppliers, number of suppliers …). In this deliverable, the focus is made on the general requirements, which reflect typical profiles of demand of an industrial sector. At the general level, three main aspects determine the profiles of industrial demands.

The industrial requirements on wood raw material are determined by products made at a production site, at the first. In other words, specifications of products made (outgoing form the site) determine specifications of wood raw material demanded by industries (incoming to the site).

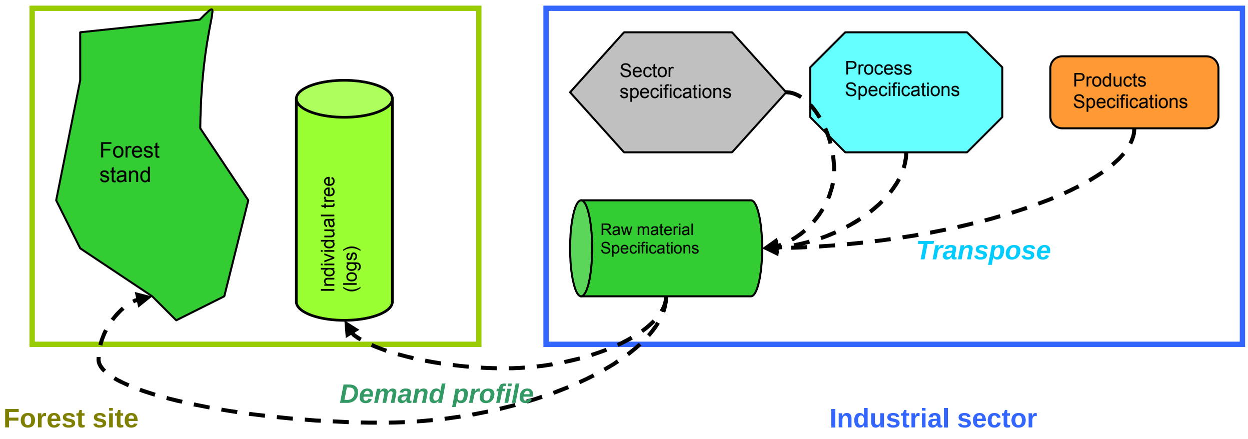
In addition, industrial requirements on wood raw material are conditioned: (1) by industrial process specifications (e.g. type of head saw, chemical – mechanical pulping, characteristics of equipments of combustion plants…) and (2) by sector specifications such as practices (e.g. fluctuations in production - regular flows of raw material to production sites like pulp mills against seasonal needs of production sites like heating plants).

In sum, the principal goal of tasks is to transpose industrial requirements (determined by specifications of sectors, of processes and of products to be manufactured) to requirements on wood raw material specifications demanded by industries, which cover characteristics of wood raw material (species, dimensions, quality properties…). The requirements on raw material define the “profiles of industrial demand” on wood. The profile of industrial demand is further transferred to characteristics of wood in forest.

In practice, other characteristics can influence industrial requirements on wood raw material (e.g. evolution of price of wood on the local market, particular relations with suppliers such as common equipments …) but they are specific to each production site, and as such out of scope of WP3000.

In front of industrial demand, the wood raw material comes from forest sites. At a forest site, the wood can be determined according to the forest stand and individual tree (or log) properties (Figure 2).

Figure 2. Industrial requirements on wood raw material



For example for sawmills this drives to:

- Determine typical specifications of boards to produce (e.g. species, types, dimensions, quality characteristics - knots…), in respect to typical sawmill's characteristics (process and equipments);
- Transpose boards' specifications into requirements on incoming logs specifications (e.g. spaces, logs characteristics such as lengths, top diameter, taper, sweep, ovality, crook, knots, rotten knots, density, …);
- Further convert requirements on logs specifications to wood in forest site (e.g. species, diameters, lengths, knots...) with priority grading (high, medium and low) of properties according to their importance.

For pulp/paper mills this means to:

- Identify typical pulp/paper products to make in respect to typical mill's characteristics (process and equipments);
- Transpose products specifications into requirements on incoming wood specifications (e.g. species, types of wood – mature/juvenile wood, slow/fast growing wood, …)
- Further transpose requirements of wood specifications to wood in forest (e.g. species, freshness) with priority grading (high, medium and low) of properties according to their importance.

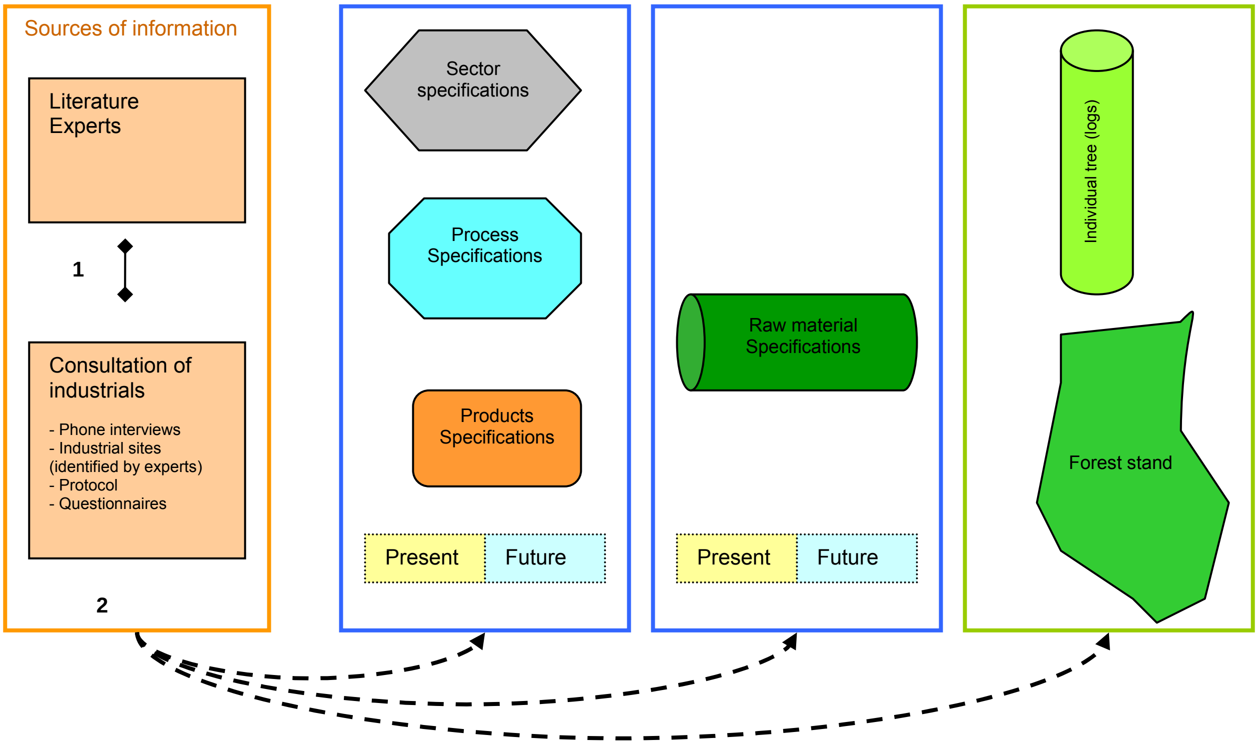
For energy production sites it is necessary to:

- Define typical products to make, in relation to the typical characteristic of the production sites (process and equipments);
- Decline product specifications into requirements on raw material specifications (e.g. characteristics of grades, moisture…);
- Further translate the requirements on raw material specifications into wood characteristics in forest (e.g. species, tree compartments– branches, needles, bark, leaves, stump, roots …), with priority grading (high, medium and low) of properties according to their importance.

3.3 Revealing industrial requirements

Identification of profiles of industrial demand, and their transposition to raw material specifications, is based on two sources of information (Figure 3).

Figure 3. Revealing industrial requirements through surveys and literature



3.3.1 Inputs from the literature and experts

The literature is the first source of information. However, in some fields still in infancy (e.g. wood quality properties in production of pellets) there is a low amount of existing references. Similarly, on several specific issues (e.g. identification of future trends, rationale behind targeted/prohibited properties, ability of models to provide information,…) the literature is diffuse. In addition due to tight deadlines, several experts having a deep knowledge of industry processes, products and needs are consulted.

3.3.2 Consultation of industrials

To complete the information, and ensure the consistency with experiences of industrials in practice, the tasks establish direct contacts with industrials (or their representatives). They take form of dialogues implementing specific questionnaires (per task) through telephone interviews. When low amount of responses is collected, it is more relevant to speak about “consultation of industrials” rather than “surveys”. However the key principals of information collection are identical. As far as possible, the priority is given to direct contacts.

In order to have a consistent approach among tasks and partners, a protocol for interviews is developed (available on request from partners). Above the protocol, specific questionnaires (available on request from partners), identifying information to collect, are constructed per task. The questionnaires are implemented in covered countries, and responses are compiled

and analysed per task. For a coherent approach and comparable results between countries, it is important to harmonise the principal characteristics of interviews.
The aim of consultations is to consider industrial situations in practice, identify and update the knowledge about their requirements on wood raw material characteristics. They are based on “subjects” (activities of industrials), identifying the typical industrial requirements and the main factors determining them.

The target population are industrial sites (enterprises), of the main industrial sectors of the WSC (sawmills, pulp/paper producers, and bio energy producers). An option would be to use the Statistical Classification of Economic Activities in the European Community (NACE Rev. 2), which is the European standard classification of productive economic activities[1], to identify the enterprises. However, due to restricted deadlines of the deliverable and the objectives (reveal the typical industrial situation without necessarily driving an extensive survey with e.g. statistical analysis) the partners decide to streamline the work towards the enterprises they consider the most relevant and willing to answer.

Therefore the “samples” of surveys[2] are identified by the experts. The experts are asked for particular attention when choosing the reporting units. The general guideline for the expert is that the selected enterprises should represent the fundamental characteristics of the target population (or of sectors) at national level. Identifying the sample by experts contains a “selection bias”. But due to the context, the extensive survey among industrials (e.g. >50 respondents per sector) is out of scope of WP3000.

The reporting unite is the entity where the sought information are collected. The reporting unites are enterprises in sense of industrial sites and not companies which can have several production sites.

The collection of information is done through direct phone interviews with the enterprises. Compared to the postal survey, the phone interview brings higher quality of responses.

The respondents to the survey are employees of industrial sites, and specifically managers of the enterprise or people responsible for wood raw material procurement.

[1] The criterion of classification of NACE is the principal activity. A unit may perform one or more economic activities described in one or more categories of NACE. One NACE code is assigned to each unit according to its principal economic activity. The classification NACE is structured on four levels. Level 1: 21 sections identified by alphabetical letters A to U. Level 2: 88 divisions identified by two-digit numerical codes. Level 3: 272 groups identified by three-digit numerical codes. Level 4: 615 classes identified by four-digit numerical codes.
[2] In case the surveys collect a low amount of reporting units (e.g. <20 responding enterprises per sector for all countries), it is more appropriate to speak about “consultation of professionals” than about “surveys” (reflecting that a low number of enterprises for instance 5-10 per sector for all countries).

4. Production of solid wood products industry requirements

4.1 Data sources and coverage

4.1.1 Experts' opinions

Structure and processes of producers of solid wood products (sawmills) are complex and highly dependant on national, regional and production site characteristics. Therefore, experts having a deep knowledge of the sector were consulted at the national level. Their inputs were used as guidelines for identifying quality requirements, and future perspectives.

4.1.2 Consultation of industrials

The questionnaire focuses on the following matters: used tree species, sawmills output per year, used amount of logs per year, short description of sawing process and typical products of the sawmill in different product groups. The sawmills are also asked to evaluate the importance of different characteristics and defects of logs. Additional questions assess the log minimum requirements concerning different characteristics and defects in the present and future situation.

The questionnaire, after testing and simplification, was implemented in Finland, Sweden, Poland, Germany and France. The answers concern softwood sawmills in Finland (2), Sweden (experts opinion), Poland (3), and France (3 profiles), and hardwood sawmills in Germany (6) and France (1 profile).

4.2 The main processes and products of sawmills

4.2.1 Finnish sawmills

The two responding sawmills represent an output of about 200 000 m^3 sawn timber. Species are Norwegian spruce (75%) and Scotch pine (25%). Spruce logs are sorted by top diameter and length, pine logs by top diameter, length and quality grade (butt log and middle/top log). Sawing method in both sawmills is cant sawing. Sawn timber is dried in compartment kilns (35…39%) and in progressive kilns (61…69%).

Typical products are construction timber (30%), panels (25%), timber for joinery and furniture (25%), timber for packaging (8%) and timber for other uses 12%.

In Finland the great majority of sawn timber is produced by medium size and big sawmill companies. They operate mostly in the same way, so there is no need to divide sawmills into different categories.

The structure of Swedish sawmill industry is to a great extent similar to Finland, and hereafter are included together.

4.2.2 Polish sawmills

Polish timber market is dispersed, with numerous, often changing small and very small entities, having low production scale. Very often, the technologies used by sawmills are out of date.

The actual number of manufacturers of sawn timber is estimated at 3,000 entities. About 50% of them are handicrafts enterprises, processing less than 1 000 m^3 of raw material annually. About 45% are small firms sawing between 1 and 10 000 m^3 of raw material.

Finally, 5% saw over 10 000 m^3 of round wood/yr, but purchase about 52% of sold raw material volume. An observed trend is a slow but permanent consolidation of sawmill sector.

All three consulted sawmills consume pine, and their main processes and products are:

Table 1. Main processes and products of Polish sawmills

	Output (sawn timber m^3/yr)	Main processes	Main products
Sawmill A	60 000 m^3	- Logs sorted by diameter and length, cant sawing method - Compartment drying 50%, progressive drying 50%	- Construction timber 10%, joinery timber 70% , other 10%
Sawmill B	18 000 m^3	- Butt logs sorted by diameter and grade - Other logs (construction timber) sorted by diameter and length - Cant sawing 95%, Live sawing 5%	- Construction timber 60%, Joinery timber 30% , other 10%
Sawmill C	15 000 m^3 (Raw material 94% pine, 4% larix)	- Sorting by top diameter and quality grade - Cant sawing 85%, live sawing 12%, profiling 3% - Compartment drying 70-80%, no drying 20-30%.	- Construction timber 97%, other 3%

4.2.3 German sawmills

Four of six German hardwood sawmills are small, consuming under 15 000 m^3. One uses raw material over 50 000 m^3. Two of them consume only one species, beech. Both cant and live sawing method are employed (table 2). Production goes mainly to joinery and furniture industry.

Table 2. Description of German sawmills

Sawmill	Species				Sorting			Drying		Products			
	Beech	Oak	Other hardwood	Use of logs	Log diameter	Log length	Log quality	Comparment kiln	No drying	Construction	Joinery and furnit.	Square jointed l.	Packaging
	%	%	%	m3				%	%	%	%	%	%
1	13	25	62	< 15 000	x	x	x	90	10		100		
2	65	35		< 15 000	x	x	x	30	70		100		
3	x	x		< 15 000		x	x	100				100	
4	80	15	5	< 15 000			x	98	2		100		
5	100			> 50 000				100			100		
6	60	20	20	15-50000	x	x	x	70	30	10	80		10

4.2.4 French sawmills

In France, sawmills account for about 2 000 companies with very different size and productions given the region they are implemented in and the tree species they consume. Additional differences are related to characteristics of processes and type of products. Due to the time constraints and difficulty to illustrate the heterogeneity of French sawmills, a focus is made on a given number of company profiles, which represent the main characteristics of the national sawmills. These profiles are:

Table 3. The main profiles of French sawmills

Species consumed	Process	Products made
• Spruce – Fir • Maritime Pine • Beech	• Industrialised (with production volume >10 000 m^3/y) • Partially industrialised (with production volumes between 1 000 and 10 000 m^3/y)	• "Construction Mix" • Low quality end products (Palette or Mass-flooring)

With this classification, small and very small sawmills producing less than 1 000 m2/y (about 900 companies) are out of scope.

Regarding the level of integration of operations within the French wood supply-chain, during the last 30 years, there has been a progressive change in the organisation of the supply chain for production of sawn-products. 30 years ago, 80% of the sawmills used to integrate wood procurement operations (forest exploitation – harvesting, etc.). Today, the integrated procurement only concerns 45% of the companies. This evolution is also reflected in the way the raw material is bought by the sawmill.

Table 4. Distribution of the Total Volume procured depending on the selling method (as reported by a survey done in 2009 on 67 French sawmills).

	Standing tree		Tree length or CTL logs		
Selling method	Hand to hand (Gré à Gré)	Auction (Enchère)	At the road side	Contracts with ONF*	others
% of the total Volume	34	26.5	17.8	12.7	9

Source FCBA 2010.
** Office National des Forêts is the French National Public Forest Management entity*

While integrated procurement means rely on the buyers skill to determine the inner quality of a standing tree plot, contractual wood selling methods drive a sawmill to express requirements in a more quantitative and "documented" way. However, both procurement methods co-exist and FR-EN standards are acknowledged as a reference for round wood classification.

Concerning the description of procurement requirements, the documents used by sawmills to specify their round wood needs to suppliers are not easily shared by companies. However, at least one real example backs each profile.

Profiles are determined according to the main processes and products.

- The main processes and products of sawmills Profile N°1

Species	Process	Products
Spruce – Fir	Industrialised (10 000 m^3/y < prod)	"Construction Mix"

Profile n°1 companies are located mainly in the big quarter north-east of France. They process Spruce & Fir which are not sorted one from another when delivered. Round wood is delivered either CTL or still at tree length (up to 20 m). For the latter, equipment is used to reduce the butt-end and circular saw cut long trees into logs. At the sorting station, logs are measured automatically by the scanner (length, diameter, geometry, non-wood content…) and their quality is manually determined by the operator. Number of sorting beans is variable from one company to another. The sorting is done by combining scanner measurement with human determined quality criteria. At the sawing station, cant method is used with circular saws. Boards are then sorted and stacked automatically.

Profile n°1 companies are oriented towards the overall construction market and produce what is understood as a “construction mix of sawn products” with variable shares of high, medium and low added-value wood products.

Table 5. Products of profile n°1 companies

Added – value level	Product use	Typical characteristics of products	% of total volume
High	Mouldings, framings, furniture…	• 30 x 30 L2.5m	15
Medium	Standard framing	• 36x97 L4m (C24, C30) and 80x180 L4m (C18, C24) for Finger joint framing • 36x97 L5m C24 for industrialised framing • 55x75 L4m and 75x225 L5m for traditional framing	50
Low	Packaging, casing	• 18x98 • 75x225 L5m	35

- <u>The main processes and products of sawmills Profile n°2</u>

Species	**Process**	**Products**
Maritime Pine	Partially industrialised (1 000 < prod < 10 000 m^3/y)	Low quality end product (Palette or Mass-flooring)

Profile n°2 companies are located in the Aquitaine basin in the south west of France. They process Maritime Pine exclusively and receive CTL (240 cm) logs which are unloaded on the mill’s deck without sorting operation. Band saw are used both for Primary and Secondary breakdowns and most of the sawn products are dried in compartment kilns.

Table 6. Products of profile n°2 companies

Added – value level	Product use	% of total volume
High	Mouldings	5
Medium	Flooring and panelling Palette	90
Lesser	Batten	5

- <u>The main processes and products of sawmills Profile N°3</u>

Species	**Process**	**Products**
Spruce – Fir	Partially industrialised (1 000 < prod < 10 000 m^3/y)	“Construction Mix”

Profile n°3 companies are located all over France. They process mainly Spruce & Fir but they can also accept other softwood species like Douglas fir, Pine or Larch. Round wood is delivered either CTL or still at tree length (up to 20 m). For the latter, equipment is used to reduce the butt-end and circular saw cut long trees into logs. At the sawing station, band and circular saws are used. Boards are sorted (with longitudinal sorter) and often stacked manually.

Profile n°3 companies are oriented towards the overall construction market and produce what is understood as a “construction mix of sawn products” with variable shares of high, medium and low added-value wood products. These companies mostly work “on demand” to supply their clients with products of specific dimensions in terms of width and length as well as quality. In such situation, they face the following challenges:

- Client's demand is changing due to recent competition between traditional products and emerging Finger-jointed structural timber;
- Large retail companies expect to be supplied with regular volumes that these semi-industrialised sawmills can not always provide.

Table 7. The overall mix products of profile n°3 companies

Added – value level	Product use	Typical characteristics of products	% of total volume
High	High quality framings	• 200 x 260 L 8 m • 75 x 225 L 5 m • on demand	10
Medium	Standard framing	• 55 x 75 L 4 m • 75 x 225 L 5 m • on demand	70
Lesser	Packaging, casing	• 18 x 98 • 75 x 225 L 5 m • on demand	20

- <u>The main processes and products of sawmills Profile N°4</u>

Species	**Process**	**Products**
Beech	Partially industrialised (1 000 < prod < 10 000 m^3/y)	"Construction Mix"

Profile n°4 companies are located all over France but most of the production (in Volume and number of Companies) is found in the quarter North-east of the country. They process mainly Beech (more than 50% of the sawn volume) but they can also accept other hardwood species like Oak, ash, maple, chestnut, wild cherry or poplar. Round wood is delivered mostly at tree length (up to 20 m). However, some companies manage to be partially supplied with cut to length logs. Added value is created with mainly two means: kiln drying (for moisture content management) and steaming (for colour management).

Profile n°4 companies are oriented towards the overall construction market and produce what is understood as a "construction mix of sawn products". Historically, beech sawmill were mainly oriented towards the furniture market but the situation of the French furniture manufacturers in the past years resulted in a shift of the balance between different outlets.

Table 8. Sawmills Profile 4 main market shares (2006)

	Furniture	Packaging and casing	Framing	Flooring	Others (incl. semi-finished products)
Share of total volume	27%	46%	8%	1%	18%

Table 9. The main product types

Product type	Typical characteristics of products	
	Length	Thickness
Boule	• from 2 to 5 m	• from 18 to 100 mm
Unedged timber	• from 2 to 5 m	• from 18 to 100 mm
Square edged timber	• from 1.2 to 3m	• from 18 to 80 mm • width from 80 to 100 mm

4.3 Importance of assessment of log and stem characteristics

The identification and importance of quality parameters are varying across countries. The parameters are identified according to log/stem properties and to detailed log/stem properties.

In Finland information of total volume of stems in the stand is regarded important (Table 10). Also total volume of log part of stems, average quality of stems, and distribution of stems by breast height and by quality are important to know. Score value of the information about average quality and geometrical properties of stems is on average two. If the same information is available from individual stems (Tables 10, 11), corresponding score is little higher.

Polish results indicate that the knottiness part of the stems, average quality grade of the stems and total number of stems are scored highly (3). On the other hand the characteristics which do not relate to sawing or sawn timber (bark properties and fibre properties) received low scores.

German hardwood sawmills have given scores only few characteristics. Total volume of stems and average quality of stems have got highest scores. Total number of stems by breast diameter, geometry of stems and general branchiness have got score value two.

Table 10. Importance of log/stem information per country

Required information before procurement	Finland	Poland	Germany	Sweden
Total volume of stems	3	1	3	3
Total volume of log part of the stems	3	2		3
Total volume of knottiness part of stems	2	3		2
Total volume of pulp wood part of stems	2	1		2
Average quality grade of stems	3	3	3	3
Total number of stems	2	2		2
Total number of stems by breast height diameter	3	3	2	3
Total number of stems by breast height diameter and quality grade	3	3		3
Stand: Average quality and geometrical properties of the stems				
1. Stem geometry: taper, sweep,…	3	3	2	3
2. Heartwood diameter (and/or content in %)	2	2		2
3. Internode length (distance between branch whorls)	2	2		1-3
4. Fibre properties of sawmill chips	2	1		2
5. Density	1	0		1
6. Green density, moisture content of logs without bark		1		2
7. Dry out after felling (freshness criteria)		2		2
8. Ring with	2	3		2
9. Bark volume	1	2		1
10. Bark properties (dry substance, water content)	1	0		1
11. Dead knot volume	2	3		2
12. Live knot volume	1	3		2
13. Rotten knot	2	3		3
14. Spike knot	2	2		2
15. Rot	2	3		3
16. Spiral growth	2	3		3
17. Bole scar	2	2		2
18. Pitch pockets	2	2		2
19. Length of knot free part	2	3		2
20. Length of knottiness part and distance from ground to crown	2	2		2

Legend: 3=Most important, 2=Important, 1=Least important, 0=Not important parameters

Table 11. Importance of detailed log/stem information per country

Required detailed description of logs/stems	Finland	Poland	Germany	Sweden
Breast height diameter	**2**	**3**		**2**
Length	**2**	**3**	**2**	**2**
Diameter series at X cm intervals	**2**	**3**		**2**
Following characteristics - measured or predicted				
1. Stem geometry: taper, sweep,…	**2**	**3**		**2**
2. Heartwood diameter (and/or content in %)	**2**	**1**		**2**
3. Internode length (distance between branch whorls)	**2**	**3**		**1-3**
4. Fibre properties of sawmill chips	**2**	**0**		**2**
5. Density	**3**	**2**		**3**
6. Green density, moisture content of logs without bark	**2**	**3**		**2**
7. Dry out after felling (freshness criteria)	**2**	**2**		**2**
8. Ring with	**3**	**2**		**3**
9. Bark volume	**2**	**0**		**2**
10. Bark properties (dry substance, water content)	**2**	**0**		**1**
11. Dead knot volume	**3**	**3**		**3**
12. Live knot volume	**2**	**3**		**2**
13. Rotten knot	**2**	**3**		**3**
14. Spike knot	**2**	**2**		**2**
15. Rot	**2**	**3**		**3**
16. Spiral growth	**3**	**3**		**3**
17. Bole scar	**2**	**2**		**2**
18. Pitch pockets	**2**	**1**		**2**
19. Length of knot free part	**2**	**3**		**2**
20. Length of knottiness part and distance from ground to crown	**2**	**2**		**2**
Very detailed description of stems				
Comprehensive 3D geometry and quality characteristics from the representative sample stems - virtual	**3**			**3**
Comprehensive 3D geometry and quality characteristics from all stems - virtual stems	**3**			**3**

Legend: 3=Most important, 2=Important, 1=Least important, 0=Not important parameters

4.4 Log requirements in the procurement

In Finland pine logs are normally graded into butt logs and middle/top logs. In some sawmills better butt logs are separated out (references are available from partners on request). Spruce logs are normally not graded by grade. Each sawmill has its own quality and dimension qualifiers which do not differ substantially from each other.

Swedish soft wood requirements differ from Finnish ones (references are available on request).

Polish pine log requirements are specified (references are available on request). More sweep is allowed in Polish requirements than in Nordic requirements.

Requirements for German hardwood logs are completely different than requirements for soft wood logs (references are available on request).

In France, the situation is more complex. The Profile n°1 companies are the largest sawmills in the French sector, in terms of wood volumes. Regarding the procurement, they have to balance their needs to supply the mill with a high volume of round wood and their objective to produce the “product mix” with the highest added-value. In addition, the sawmills are facing competition on the raw material, particularly sensitive regarding the volumes needed. The high level of competition on raw material has an influence on this balance and explains that while sawmill can indeed express quality specifications, their supply requirement are mainly focusing on quantitative criteria (volumes). The wood quality requirements are:

- Species;
- Log length: only minimum is quantified (~ 3 m);
- Diameter: with minimum (~ 15 cm) and maximum (~ 55 cm);
- Geometry is quantified according to normative classification EN 1927-1 (for example log bow (in cm per m) is one of the criteria for A-B-C-D classification);
- Quality (Sound knots, black knots…) is quantified according to normative classification;
- Non-wood elements are excluded (such as ammunition from past wars);
- Colouration (Blue stain, Heart wood colour reflecting degradation of wood…) is discriminatory.

The Profile 2 sawmills processing maritime pine have specific requirements due to the specificities of this tree species (geometry, knots and inter-knots length, resin, fire damages…). The organisation of the supply chain in the Aquitaine basin is quite specific with high majority of automated harvesting operations and CTL system – which is not necessarily the average for the French forest-based sector. The wood quality requirements are:

- Species;
- Log length (for example 220 cm or 240 cm);
- Diameter: with minimum (20 cm) and maximum (55 cm);
- Log bow is quantified (for example 2 cm/m);
- Sound knots are quantified (for example: less than 3 knot rings on the log length with know diameter <4 cm);
- Black knots are discriminatory;
- Fire damages and non-wood elements (mainly metal) are excluded;
- Colour (blue stain) is discriminatory;
- Resin pockets are quantified (for example: maximum 1 per log).

Organisation of the procurement of Profile n°2 companies depend on their level of integration. Many groups with varied wood productions are present in the Aquitaine basin and they usually have their own harvesting and supply company.

Profile n°3 companies is the largest population of sawmills in the French sector. The share of “on demand”-products in their overall activity influences the initial procurement requirements, especially long & high quality framing which must be produced out of logs with specific length and quality. Because of this need to look for logs with the highest potential added-value, semi-industrialised sawmills manage to get a product-mix with a limited share of low-quality products (for packaging or casing use). The wood quality requirements are:

- Log length: only minimum is quantified (~ 4,20 m);
- Diameter: only minimum is quantified (~ 20 cm);
- Geometry is quantified according to normative classification EN 1927 (for example log bow in cm per m);
- Quality (Sound knots, black knots…) is quantified according to normative classification EN 1927 and Classes B & C are the most looked for;
- Non-wood elements are excluded (such as ammunition from past wars);

- Colouration (Blue stain, Heart wood colour reflecting degradation of wood…) is discriminatory.

For sawmills belonging tot the Profile 4 very few procurement documents exist to state the sawmills' requirements which mainly are:

- Species;
- Log length: only minimum is quantified (~ 3 m);
- Diameter: only minimum is quantified (~ 20 cm);
- Geometry quantified according to normative classification EN 1316 (for example log bow in cm per m);
- Quality (Sound knots, black knots…) quantified according to normative classification EN 1316;
- Non-wood elements are excluded (such as ammunition from past wars);
- Colouration (Blue stain, Red Heart …) can be discriminatory.

4.5 Linking products specificities to raw material properties

In the literature attempts are made to link solid wood products and process characteristics to the raw material properties. Hereunder are summary tables (Tables 12, 13) were main solid wood properties of products are related to log characteristics and their impacts on the production process.

Table 12. Key relations between log properties and solid wood products

Key properties	Relation to log characteristics	Impact on solid wood product
Density (kg/m^3)	• Growth rate • Log position in the stem (butt-log, second log, branches…) • Species-dependent	• Strength and toughness of the product
Knot size and status	• Visual appearance of the knots (dead or alive) • Log position in the stem (butt-log, second log, branches…) • Species-dependent	• Visual grading of sawn timber before sorting (for usability) • result of the drying process (distortion risk) • Product strength (reduced if knot ratio is too high)
Reaction wood	• Linked to wood cell characteristics and hardly detectable visually	• Density variation in the production • Result of the drying process (distortion risk)
Hardness	• Growth rate • Species-dependant	• Usability of the product
Appearance	• Knot size and status • Grain angle • Log position within the stem • Stain • Damage and rot	• Usability of the product
Durability / Permeability to preservatives	• Natural durability is species-dependent • Impregnative capacity is species-dependent • Percentage of heartwood • Tree age	• Usability of the product for outdoor application
Moisture content	• Percentage of sapwood • Log position in the stem	• Result of the drying process (distortion risk)

Source: Lundqvist S. O. et al. (2007)

Table 13. Key properties of logs and their impacts on process and products

Key log properties	Impact on the process	Impact on the product
Stem size	• Upper and lower size limits that units are able to handle	• Size-dependent usability of the product
Straightness and roundness	• Ability to processes (laminated timber, peeling, gluelam…) • Yield	• Physical and visual appearance properties
Knot size and status	• Result of the drying process (distortion risk)	• Visual grading of sawn timber before sorting (for usability) • Product strength (reduced)
Appearance	• Choice of the value chain (sawmilling, panel, veneer…)	• Usability of the product
Hardness	• Can influence the choice of the value chain (parquet)	• Usability of the product

Source: Lundqvist S. O. et al. (2007)

4.6 Future trends

Only the French situation is represented.

For the sawmills of Profile 1, in the future, the share of round wood delivered directly to industrialised softwood mills will keep growing. In parallel, it is foreseen that using scanner measurements as the reference for round wood transaction will become usual practice. Evolutions in the products mix is forecasted as industrialised softwood sawmills are adapting equipments to create more added value products such as: Kilns for MC management, Strength grading machine, Finger-joint equipment. Further process with the semi-finish product, such as Glue laminated timber production is at the moment still limited to the largest sawmills. Finally, recent legislation (2010) on energy production (CHP) opens new opportunities. The threshold for a co-generation plant to be eligible to financial incentives has been lowered to 1MWe and sawmills willing to enlarge their activity to co-generation has to be equipped with kilns. This incentive will probably push some of the industrialised sawmills to invest in co-generation with following consequences: (1) higher share of kiln-dried products, and (2) higher round wood demand to supply the co-generation plant.

For the Profiles 2 sawmills, in early 2009, the Aquitain basin was struck by a storm which had an important impact on the resource. It impacted the supply of the companies, with only wind thrown trees being harvested. This post-crisis dynamic will last for a couple of years still.

Evolution of the supply chain integration (chapter 4.4) changed the procurement of profile n°3 sawmills. In the future, the share of round wood delivered directly to industrialised softwood mills will keep growing. Within the production unit, it is foreseen that semi-industrialised sawmills will keep working on gaining productivity. Investments are foreseeable on automatic sorting and stacking equipments for sawn-products. Individual or collective projects are also imagined to create more added-value: Kilns for drying, Planing of the sawn-products, etc.

For sawmills of Profile 4, beech processing companies will need to improve their supply:

- Specify the company's needs in a round wood specification document stating the expected qualities, dimensions as well regularity of the volume delivered;
- Use common vocabulary and description, improve the adoption of the round wood normative by the supply chain actors;
- Implement more supply contracts between wood providers and industrial users;
- Implement automatic procedures to gain efficiency (e.g. scanner at log reception).
- Individual or collective projects target creation of more added-value products (finger-joint products and laminated products, Planing, carving of the framing products, etc.).

5. Producing pulp, paper and fibre industry requirements

The industrial requirements on wood for pulp and paper production are dependent on the type of pulping process. Several different processes exist however commonly classified in two main groups:

- Mechanical pulping.
- Chemical pulping

Pulp and paper producers are using two categories of wood raw materials in general:

- Chips (dominated by sawlog slabwood from sawmills);
- Logs (delivered as roundwood from forest sites or terminals).

This chapter focuses on requirements of the roundwood.

5.1 General key parameters for log requirements and characterisation

Generally, in Europe, wood supply from harvest to industry is commonly handled by large companies taking responsibility and action to keep deliveries within the hard requirements stated by general and/or specific rules with respect to each delivery. Smaller suppliers and private forest owners may not always be aware of the rules. However in both cases mistakes or even deliberate attempts to cheat may occur. Therefore control of the quality of delivered wood at the mill gates/wood intakes is an important link of the chain. There are several parameters controlled before a truckload can go through the gate and get unloaded. The number and relative importance of quality parameters may vary not only between pulping processes but also between production chains, customers and production units. Below, we present examples of common assortments and hard requirements in some different countries. From a FlexWood point of view these requirements should be seen as bottom levels of what can be accepted in deliveries. Further down the principles of impact from important wood and fibre properties and customer's preferences are described below in "Wood and fibre properties - impact on products and origins of variation".

5.1.1 An overview of log reception and the importance of basic requirements

Below is presented an overview of log reception at French pulp mills. In most parts this is similar to log receptions at pulp mills in other countries, and the differences may be larger between mills than between countries. However a difference concerning Sweden is the existence of a third party organisations responsible for independent measurement and control of wood deliveries to industries, Swedish Timber Measurement associations (VMF South, Qbera and North and the central Council VMR).

When a log delivery comes to the mill gate, first the general aspect of the delivery is controlled. If a mill has specific requirements for log organisation and piling (long or transverse) due to unloading methods, main observations are devoted to identifying undesired products. The most evident are non woody elements (plastic, metal, gravel etc.). Some can be forbidden species that could unfit the process.

Regarding the quality of logs, the pulping processes require absence of wood from dead trees, burnt or unacceptably decayed logs (rot contaminated) etc. In practice the presence of unacceptable materials is very low because it has important consequences for the transporter: the delivery will be refused and a contract certainly discussed. For pulp and paper producers the absence of too low quality wood is important: such material would be detrimental for pulp production as contaminating material can be found several days after introduction in the process (detrimental incidence on process).

Second, the size of logs is inspected. Diameters of logs are important. Too small logs will be fragile and a risk of breakages during unloads or debarking, resulting in losses of production, could occur. A broken log in the debarker will create increase of small particles (fines) that will be screened with bark, resulting in losses of yield. An additional risk is debarker plugging. Too large logs/stems will be problematic as they cannot enter the chipper which is limited in acceptance of log diameter. Some mills are equipped with huge chippers and can process almost all sizes. If not, a separate processing is required or trees are excluded from the processing. Different log sizes may also reflect differences in average fibre properties as well.

Lengths of logs are also important. Depending on conditions at the roundwood storage at the mill, long logs cannot be unloaded. Debarking could be inefficient resulting in the presence of impurities in the pulp. In addition convey of logs can be difficult. In practice, the organisation of the woodyard is commonly depending on investments realised by the mill. In some cases, straight angles can be found at the end of the debarker, before the chipper. Then it becomes impossible to process long logs. Consequently, some strict limitations are requested on the length of logs. Long logs can be used only by mills presenting a linear processing at woodyard. If not, some mills can halve the logs by specific equipment.

5.1.2 Assortments of pulpwood

According to the Swedish Timber Measurement Council (VMR; Anon 2006) pulpwood assortments are defined as roundwood intended for pulp manufacturing. The T-code, stands for species or group of species and should always be specified when trading pulpwood. Examples of the most common pulpwood assortments from Sweden and their T-codes are presented in the table below:

Table 14. Examples of different pulpwood assortments (Swedish market)

Assortment	T-code	Species
Spruce pulpwood	2	Spruce (*Picea abies*) and sitka spruce (*Picea sitchensis*)
Softwood pulpwood	0	Any mix of softwoods, unless otherwise stated
Birch pulpwood	4	Birch (*Betula*)
Aspen pulpwood	5	Aspen and poplar (*Populus*)
Beech pulpwood	6	Beech (*Fagus silvatica*), maple (*Acer*) , mountain ash (Fraxinus), Swedish whitebeam (*Sorbus*).
Alder pulpwood	7	Alder (*Alnus*). Single logs of other hardwoods, **except**
		Oak (*Quercus*) and elm (*Ulmus*), are allowed.
Hardwood pulpwood	3	Any hardwoods, **except** oak and elm, unless
		otherwise agreed
Mixed pulpwood	9	Species according to contract

In addition to these assortments, most species e.g. larch, contorta pine and eucalyptus can be traded using their common names (As T-codes).

The quantity of a delivery is determined as volume under bark, as raw weight or as dry weight (VMR; Anon 2008). Sampling methods are allowed. The volume is determined either by stack measurement in conjunction with estimation of wood volume percentage, or by measuring the top and butt end diameter of individual logs. When the measurement unit is a stack and the stack is placed on a bedding of logs these logs are to be included in the stack volume.

5.2 Pulp wood requirements per country

Below three examples of hard pulpwood requirements per country are given.

5.2.1 France

To date, in France there are 10 mills producing pulp consuming round wood. Each production unit has its own specificities on the raw material requirements and on the supply conditions.

Nevertheless general requirements on wood raw material quality can be illustrated by example of two different mills.

The first mill produces paper for magazines with mechanical pulping. It consumes 180 000 dry tones of wood per year (50% logs and 50% chips) only from fir and spruce. Mixtures of species are prohibited. The main quality requirements are summarised in table x. Deliveries of logs are organised per week. Visual contrails of quality are realised at reception gate. In addition, the control of volumes, of weight (platform scale) and of freshness (4 weeks in winter and 3 weeks in summer) are realised at reception.

The second mill produces fluff pulp for absorbent products (baby diapers, hygiene products, etc.) with chemical pulping. It consumes in average 750,000 tons of raw timber and produces 165,000 tons of pulp per year. The main quality requirements are summarised in table 15. Deliveries of logs are organised per week. Visual controls are realised at reception gate. In addition the control of volumes, of weight (platform scale) and of freshness are implemented.

Table 15. General overview of hard requirements on pulpwood in France

		Frequently controlled by mills	Mechanical pulping	Chemical pulping (kraft and bisulfite)
Delivery	**Log piling (delivery)**			
	Long,	yes		
	Traverse	Yes		
	Undesired elements			
	Plastics,	yes	Prohibited (0% tolerance rate)	
	Metals	yes	Prohibited (0% tolerance rate)	
Parameters of log characterisation	**Contaminants**			
	Fungi / rot	yes	Prohibited (0% tolerance rate)	
	Dead trees	yes	Prohibited (0% tolerance rate)	
	Burnt trees	yes	Prohibited (0% tolerance rate)	
	Size			
	Diameter	yes	Range of acceptance: 5 cm – 40 cm	Range of acceptance: 5 cm – 60 cm Range of tolerance : 8 cm – 45 cm
	Length	yes	Range of acceptance: 2 m– 7.5 m	Range of acceptance:2 to 2.40 m
	Knot height			
	Trimming (branches)	yes	Well trimmed	Well trimmed
	Sweep	Yes, to a limited extend		10 cm / ml
	Species	yes		
	Accepted,		Spruce and fir	Softwood (100%)
	Prohibited		All other (prohibited)	Hardwood (prohibited)
	Volumes	yes		
	Weight	yes	Weight platform scale	Weight platform scale
	Cutting date (freshness criteria)	yes	3 (summer) to 4 (winter) weeks	15 to 40 days
	Dry matter content	yes		

5.2.2 Poland

The overview of requirements in Poland is based on discussions with skilled harvest managers (Table 16).

Table 16. General overview of hard requirements on pulpwood in Poland

	Frequently controlled at mills gate	TMP	Chemical pulping
Species	Yes	Mainly Norway spruce	Main species: Softwood (Mainly Scots pine) and Hardwood (mainly Birch, Aspen)s pine
Top diameter – min.	Yes	≥ 5 cm	≥ 7 cm
Sweep	Yes	Single sweep - up to 2 cm per log length (usually 2.4m) Multi sweep – not allowed	Single sweep - up to 10 cm per log length (usually 2.4m) Multi sweep - up to 5 cm per log length
Knot stubs, height	Yes	Up to 3-4 cm	Up to 3-4 cm
Rot	Yes	Not allowed	Soft rot not allowed
Discoloration	Yes to some extend	Not allowed	Acceptable
Insect-holes		Not allowed	Acceptable
Undesired elements (metal, plastics)	Yes	Inadmissible visible	Inadmissible visible
Burnt wood	Yes	Not allowed	Not allowed
Damage due to mechanical harvesting		Allowable only with depth up to 1 cm	Allowable

Sweep of pulpwood logs is a certain problem in Poland, specially for those harvested at clear cuts, due to two reasons – excessive sweep can cause problem in debarking and influence on the accuracy of wood measurements. Volume measurement starts with calculation of pile volume then, using a coefficient factor, volume of solid wood is calculated. In the case of chemical pulping rot, discoloration and insect holes can be accepted to limited extend, upon agreement. Other features, according to harvest managers, are not taken into account.

5.2.3 Sweden

The table 17 below, shows hard pulpwood requirements recommended by the Swedish Timber Measurements Council.

Table 17. General overview of hard requirements on pulpwood in Sweden

		Controlled at mill gate	Mechanical pulping (Mainly Spruce)	Chemical pulping (Softwood, hardwoo)
Delivery	**Origin of delivery**	Order number registered at delivery		
	Undesired elements			
	Plastic, Metals, gravel	Yes	The stack must not contain coal, soot, rubber, stones or metal. Neither may wood or bark contain noteworthy amounts of penetrated gravel (the fraction size of gravel is 2- 20 mm).Prohibited (0% tolerance rate)	
	Contaminants			
Parameters of log characteris ation	Forest rot (i.e. but rot)	Yes	< 10 % of end-surface	< 67 % of end-surface
	Storage rot	Yes	0 %	< 10 % of end-surface
	Other	Yes	A pulpwood log should be cut from a live stem section.	
	Size			
	Diameter	Yes	Range of acceptance: 5 cm – 70 cm	Range of acceptance: 5 cm – 70 cm
	Length	Yes	Range of acceptance Variable lengths: 2,7 m– 5,79 m Standard lengths: Required length ± 30 cm	Range of acceptance Variable lengths: 2,7 m– 5,79 m Standard lengths: Required length ± 30 cm
	Knot stubs accepted	Yes	< 15 mm unlimited ≥ 16 mm max 12 cm	< 15 mm unlimited ≥ 16 mm max 16 cm
	Delimbing (branches)	Yes	Well delimbed	Well delimbed
	Sweep	Yes, when visible	Width of crook must not exceed largest diameter with more than 30 cm, nor the largest allowed diameter with more than 10 cm.	Width of crook must not exceed largest diameter with more than 30 cm, nor the largest allowed diameter with more than 10 cm.
	Species	Yes		
	Spruce pulpw, accepted		**Norway and sitka spruce**	**Softwood (100%)**
	Hardwood, accepted		Aspen, birch. Specific	Hardwoods (see above)
	Volumes	Yes	Direct or indirect (see dry matter content)	Direct or indirect (see dry matter content)
	Weight	yes, commonly	Weight and sampled moisture content can be used to calculate delivered volume when agreed on between partners. Weight is also commonly used to determine payment to carrier.	
	Cutting date (freshness criteria)	Yes	Spruce pulpwood has to be fresh. Pulpwood is regarded as fresh if the bark comes off easliy and/or the moisture content of the wood exceeds a specified minimum. Examined when questionable. Wood is always regarded as fresh within 3 weeks from felling. Freshness registered at stack level ≥ 90 % of stack volume should meet requirement.	Other pulpwood assort-ments should be satis-factory fresh. The requirements for that are agreed upon by the trading parties. Freshness registered at stack level ≥ 90 % of stack volume should meet requirement. Pulpwood can, according to agreement, be traded as "not fresh" in which case a separate assortment code should be used.
	Dry matter content	Yes	Weight and sampled moisture content can be used to calculate dry matter content by e.g. monthly averages	
	Maximum pro-portion of rejected logs (to accept a stack)	Yes	The proportion of rejected logs must not exceed 15 % of the gross volume in a single stack. However, rejects due to species must not exceed 5 %. For spruce pulpwood, a single stack must not contain more than 10 % rejects due to forest rot.	

Logs with more rot or decay than the limits set in the table above are rejected. For pulpwood assortments other than spruce pulpwood, logs with 10 to 33 % storage decay at cross section may, according to agreement, be traded as ”storage decayed” and registered using a separate assortment code. Other specific requirements may also occur.
The Swedish situation is also based on direct contacts (interviews) with representatives of some Swedish mills. Here under are summarized the main results from discussions with two representatives for pulp and paper industries.

The first company defines the basic demands on kraft pulpwood as:

- Volume;
- Species;
- Bolt diameter and length;
- Limited amount of decayed wood;
- Clean from contamination.

Generally, company 1 and 3 produce unbleached and bleached kraft pulp based on conifers (pine and spruce) or broadleaves (birch, aspen). Company 2 and 3 produce TMP and main products as improved Newsprint and Magazine paper. The pulp / paper mills are striving to get even wood and fibre properties of the flow of pulpwood and sawmill chips over time.
In the near future the company the Wood Supply department do not have plans to introduce a larger number of specific assortments of wood, chips and pulp qualities aiming for specific products. However, the company clearly realizes the significant interrelationship between raw material properties, process efficiency and product qualities. Therefore, in a longer time perspective the mill finds it potentially interesting to consider control of the raw material flow based on improved and more detailed information. “*Relevant, quality certified information is a prerequisite for future progress in this field*” one interviewee assured.

All parameters listed in the tables below are considered relevant for pulp and paper production. However parameters of the highest and high priorities in a short time perspective are indicated by 3 and 2 respectively Date and time from harvesting are also important parameters related to freshness affecting debarking resistance and processability and yield.

The priorities of interviewees representing the different pulp & paper mills are summarized in table 18. The level of details presented varies between interviewees and companies. It contains a set of wood material properties of primary and secondary priorities and a number of properties of potential importance for pulp and paper products and/or process efficiencies with respect to the mix of products produced by the different companies. Each of company 1 and 2 reflects single mills while company 3 reflects both kraft and TMP pulp & paper mills.

Table 18. Pulpwood demand and level of importance of wood material properties

Wood material properties	Company 1 & 2 Process efficiency		Company 3			Information available by
	Kraft Co 1	TMP Co3	Process efficiency	Product quality	Delivery accuracy	
Species	3	3		3		G
Volume tot m3	3	3			2	M
Dry substance (kg wood)	3	3	3			P, M
Pulp log diameter	2	2	2			M
Pulp log lengths	2	2	2			M
Sawmill chips fractions (sizes)	3	3	3			M
Green density kg/m3		3				P, M
Basic density kg/m3		2	Se dry subst			P
Moisture content (% of total weight	3	3	3			P, M
Heartwood content			See extractives			P
Fibre wall thickness		2		3		P
Fibre width						P
Fibre length		2		3		P
Carbon sequestrated						P
Bark %		2	3			P
Bark density			Se bark%			P
Bark moisture content						P
Debarking resistance		2	3			P
Cellulose						
Lignins						
Hemicelluloses						
Extractives			3	3		P
Minerals			2			(P)
Metals			2			(P)
Decay	2	3	3, Accepted amounts			G, P
% volume loose knots						P
% volume sound knots						P

Legend:
- 3=Most important, 2=Important parameters, all others relevant although not of primary importance
- G=Graded by operator, M=Measured, P= Predictable

5.3 Linking products to raw material properties

5.3.1 Pulp/paper/fibre industry needs in respect to wood and fibre properties

Table 19 provides a list of properties and their relevance for pulp, paper and other fibre products based on present knowledge. This table was the basis for designing a questionnaire for discussions with representatives of pulp and paper industries in Sweden.

Table 19. Properties and their industrial relevance for pulp, paper and other fibre products

Property	Units	Industrial relevance
Basic density	kg/m³s.ub	Pulp yield. Correlation with fibre dimensions.
Green density at felling	kg/m³s.ub +bark	To be compared with green density at transportation/delivery
Green density at transportation/delivery	kg/m³s.ub +bark	Freshness criterion. Weight at transportation. To be compared with corresponding values at felling and basic density
Decay, % of volume	%	Discoloration, pulp yield
Degree of decay	%	Characterisation of the average dry substance content of decayed wood
Fibre dimensions Fibre length Fibre width Fibre (cell) wall thickness	 mm µm µm	Fibre dimensions affect industrial processes. Energy used for grinding or refining and the collapsibility of the fibres are related to the ratio between fibre width and the fibre wall thickness. The degree of fibre (cellwall) collapse and the number of bonds per surface unit. Collapse resistance could be expressed by a relationship between fibre width and fibre (cell wall) width (Jonsson, 1979). Strength properties (Tensile, tear, burst etc.) Optical properties, surface properties Permeability (porosity)
Microfibril angle	°	Strength, shape stability, process energy consumption
Fibre flexibility (Form-factor)	%	Surface and strength properties
Latewood	%	Distributions of variation in fibre width and cell-wall thickness (see fibre dimensions)
Reaction wood	no/yes	Characterised by short and comparatively wide fibres with thick walls (see fibre)
Sound knot %	% of vol.	Different type of fibres
Loose knot %	% of vol.	Discoloration and undesirable fibres.
Bark thickness	mm	Diameter under bark and volume of wood and bark
Debarked % of surface	%	Drying rate - freshness criterion and reduced volume of bark
Bark volume	% of m³s.ub	Energy
Bark dry substance	kg/m³	Energy
Bark moisture content	%	Energy

Source: Wilhelmsson, 2005.

5.3.2 Wood and fibre properties - impact on products and origins of variation

The qualities of pulp and paper products are dependent on wood and fibre properties of the raw material and the tuning of different processes with respect to the wood and fibre properties (Chantre, 2000).

Generally wood and fibre properties will influence pulp and paper quantity and quality parameters to a large extent. Pulp and paper yields per cubic meter solid wood, bulk, porosity, brightness, gloss, treatability, printability, e.g. strength in Machine (MD) versus Cross machine Direction (CD), tensile vs. tear strength are all examples of properties related to wood and fibre properties in interaction with different industrial processes. Implementation of characterised wood raw-material in combination with new knowledge concerning interactions between raw material and process control has a potential to increase pulp and paper yields, improve paper qualities, energy consumption, amounts of chemicals and fillers needed, etc.

Physiologically, fibre lengths of spruces and pines and other **conifers** are to a dominating extent determined by the ring number of the cambium and/or its distance from the pith (e.g. Larson 1994). Pulpwood from **an older tree** generally contains longer fibres than wood from **a younger tree**. Fibres also tend to be longer with an increasing proportion of narrow growth rings in a log when compared with other logs of the same size, i.e. a relatively higher proportion of latewood fibres. Genetic and environmental variation within and between species will also affect variation in fibre length as well as other important properties like cell wall thicknesses and cell width.

Long fibres with relatively thick cell walls are desirable in products demanding high tear strength or filter products demanding high porosity. Cell-wall thicknesses are much thinner in **earlywood** than in **latewood**, while lengths show a slight and relatively lower degree of variation within rings (Larson 1994).

In conifers growing under boreal conditions the proportion of earlywood is largely influenced by the growth rate, whereas that of latewood is mainly determined by the length of the growing season (e.g. Mäkinen et al 2002). Thus, slow-grown wood, at least in the Nordic and alpine (humid) regions, contains a high proportion of latewood. The cell-wall thickness also has a strong influence on the flexibility of the fibres and their tendency to collapse.
If the distributions of fibre dimensions are known by measurements or models (e.g. Ekenstedt et al. 2003), each papermaking process can be optimized and the subsequent properties of the paper can be improved and possibly optimised as well. The basic density of wood mainly depends on the ratio of the cell-wall thickness to the fibre width. Differences in log basic densities indicate differences in average fibre properties, but wood with varying proportions of different kind of fibres may have similar densities. Wide fluctuations in density lead to unevenness in the refining process and reduce the quality of the pulp. The basic density also influences the pulp yield and, hence, the volume of raw material needed to produce a tonne of pulp (e.g. Wilhelmsson et al. 2002; Moberg & Wilhelmsson, 2003).

Juvenile wood is commonly demarcated as the innermost part of the stem where a number of wood and fibre properties are still considerably different from those of the outer "mature" wood. The definition of juvenile wood varies, since it can be based on diverse properties like microfibril angle, fibre length or basic density. Broadly, for spruce and pine growing under Nordic conditions, juvenile wood may comprise the first 10–25 growth rings (commonly 15–20) nearest to the pith and is typically distinguished by short, thin-walled fibres. Pulpwood from thinnings contains a high proportion of juvenile wood, particularly if it comes from a fast-grown stand (e.g. Duchesne et al. 1997). By contrast, wood chips from sawmills, produced from the outer part of the tree, contain hardly any juvenile wood at all. The fibres in juvenile wood collapse easily, so a greater number of fibres can be accommodated in a sheet of paper of given thickness. Thus, paper containing a high proportion of fibres from juvenile wood could present a better sheet formation with good optical properties and printing surface (e.g. Berg et al 1995).

On the other hand, the short fibre length reduces the tear strength of the paper, requiring expensive reinforcement kraft pulp to be added (e.g Lundquist et al 2004). Heartwood content largely depends on the age of the tree and the longitudinal position (height) in the stem (e.g. Wilhelmsson et al. 2002). Sawmill wood chips, tops and stems of young thinnings mainly contain sapwood. Heartwood has a higher content of extractives and lower moisture content than sapwood. The high concentrations of extractives in heartwood of many pine species make their wood less suitable for manufacturing of mechanical pulp.

The quality of sapwood falls when it dries out, since its resistance to barking increases. Low moisture content can also lead to inferior strength and optical properties, due to poor fibre separation, fibre shortening and poorer processing of the cell wall (Persson et al 2002). On the other hand, haulage costs per kg dry substance is higher for wood with higher moisture content.

Fibre properties of hardwood species are quite different from softwood fibres. Typically hardwood fibres are shorter, a little thinner but with relatively thick cell-walls. Consequently, their use is devoted to chemical pulping only. There are considerable differences between hardwood species, between different part of the stems and between individual trees. Hardwoods also contain vessels which present limited bonding potential leading to some defects when printing. Like for softwood improved knowledge about the magnitudes and sources of variation in fibre and vessels properties, extractive content etc may increase the possibilities to add value to customers and production chains. So far, however models for predicting wood and fibre properties of hardwood species based on gatherable key parameters seem to be less developed than for softwoods even if some breeding program are under progress for poplar or eucalyptus (Chantre, 1996, Da Silva Perez, 2007).

5.4 Wood supply to pulp/paper/fibre industry

5.4.1 Some characteristics of supply of round wood

The general conditions of wood supply (orders of magnitude) to pulp mills in France and Sweden are provided in Table 20.

Table 20. Data on general situation of supply to pulp mills in France and Sweden

	France typical pulp mill	Poland typical pulp mill	Sweden typical pulp mill
Number of weakly deliveries	300 up 1 000 (trucks)		550-750 deliveries (each about 40 m³s u.b)[1)]
Reception hours	5-21 hours (Monday – Friday)	Trucks – 24 hours (Monday-Friday) Railway – 7/24	6-24 (Monday-Friday) to 24 hours a day 7 days a week
Max. number of trucks at site	5-10		
Number of unloaded trucks per hour	8	10	2 - 8
Weight of weekly deliveries	4 500 - 10 000 fresh tonnes	45 000 m^3	20 000 -30 000 fresh tonnes
Average stock at site	2-3 days of functioning up to 2.5 months of production	100 000 m^3	1 - 4 weeks
Average radius of supply	50 – 250 km		115 km [1)]

[1)] *Source Mikael Frisk Skogforsk (pers. com.)*

5.4.2 Common agreements concerning wood supply

In Sweden, most agreements about raw materials are set up for a period of 6–12 months with deliveries specified as a certain volume per month, even though the customers do not have a volume of orders greater than 2–3 months. Consequently, all logging is done according to customer order, but not necessarily an order from an end customer. These agreements have few variations. Consequently, most customers purchase on the basis of projected needs based on previous sales volumes. With a stable customer structure, needs are consistent and only minor changes are made to the order (Forsberg 2003;2010).
In addition to agreed delivery volumes, agreements often include responsibility for supply where the supplier maintains a recommended stock at the customer with a permitted tolerance (plus/minus deviation). The responsibility for the raw material is often transferred to the supplier once the roundwood is taken into production. Consequently, the supplier is expected to integrate his own information structure with the customer to a requested degree. Knowledge about stock status, consumption and planned rate of production will commonly be obtained through status meetings (monthly), and stock reports from the customer (weekly), in some cases by direct access to customer's consumption data (updated from Forsberg, 2003).

5.4.3 Activities affecting the quality of wood

Harvesting and transport activities should be designed and handled to avoid unacceptable damage of produced stems or logs in accordance with the hard requirements listed above. Suppliers should also maintain and develop their ability to detect downgrade or reject wood that is not acceptable with respect to agreed or general limitations for a specific assortment/customer. There is theoretical optimum for the occurrence of rejected logs and the cost for avoiding rejection and finding a higher net value of a better alternative available. At the pile level, however, rejected deliveries should always be avoided.

5.5 Future trends

Trends of the future are always hard to predict. However the competition from wood for energy supply is expected to increase. Building components based on solid and engineered wood products may also increase based on economic and environmental advantages. Even if some of the traditional pulp and paper products like newsprint and magazine paper may somewhat decline there are still many existing and, most likely, also new pulp and paper products that will require pulpwood and chips. For these reasons new and alternative sources of pulpwood e.g. additional species not presently utilised for pulp and paper production, or flexibility of production processes to other species, should be considered and investigated (Lecourt, 2006).

At least in theory there may be several possibilities for each tree to serve different value chains. Improved knowledge of the standing forests, sharper economic expressions of both hard and soft (preferred) requirements and the novel logistic concept, all parts of FlexWood, will improve the possibilities to increase the value of pulp and paper products and decrease environmental load.

Improved systems for valuation of the most suitable pulpwood and sawmill chips to increase the ability to compete for the most suitable and avoid the least suitable wood materials is another field of development along the value chains. Both these fields may also benefit from the research and development going on in FlexWood.

6. Producing bio-energies industry requirements

A particularity of bio energy industry is the existence, in most of cases, of an intermediary level between energy production plants and forest exploitation. There are producers of wood products (e.g. wood chips, pellets) oriented towards energy plants or households. Characteristics of wood products demanded by industries (grades, moisture content …) depends on the size of energy plant, in general. On the other side, a wood pellets producer determines the quality of pellets to produce in function of the customer (industrial vs. households). This chapter covers requirements of production of wood fuel products (wood pellets) and of energy production sites (heat and power plants).

6.1 Data base and coverage

This chapter covers two productions: wood pellets and heat (power) plants consuming wood bio fuels. For each of them specific questionnaire is elaborated and consultations with the corresponding industrials across several European countries are implemented.

6.1.1 The main characteristics of wood pellets producers

A specific questionnaire is implemented through phone interviews (around 1 hour) of production sites' managers or engineers responsible for production or wood supply. The questionnaire emphasis round wood and forest residues as raw material. The objective was not to obtain an extensive coverage of wood pellets producers, but rather the most relevant information from several operators, in order to lead and streamline the work.

In all, answers from 18 producers of pellets, from 4 countries, are collected (Germany - 6, France -6, Austria -5, Poland -1).

The average annual production of a respondent is 58 kt of high quality pellets, 7 kt of medium quality and 6 kt of low quality, respectively industrial pellets.

For the production of high quality pellets mainly the following standards are applied: DINplus (Germany), ÖNorm M 7135 (Austria), NF Granules Biocombustibles – high performance (France). For low quality pellets DIN 51731 (Germany), NF Granules Biocombustibles – industrielle (France), or no standards are applied.

Within the annual production there are no seasonal peaks. This may be due to the fact that most of the pellet producers are connected directly to a sawmill. Sawmills usually produce throughout the whole year, which leads to a permanent availability with saw dust and wood chips for the pellet production sites.

Within the class of high quality pellets the largest part (89 %) is sold to retailers, whereof 28 % in bags. Big customers (CHP, heating plants, co-firing) up to now represent a small share (figure 4). Medium quality pellets are sold to retailers and co-firing only. Low quality pellets are sold to CHPs, heating plants and co-firing and to a low percentage in bags.

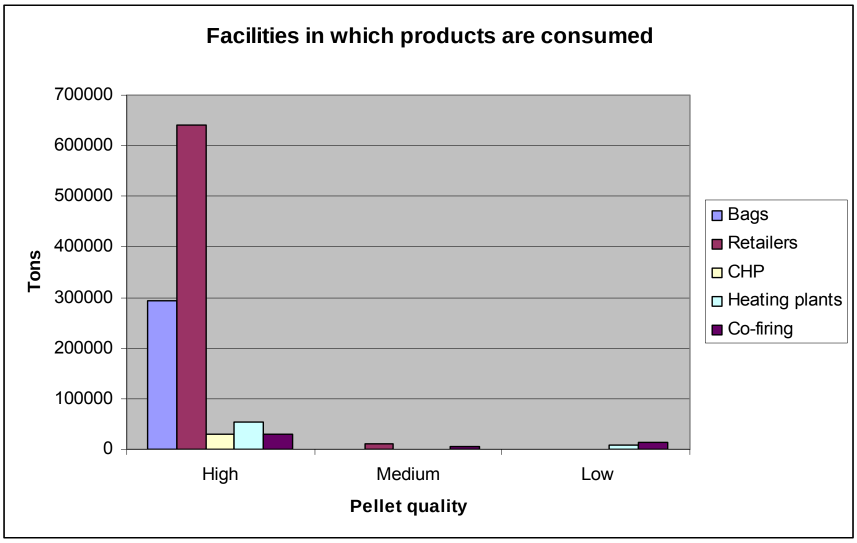


Figure 4: Main customers according to pellets' quality

6.1.2 The main characteristics of heating power plants

The total installed power for wood bio fuels of the consulted heating (power) plants (HPP) amounts to 109 $MW_{thermal}$ and 15 $MW_{el.}$. The average heating (installed) power per plant is 3 $MW_{thermal}$ within a range between 0,15 $MW_{thermal}$ and 23 $MW_{thermal}$ (figure 5).
Over 59% of the respondents are constructed with a nominal capacity up to 1,5 $MW_{thermal}$. So far few consulted heating power plants are build for capacities > 3 $MW_{thermal}$. A class > 3 $MW_{thermal}$ covers a range from 3 up to 23 $MW_{thermal}$ (5 HPP).

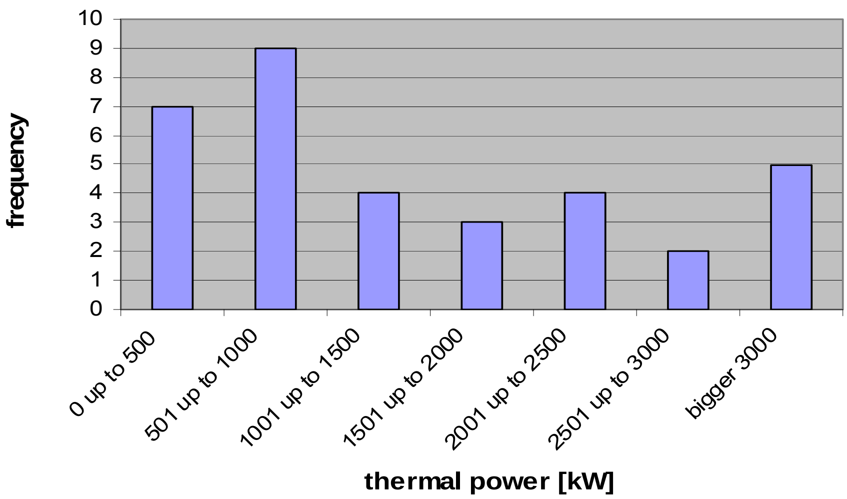


Figure 5: Distribution of respondents according to classes of installed power

18 out of 35 HPP are producing heat for a local district heating. 9 of them use heat for internal building and water heating. Other 4 use the produced heat for internal timber drying and for greenhouse heating. One produces the heat for internal paper production. 9 of the 35 HPP produce electricity for network supply and internal use.

Regarding the types of equipments installed several points are revealed. 60% of HPP are using a pusher as feeding system. Further 36% a screw an 4% a conveyor. Three different furnace systems are in use. In 65% HPP run a fixed bed furnace, 27% a underfeed furnace and 8% a fluidised bed furnace. Most of time HPP use more than one filtering systems. The most of HPP (79%) are using a cyclone filter system, followed with an electronic filter system (38%), and a filter bag system (8%). A compensator and air pressure filtering system is employed in 2% of cases.

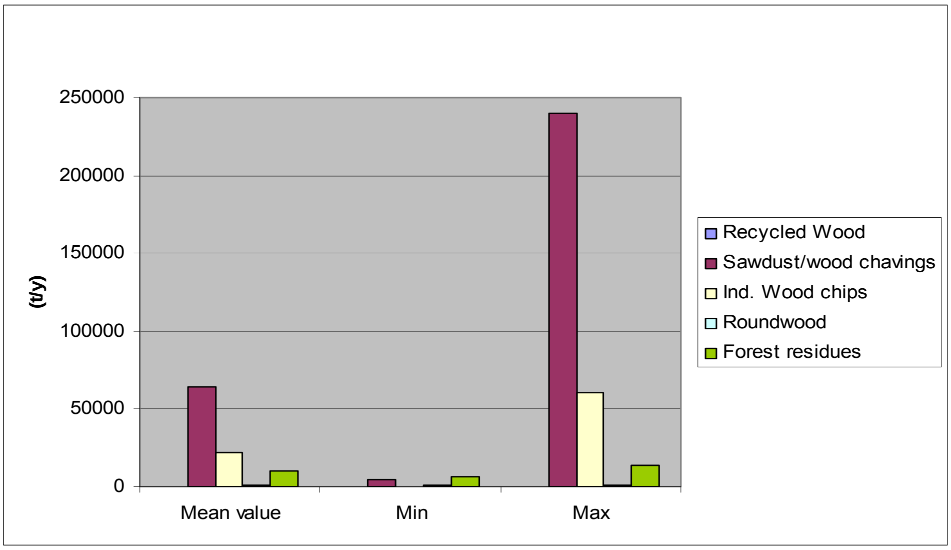
6.2 The main requirements on wood raw material

6.2.1 Wood pellets producers

The producers are asked the types of raw material consumed, as well as the related wood quality properties that are searched for or to be avoided. In addition, the rationale behind these properties and their impact on production and on quality of pellets are demanded.

The main raw material used by pellet producers is saw dust or wood shavings (60-65 %), followed by industrial wood chips (20-25 %) and forest residues like branches and crowns (10 %). Round wood is just used in a very low portion. Recycled wood is not used (figure 6).

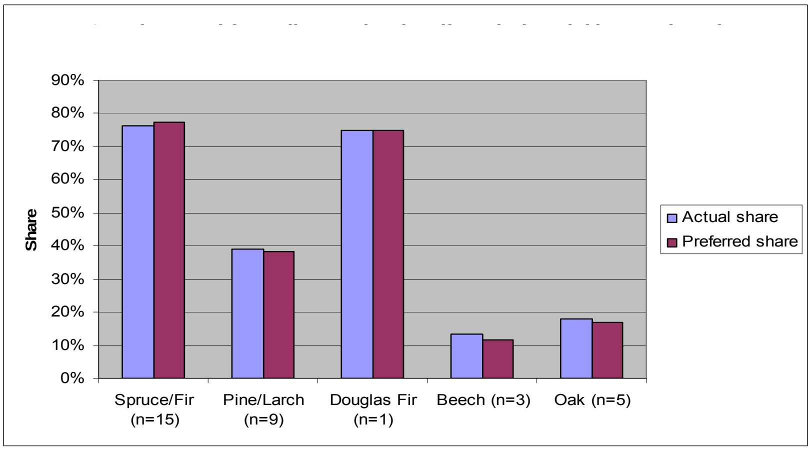
Figure 6. Annual input for pellet production according to type of wood raw material



- Industrial by-products for pellet production

The wood species consumed are Norway spruce/Silver fir, Pine/Larch, Beech, Oak and Douglas fir. The mainly used raw material is from Norway spruce/Silver fir, which will also be the group with the main significance in the future according to the answers of the pellet producers. The second-important group is and will be Pine/Larch (figure 7).

Figure 7. Species used for pellet production (from industrial by-products)



The reasons for selection of species (ordered from the most often identified to the least often identified by the respondents) are: ash content, calorific value, chemical composition/stickiness, availability and quality of end-product (abrasion, colour, etc.).

Species or groups of species which are excluded from pellet production have been identified by 9 producers (number of respondents between brackets): Hardwood (9), Pine (3), Larch (1), and Norway spruce (1).

The main reasons for exclusion of hardwood are abrasion on the machines producing the pellets, low calorific value, high ash content and bad compaction properties (stickiness). For Pine the reasons were bad smell (discriminatory for household use), problems with abrasion on machines and certain problems with storage. In the case of Larch, the pronounced colour of the product was named as an inconvenient. Customers buying pellets for households prefer to buy light-coloured pellets, considering them as products of better quality. For Norway spruce one producer said that ash melting temperature is too low.

The quality requirements on saw dust are (ordered from the most often expressed to the least often expressed properties): “without bark”; “maximum 45-50% wood moisture content”; “fresh”, “without pollution” (soil, etc.), “minimum10-15% wood moisture”. In case of industrial wood chips the demands are “without bark”; “35-45% wood moisture” and “fresh”.

- Log procurement

Only one respondent purchases round wood. Four other producers forecast to consume it in the near or medium-term future as raw material.

4 producers identified that the intended quality of the end-product is influenced by the quality of purchased round wood. The most important quality characteristic is wood species (or group). The preferred wood species are Norway spruce, Silver fir and Pine. Second important characteristics are moisture content and log quality (for example curving which hampers debarking). Dimension of logs (length, diameter) follows on third place.

The portion of round wood consumed influences the ash content of the pellets: the lower the diameter of round wood the higher the percentage of bark and consequently of ash. Bark also causes a high abrasion on the machines.

- Forest residues

The main properties, identified by respondents as having negative impacts on production are bark and contaminants (soil, sand, metallic particles, etc.). Bark affects the pellet quality due to high ash content and abrasion of machines. Contaminations cause the same problems as bark. Industrials also named leafs/needles (inducing higher ash content) and moisture content (requires drying).

The maximum level of bark integration into production of high quality pellets is uncertain, while needles cannot be used at all. Wood chips from forest residues can be used up to 70% for low quality pellets.

6.2.2 Heating power plants

The HPP are most of time consuming more than one raw material source (Figure 8). It is noticeable that 76% are using forest chips, the main raw material source. 47% of all HPP are using "other wood". 88% of class "other wood" are using landscaping residues. 44% of plants are using sawmill by-products. 44% of HPP are using sawmill by-products.

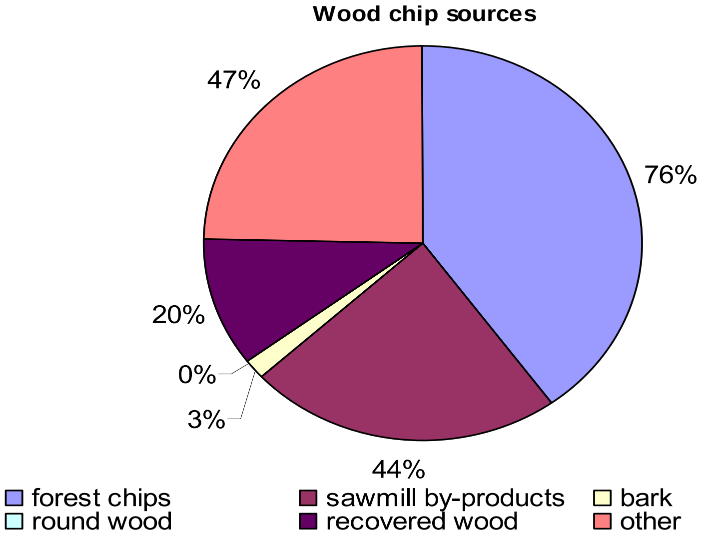


Figure 8: Percentage of the HPP wood chip sources

The forest chips are used in 77% of all heating (power) plants but represents only 11% of volumes. The main are sawmill by-products (Figure 9). 60%$_{vol}$ of the total used wood chip volume are sawmill by-products. 25%$_{vol}$ are other wood chips like landscaping residues (23%$_{vol}$). <1%vol are wood chips made from bark.

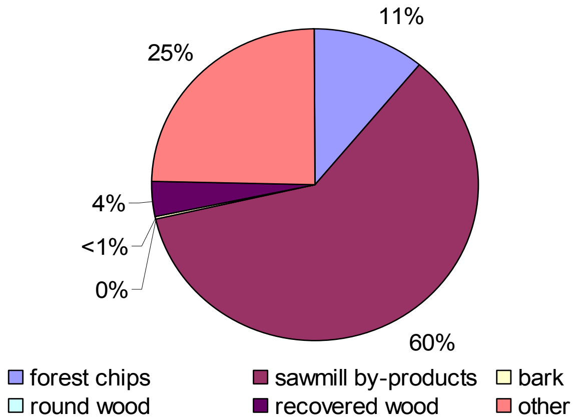


Figure 9: Volume percentage of the HPP's wood chip sources

Properties related to the quality of wood raw material are distinguished when common to all wood products and when specific to forest chips.

- All wood raw material
  - **Species**

Most of plants have no exclusive preferences among groups of wood species (hardwood and softwood). The consultation results show that 70% of HPP accept all hardwood species and 69% all softwood species (multiple answering possible). However 60% of plants prohibit poplar and 30% willow. The most appointed reasons were the calorific value (53%), moisture content (20%), dust constitution, silicate fraction, technical reasons and lightweight (each 6,75%).

  - **Mixture**

62% of the respondents accept mixtures of hard- and softwood. Only one plant defines such a mixture as 30% hardwood and 70% softwood per delivery. All other plants did not specify.

  - **Bark**

Chips with bark are accepted by 50% of plants.

  - **Leaves and Needles**

44% of plants are accepting leaves and needles with the wood chips, but the maximum share should not exceed in the average 3,4% (range from 1 to 5%). The top reason against leaves and needles is slagging (50%). Further 25% are technical reasons as well as the moisture content in fresh leaves and needles.

- **Characteristics of wood chips**
  - **Moisture content**

The average targeted moisture content is 38% (mini. 28% and maxi. 49%).

  - **Grades**

The average targeted grade is around 20mm, of 83% of each delivery. The maximum length should not exceed 188mm, at maximum of 6% per delivery. The fines fraction should not be smaller than 6,4mm.

  - **Acceptable degrades**

Spoiled wood, sap stain and fungi are acceptable by 50% of respondents. Detailed percentages were not given. However, they can only represent a small volume of deliveries.

  - **Acceptable contaminants**

For all HPP containments like soil, sand, stones, plastic, metals or other are not accepted. The always named reason is slagging.

  - **Ash content and melting temperature**

For 41% of plants, the ash content is an interesting topic. The average ash content is 4,5% within a range between 1 to 10%. Only 11% of HPP are able to provide details for the melting temperature. The middle melting temperature should not overtop 875°C by a range from 800 to 1000°C. For 3% the ash content and melting temperature is not interesting. The rest of plants gave no answer, similar to the substances of content (N, S, C, Cl).

6.3 The main requirements on wood supply

- **Weekly quantity of deliveries**

In average a HPP receives 3,5 (range between 0,125 and 15) deliveries per week, representing roughly 407 m³ (36 to 4020 m³) per week in the operating season.

- **Transport organisation**

In 40% of cases the transport is organised by the operator of the plant, in 34% by wood supplier and in 26% of cases by the plant itself.

- **Transport mean**

The track is the main transport mean (74% of plants). 55% of plants employ containers, while other 3% use trains and 6% agricultural tractor with trailers.

- **Reception conditions**

57% of plants are buying wood raw material on m³ basis, 4% on wet tons and 9% on oven dried tons. These masses are assessed by volume measuring (57%), weighing (4%) and oven drying (9%).
30% of plants bill after delivered power in MWh rated by a heat counter.

- **Distance of procurement**

The average distance of procurement is 40 km within a range between 3 km (minimum) and 150 km (maximum).

- **Stock at wood yards**

23% of plants have no wood yard. The rest have a wood yard in a range from 90 to 100.000m³ (average 8 097 m³). With these volumes, plants can run between 3 to 150 days (average 27 days) in the operating season without other deliveries.

- **Chipping at plant**

24% of plants run a chipper and 5% a shredder. Other 71% of plants have neither of them.

- **Applying stands to monitor the deliveries**

26% of pants have own values for purchasing wood chips. Further 18% apply the Austrian Ö-Norm, 15% apply neither a standard nor own values, 3% apply the German QM-Holzhackschnitzel and 38% provide no details.

6.4 Linking process, products to raw material quality

6.4.1 Wood pellets production

6.4.1.1 Importance of process

According to industrials there are several components or chemicals which are critical not only for the process of production but also for the treatment of ash as one of the final products of the burning process.

Contamination is ranked first because it causes intense abrasion on the machines producing pellets and affects ash melting temperature negatively. Bark is ranked second as it increases the ash content and the abrasion of machines. Also named were heavy metals, contained in wood, especially for wood which grows in areas with a high density of industrial sites. Heavy metals are problematic for deposition of ash.

The raw material is processed as shown below:

(Debarking → chipping →) drying → grinding (dry or wet hammer mill) → compaction

For compaction ring cavities with paddies (Koller) are used. Just in one case a specific correlation between the compression technology used and the preference for certain raw material species was named. It was stated that hardwood has bad compaction properties.

6.4.1.2 Importance of wood chemical properties

Concerning the requirements of wood pellet producers on the quality of round wood or forest residues as raw material for pellet production, no literature could be found, which deals with this topic in particular. A certain amount of literature deals with the quality of pellets and chemical properties of solid wood bio-fuels in general, which gives in turn some information on the properties that raw material good for the pellet production has to have. It gives an idea of the suitability of round wood and forest residues as raw material for pellets.

The different compartments of a tree like wood, bark and leaves/needles which can be used as raw material for pellet production are composed of different chemical elements. Certain chemical elements will e.g. be found in a much higher concentration in one compartment than in another one. Therefore the chemical composition of some tree compartments is a limiting factor for their use in pellet production

The existing standards on pellets according to the intended quality set limits for the content of different chemical elements as these elements and the physical characteristics of pellets like moisture content and calorific value affect the combustion process and the operational activities in the heating plant.

The following chapter characterize the significance and impact those elements have as well as their distribution according to the different tree compartments.

There are two basic criteria for judging wood pellet quality: chemical and compositional characteristics as well as physical characteristics.

The following parameters are commonly used as a basis for judging the quality of pellets as bio-fuels (table 22) due to their effects on combustion and manipulation.

Table 22: Parameters of solid biomass fuels and their most important effects

Parameter	Effects
Cl	HCl, Dioxin/Furane emissions, corrosion in superheaters
N	NOx, HCN and N2O emissions
S	SOx emissions
K	Corrosion in superheaters, reduction of ash melting point
Mg, Ca, P	Raising of ash melting point, effect on pollutant retention in ashes und use of ashes
Heavy metals	Pollutant emissions, use or disposal of ashes
Ash content	Particle emissions, costs for use or disposal of ashes
Ash softening behaviour	Operational safety, level of pollutant emissions

To reduce the negative effects of these parameters on combustion and manipulation (e.g. disposal of ash) and the environment, the existing and upcoming standards on pellet quality (DINplus/ÖNorm M 7135, ENplus (prEN-14961-2)) give their maximum levels of content. The upcoming ENplus-standard sets the limits for the elements/parameters named above as shown in table 23:

Table 23: Parameters and limits as set in coming ENplus

Parameter	Unit	ENplus-A1	ENplus-A2
Ash content	wt% daf	≤0,7	≤1,0
Ash softening behaviour	°C	≥1200	≥1100
S	wt% daf	≤0,05	≤0,05
Cl	wt% daf	≤0.02	≤0.03
Cu	mg/kg d.b.	≤10	≤10
N	wt% daf	≤0,3	≤0,5
Cr	mg/kg d.b.	≤10	≤10
As	mg/kg d.b.	≤1	≤1
Cd	mg/kg d.b.	≤0,5	≤0,5
Hg	mg/kg d.b.	≤0,1	≤0,1
Pb	mg/kg d.b.	≤10	≤10
Ni	mg/kg d.b.	≤10	≤10
Zn	mg/kg d.b.	≤100	≤100

Legend: daf= dry basis, ash free; d.b.= dry basis, ash content measured according to ISO 1171 (1997) at 550°C

Obernberger *et al*. (2006) analysed intensively the chemical properties of different solid bio-fuels and their significance and impact on combustion. Below is given a summary of their findings concerning pellets.

A tree is composed of substances: carbon (C), hydrogen (H), sulphur (S), chlorine (Cl) and nitrogen (N) as well as major (Al, Ca, Fe, K, Mg, Na, P, Si, Ti) and minor elements (As, Ba, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, PB, Sb, Tl, V, Zn). The concentration of these elements varies according to species, the origin (site of growth) and wood compartments. Table 24 shows typical values for element and ash concentrations:

Table 24: Typical mean values for the chemical composition of wood fuels

Para-meter	Unit	Wood without bark		Bark		Logging residues	
		Coniferous species	Deciduous species	Coniferous species	Deciduous species	Coniferous species	Deciduous species
Ash	wt% d.b.	0.3	0.3	4.0	5.0	2.0	1.5
C	wt% daf	51	49	54	55	52	52
H	wt% daf	6.3	6.2	6.1	6.1	6.1	6.1
O	wt% daf	42	44	40	40	41	41
N	wt% daf	0.1	0.1	0.5	0.3	0.5	0.5
S	wt% daf	0.02	0.02	0.1	0.1	0.04	0.04
Cl	wt% daf	0.01	0.01	0.02	0.02	0.01	0.01
F	wt% daf	< 0.0005	0.0005	0.001	-	-	-
Al	mg/kg d.b.	100	20	800	50	-	-
Ca	mg/kg d.b.	900	1200	5000	15,000	5000	4000
Fe	mg/kg d.b.	25	25	500	100	-	-
K	mg/kg d.b.	400	800	2000	2000	2000	1500
Mg	mg/kg d.b.	150	200	1000	500	800	250
Mn	mg/kg d.b.	147	83	500	190	251	190
Na	mg/kg d.b.	20	50	300	100	200	100
P	mg/kg d.b.	60	100	400	400	500	300
Si	mg/kg d.b.	150	150	2000	10,000	3000	150
Ti	mg/kg d.b.	<20	<20	-	-	-	-
As	mg/kg d.b.	<0.1	<0.1	1	-	0.3	-
Cd	mg/kg d.b.	0.1	0.1	0.5	0.5	0.2	0.1
Cr	mg/kg d.b.	1	1	5	5	-	-
Cu	mg/kg d.b.	2	2	5	5	-	-
Hg	mg/kg d.b.	0.02	0.02	0.05	<0.05	0.03	0.02
Ni	mg/kg d.b.	0.5	0.5	10	10	-	-
Pb	mg/kg d.b.	2	2	4	5	3	5
V	mg/kg d.b.	<2	<2	1	-	-	-
Zn	mg/kg d.b.	10	10	100	50	-	-

Legend: daf= dry basis, ash free; d.b.= dry basis, ash content measured according to ISO 1171 (1997) at 550°C

- **Carbon (C), hydrogen (H) and oxygen**

C, H and O are the main components of wood. The contents of C and H contribute positively to the gross calorific value, the content of O negatively. H also influences the net calorific value due to the formation of water (the more water the wood contains, the more initial energy is required). CO_2 is formed and emitted as a major product of complete combustion. Incomplete combustion can lead to emissions of unburned carbon-based pollutants as carbon monoxide, hydrocarbons, polycyclic aromatic hydrocarbons, tar and soot.

- **Nitrogen (N)**

Wood has relatively low N content. Higher concentrations are found in bark, logging residues and short rotation coppice. During combustion N is almost entirely converted to gaseous N2 and nitric oxides (NO_x [NO, NO_2]). One of the main environmental impacts is caused by NO_x emissions. NO_x can be formed via three different pathways. The most important mechanism in biomass combustion units is NO_x formation from the oxidation of N (during a series of elementary reaction steps). The NO_x emissions increase with increasing N content. Only an insignificant amount of N is incorporated in the ash. Emission related problems (exceeding the emission limits) can be expected at N concentrations above 0,6 wt% (d.b.). The typical mean value of N in wood is 0,1 wt%, bark 0,5 wt% (table x).

- **Chlorine (Cl)**

During combustion of the fuel, Cl mainly forms gaseous HCl, CL_2 or alkali chlorides such as KCl and NaCl. A large part of the Cl condenses as salts on the heat exchanger surfaces or on fly ash particles in the flue gas due to the subsequent cooling of the flue gas in the boiler section. The Cl content in wood is generally very low. Cl induced corrosion and HCL emission problems are to be expected at fuel concentrations above 0.1 wt % (d.b.) and are therefore usually not of relevance for wood, bark and forest residues.

- **Sulphur (S)**

S contained in the fuel forms mainly gaseous SO_2 and alkali as well as earth-alkali sulphates. Due to the cooling of the flue gas in the boiler section, SO_x forms sulphates and condenses on the heat exchanger surfaces or forms fine ash particles. 40-90% of the fuel S is integrated in the ash. The efficiency of S fixation in the ash depends on the concentration of alkali and earth-alkali metals (especially Ca) in the fuel. Wood chips and bark can contain high Ca contents and therefore cause a high S fixation. Emission related problems are to be expected at S concentrations above 0.2 wt% (d.b.) and are therefore usually of no relevance for wood, bark and forest residues.

- **Ash content**

Wood usually contains relatively low amounts of ash. Significantly higher values of ash are typically found in bark. The composition, density, size and amount of fly ash emissions formed are influenced by the amount of ash-forming elements in the fuel as well as by the combustion technology and process control applied. More information on ash formation is given in the following section.

- **Major and minor elements**

These elements are of relevance for ash melting, deposit formation, fly ash and aerosol emissions as well as corrosion (together with S and Cl) and the disposal of the ashes. In Table 3 typical concentrations of minor and major elements are given, table 25 shows concentration ranges for selected minor and major elements in ashes of solid wooden fuel.

Table 25: Concentrations of major and minor elements in ash of solid wooden fuel

Ash/Element	Wood chips (spruce) (wt% d.b.)	Bark (spruce) (wt% d.b.)
Si	4-11	7-17
Ca	26-38	24-36
Mg	2.2-3.6	2.4-5.6
K	4.9-6.3	3.5-5.0
Na	0.3-0.5	0.5-0.7

	(mg/kg d.b.)	(mg/kg d.b.)
Zn	260-600	300-940
Cd	3.0-6.6	1.5-6.3

Major and minor elements influence the ash melting point. Ca and Mg usually increase the ash melting point, while K decreases it. In addition chlorides and alkali- and alumosilicates with low melting can significantly decrease the ash melting point. Melts can cause sintering and slag formation in the combustion chamber, which results in a reduced plant availability and lifetime. Melts occurring in fly ash particles may cause hard deposit formation on cooled furnace walls or heat exchanger tubes. Hard deposit formation due to sticky fly ash particles can be accelerated by alkali and heavy metal salt mixtures (mixtures of alkali chlorides and sulphates with Zn and Pb chlorides).

K and Na play, together with Cl and S, a major role in corrosion mechanisms. Moreover, low melting mixtures of alkali and heavy metal chlorides can also cause corrosion by sulphation reactions.

During combustion, a fraction of the ash forming compounds in the fuel is volatilised (especially K, Na, S, Cl, Zn, Pb, Cd and to some degree also Ca, Mg and Si) and released to the gas phase. The volatilised fraction depends on the chemical composition of the fuel, the surrounding gas atmosphere, the local temperature and the combustion technology. These volatiles, together with solid phase sub-micron particles released from the fuel bed, form the fly ash particles (aerosols), by subsequent nucleation or condensation. They mainly consist of K, Na, Cl and S. Due to their high volatility, Cd, Zn and Pb can also be present in the aerosol fraction. Particulate emissions, together with NO_x emissions, are considered as one of the main environmental impacts from biomass combustion. Effective precipitation of aerosols requires electrostatic precipitators or bag-house filters. These filters are costly and thus economically viable only for medium and large-scale combustion units. If no dust precipitation technology is applied or if the technology used is characterised by limited efficiency, as in case of small-scale combustion units, only fuels with low ash content and low concentrations of volatile ash forming elements (like K, Na, S, Cl, Zn and Pb) are recommended for use (e.g. wood pellets and chips). The ash should, in favour of sustainable utilization, be recycled to forest soils (in order to close the natural cycles of mineral nutrients. But the environmental pollution of the last decades has led to higher concentrations of heavy metals in solid biofuels. Problems with ash utilisation for recycling purposes are to expected at Zn and Cd concentrations above 0.08 and 0.0005 wt% (d.b.) and therefore of relevance for bark, wood chips and sawdust (according to “guiding values for ashes related to solid bio-fuels” (at 550°C), ISO 1171 (1997)).

The analysis and further explanations of Obernberger *et al*. (2006) show that wood fuels (coniferous and deciduous wood, bark, logging residues and short rotation coppice) contain usually relatively low amounts of N, S, and Cl. With the exception of bark they are also characterised by low ash content.

- **Other energy source specific properties**

The water content is the most significant parameter which influences the calorific value of solid bio-fuels. As there is no water free biomass in nature, more or less moisture has to evaporate during the thermo-chemical conversion. The heat which is necessary for evaporation is taken from energy which is set free through the thermo-chemical conversion and by this the net calorific value decreases. The water content also influences the suitability for storage. Water contents above 16% lead to biological degradation processes which are connected with losses in calorific value. The water content of fresh harvested wood is between 45 and 60%, depending on tree age and season.

The calorific value of solid bio-fuels is influenced much more by the water content than by the kind of biomass. That’s why their calorific value is always compared in totally dry condition. The calorific value of the wood of coniferous tree species is 2% higher (on average) than the wood of deciduous tree species. This is due to the higher proportion of lignin and partly due to the higher proportion of extractive substances (e.g. resins, fats) in coniferous wood. The higher calorific value of lignin is caused by the much higher carbon content in lignin (64%) than in cellulose (42%).

The ash content of wood is (as shown above) with 0.3% in the dry mass (0.5% incl. bark) - relatively low. Higher values are mostly caused by secondary pollution (e.g. soil). Just wood from short rotation plantations (e.g. poplar, willow) show a much higher value with an ash content of ca. 2%. This is due to the higher percentage of bark in the young trees. The ash content has impacts on environmental pollution as well as on the technical design of a combustion plant.

6.4.1.3 Importance of wood physical properties

In addition to chemical and other specific properties also the physical properties play an important role for the combustion process (as well as storage and logistics). The physical and mechanical properties interact to a high extent. The physical properties which are influenced by the raw material (e.g. species, bark content) are abrasion and fine particles.

The abrasion resistance (the coherence of fuel particles in a high-compressed pellet) is affected by the adhesion/bonding of the particles of a pellet. The adhesion/bonding depends on the compaction technology (forming pressure, temperature, moisture content) and on the quantity of adhesive agents origin from raw material or added. Raw material based adhesive agents are lignin and resins. Due to the higher content of lignin and resins, coniferous wood has better natural bonding properties than hardwood, and therefore needs no or less added adhesive agents for pellet production.

The better the abrasion resistance, the less fine particles are produced by transportation and storage processes. The content of fine particles in the fuel disturbs the regulation of highly automated heating systems or interrupts automated fuel feeding. In addition fine particles burn quicker and the resulting higher temperatures can favour ash melting. Furthermore dry wood dust results under pneumatic feeding in a high development of dust and also increases the risk of explosion by deflagration.

6.4.1.4 In summary

There are nearly no restrictions on using wood (without bark) as raw material for pellets. One problem which can occur concerns the ash content, and its disposal. Environmental pollution during the last decades has led to higher concentrations of heavy metals in solid bio-fuels. Problems with ash utilisation for recycling purposes are to expect at Zn and Cd concentrations above 0.08 and 0.0005 wt% (d.b.) and therefore of relevance for bark, wood chips and sawdust (according to “guiding values for ashes related to solid biofuels” (at 550°C), ISO 1171 (1997)).

Concerning physical properties only for hardwood problems can occur concerning the abrasion resistance (and by this higher percentage of fine particles) due to lower contents of lignin and resins and by this lower natural adhesiveness (compared with coniferous wood). This problem can be either solved by mixing deciduous with coniferous wood or add other natural based adhesives such as potato starch or corn starch (maximum extent of 2 % allowed for high quality pellets according to DINplus and ÖNorm M 7135).

In contrast to wood (without bark) there are several parameters which set restrictions for the suitability of round wood and forest residues for high quality pellets. The amount of round wood as well as forest residues for the production of high quality pellets is limited especially due to high amount of bark in the raw material. Bark contains much more ash forming elements like Na and K. Together with Cl and S Na and K (as well as some other elements) they form the fly ash particles. Due to their high volatility also Cd, Zn and Pb can be present in the aerosol fraction. These particulate emissions, together with NO_x emissions, are considered as one of the main environmental impacts of biomass combustion. Effective precipitation of aerosols requires special cost intensive filters and thus economically not viable for small-scale combustion units.

Due to environmental pollution of the last decades biomass contains more or less high concentrations of Zn and Cd and therefore can be certain problems with ash disposal. In addition the high amount of K in bark and forest residues increase the probability of ash melting (which results in a reduced plant availability and lifetime). Round wood and forest residues have higher moisture content, in contrast to industrial by-products which usually have been dried to relatively low moisture content. Wood chips made from round wood or forest residues have to be dried first before being used for pellet production.

Round wood and forest residues in pellet production can only be used in a low proportion due to bark content or they have to be debarked first and afterwards chipped, dried and put into a hammer mill (expensive process). Therefore round wood and forest residues normally are no preferred raw material for the production of high quality pellets, which actually dominate the market.

The criteria mentioned above all consider first of all the quality requirements for high quality pellets. For the production of pellets for industrial use there are much lower requirements to the raw material. Big-scale combustion units are less susceptible to the problems which are caused e.g. by high ash concentrations (e.g. sintering and slag formation). By using electrostatic precipitators or bag-house filters also emission related problems, which would occur at small-scale combustion units without these kinds of filters, are of no relevance. Due to the given technologies at medium and big-scale combustion units the application of a much broader range of raw materials is possible.

6.4.2 Wood chips fuel quality

The quality requirements for wood chips depend on the size of the installed power of boiler:
- Small boiler (< 250kWthermal) requires a high quality wood fuel with a low moisture content (< 30%) and a small, regular chips;
- Medium boilers (250 kW to 1 MW) are more tolerant of moisture content (30 – 40%) and can handle a coarser chip than small boilers. Still the amount of oversize and overlong particles should be limited;
- Large boilers (> 1MW) are tolerant of both moisture content (30 – 55%) and on chip quality (Kofman, 2006).

Quality of wood chip fuel mainly depends on (Kofman, 2006; Landesbetireb Hessen-Forst, Cremer, 2007):

- **Moisture content**

Moisture content is expressed as percentage of water of the total weight, and determines to a large degree where the wood chips can be used an if they can be stored.

For all installations, a drier wood will result in a better efficiency of the boiler. Before wood can burn, the moisture has to be evaporated. In large installations, the evaporation heat regained by cooling the flue gas. This process is generally too expensive for small installations (Kofman, 2006; Kaltschmitt et al. 2009). Studies report that the required average moisture content is around 42% (Cremer, 2007)

For storage of chips, the ideal moisture content is below 30%. In such chips stacks, the biology activity will be minimal (Kofman, 2006, Hartmann *et al*. 2005; Ball, 2001).

- **Particle size**

There are two main types of machine for wood chipping: disc or drum chippers and shredder. The particle size of wood chips depends on the type of chipper, the setting of the knives and the level of maintenance of the machine. Usually disc chippers deliver a more homogenous chip (Kofman, 2006). However Cremer (2007) and Hartmann *et al* (2005) do not confirm this issue. The knives of the machine as well as the anvil should be well maintained. If a knife becomes blunt, the amount of fines increases, as well as the amount of overlong particles (esp. in case of shredded chips) and the general shape of the chips becomes less well defined (Kofman, 2006; Cremer 2007, Kaltschmitt 2009).

- **Tree species**

Tree species has an influence on the quality of fuel. Hardwoods such as oak and beech have a higher calorific value than softwoods like fir and pine.
The bulk density of hardwood is higher than softwood. It means that a smaller volume of hardwood chips is needed to be fed in the boiler to get the same amount of energy as for softwood (Steinmann, 1996, Kofman, 2006). However, on a unit dry weight basis, the amount of energy is almost equal for all trees (~ 20MJ7kg) (Golser et al. 2005, Kaltschmitt et al. 2009).

- **Ash content**

The ash content of pure wood without bark is quite small, as low as 0,5%. If wood with bark is burned, the percentage increases to about 1%. If wood chips with bark and needles is burned, the ash percentage might be slightly higher. If wood chips has contaminated with soil or sand, then the ash content can easily reach 5 - 10% or higher. For this reason, alone wood chip should be as clean of soil as practicable (Kaltschmitt , 2009, Kofman, 2006).

6.5 Future trends

6.5.1 Wood pellets

11 industrials expressed their vision of future trends in quality of pellets. 5 of them forecast an increase in share of high quality pellets, while 2 respondents foresee an increase of industrial pellets. 4 respondents don't forecast any change in shares but an increase in production for both quality classes.

The importance of round wood, in supply, is expected to gradually increase during the next years. 6 respondents are planning to use round wood or forest residues in the future.

6.5.2 Heating power plants

The policy targets an increase of share of Renewable Energy Sources (RES) in the energy consumption in the EU countries, among which the solid wood products uses. The future requirements on wood raw material quality are highly uncertain. However, according to some industrials consulted, it is reasonable to forecast two evolutions. The first concerns installations with high power capacity installed (>3 MW_{th}). These HPP will become more flexible regarding the quality of wood raw material due to technical improvements of installations that are expected (accepting raw materials of variable qualities). The second evolution relates to installations with low power capacity installed (<1 MW_{th}). These HPP will become more demanding on the wood quality requirements (stronger specifications).

7. Linking industrial requirements to forest resource characterisation and logistics

7.1 Key links with forest resource and logistics

The WP 3 000 identifies demands and preferences of industrials in terms of wood specifications. WP 4 000 characterises the (forest) wood resources by means of remote sensing tools and existing geo-spatial data (ALS) (4100), integrating terrestrial sensor techniques (4200, 4300) and additional information like tree ages, occurrences of documented damage through the establishment and growth of stands, etc. coming from other sources available (forest inventories).

In addition, WP 5000 develops and evaluates new logistic concepts, aiming to optimise forest wood supply chains to match industrial demands. The WP 3000 reveals that several activities along the supply chain from harvesting to delivery to industries affect the quality of wood raw material. Therefore, the importance of these activities, between sectors, should be identified.

7.2 Information sources on quality properties of wood

Quantification of quality properties of wood can be measured (directly) or estimated by the use of models. In most cases both sources are combined, where direct measurements are providing data inputs to models. For instance, the ALS measures individual tree heights of detected trees, but species, diameter stem taper, species and all other properties are obtained from models. Tree age might be measured on a subsample of trees and then individual tree ages of the remaining trees are modelled. Tree height and diameter might be measured in a harvester felling head but the breast height diameter and total tree height are not actually measured but modelled (fairly high accuracy, but still not measured) and so on. In consequence, different levels of accuracy exist, depending on methods of data gathering (including sampling frequencies), on availability and efficiency of models, on forest characteristics (even aged normal distribution, uneven aged bimodal or other skewed distributions of stems), etc.

7.2.1 Measurability by remote sensing technologies

Up to date, the level of precision of remote sensing technologies varies with resolution and the kind of forest measured. The technologies are still young and in progress, though already applied on a commercial basis. It is expected that the remote techniques supported by terrestrial sampling are capable to generate data, as a baseline level, on: average tree diameter (dbh), average height and species distributions at the harvesting object level (stand). In a second level, data would include positioning, diameters (dbh), tree heights, species and tree ages of individual trees. If possible in addition, data on crown sizes and reduced tree vitality (severe damage) may be gatherable as well. Detection of species will probably require multispectral information in addition to airborne laser scanning or detailed terrestrial information. A third level would include measurements of more quality parameters like straightness, taper, branchiness, and defects such as stem scars, rot, etc. which may become possible by advanced terrestrial sensing (TLS). Hereunder are identified parameters that are measurable by these technologies, at the current rate of knowledge of the technologies.

7.2.2 Estimation of wood properties

Many wood and fibre (quality) parameters, like stem tapering, branch sizes and types (green or dead), basic and green density, heartwood proportions, wall thickness and length distributions of fibres, calorimetric energy content, chemical compounds etc. are commonly possible to characterize by means of prediction models. These models can be applied by use of explanatory variables generated by the baseline, second or third level of data acquisition indicated above (4100- 4400), and into tools used for characterisation of internal wood properties, branches, stumps and valuation of properties in 5300, 5400, 6100 and 6200 respectively.

Numerous models in forestry and processing industries exist, although applied total limited degree in manufacturing of wood products. However, the existence and coverage of predictive models (geographical, species) are unevenly distributed among countries and species. In some countries, such predictive models are yet to be constructed or validated. In addition, the results of models are dependant on quality of input / measured data. An overview, and detailed documentation, of models estimating or predicting log properties relevant for effeminacy in wood manufacturing productions and the quality of final products are provided by Lanvin *et al.* (2007). Similarly Wilhelmsson (2005) identifies wood properties and their industrial relevance for solid wood, for pulp, paper and fibre products and energy uses.

Table 26 and 27 identify parameters that are possible to obtain from these models, to the currant rate of their development.

7.3 Summary tables of industrial requirements

Here under are provided parameters that characterise industrials requirements, identified per main wood consuming sectors (per tasks of WP 3 000). The requirements summarise the work of tasks 3100-3200-3300. The industries belong to the first level of wood transformation (sawmills, pulp mills and energy installations). Needs of industries from the second level of transformation (furniture, paper and board, etc.) are not examined.

The characterising parameters of wood properties are sometimes shared between sectors (e.g. species). But their relative importance can be different among sectors. Therefore quality requirements are represented in a table common to three sectors (solid wood, fibre and bio fuels), specifying their respective parameters and level of importance (high, medium and low).

Some sectors consume wood raw material coming as by-products from other industries (e.g. sawmill chips for pulp production or bio fuels). Natural quality parameters related to these by-products can be deduced from properties of the wood providing the by-products (sourcing raw material). However technically induced properties (e.g. chips size) can vary. Flows of by-products between industries (e.g. sawmills -> pulp mills or sawmills -> bio-energy industry), and thus the related requirements, are not subject for further analyses in WP 3 000.

Industrials requirements on wood raw material can be expressed in different ways. Hereunder, characterisation of wood parameters is done following three levels relating to variation selection and sorting of wood according to properties:

- Stand (Table 16);
- Individual trees (logs) within stands (Table 17)

Table 26. Characterisation of stand properties according to industrial requirements

Wood properties on stand level	Solid wood WP 3100 level of import.	Fibre WP 3200 level of import.	Bio energy WP 3300 level of import.	Source of data: Measurable	Source of data: Predictable
Height distribution of stems	3	2	0	Measurable	Models
Number of trees per species	3	3	1	Measurable	Models?
Volume (total) of trees	3	3	1	Measurable	Models
Volume aimed for logs (dm > 7cm)	3	2	0	Measurable	Models
Crown size and volume	1	2	1	Measurable	Models
Volume aimed for pulpwood	1	3	0	Measurable	Models
Volume of logging residues for energy	1	2	3	Measurable	Models
Geographical coordinates	3	3	0	Measurable	
Size of stand (ha)	3	3	0	Measurable	
Slope (stand characteristics)	3	3	0	Measurable	
Volume of sound knot part	2	1	0	Measurable?	Models
Diameter distribution, at breast height (dbh)	3	2	2	Measurable?	Models
Age (dbh)	2	2	1	Measurable?	
Species	3	3	3	Measurable?	
Taper curve per species	0		0	Measurable?	Models
Height of the first living branch by species and tree size	3	1	0	Measurable?	
Rot (damage by fungi)	2	2	1		Models?
Damage by insects	2	2	1		Models?
Damage by fire	2	3	1		Models?
Site index (fertility)		2	0		Models

Legend		
	High importance	3
	Medium importance	2
	Low importance	1
	Not identified	0
	Measurable by remote sensing tech.	Measurable
	Potentially measurable by remote sensing tech.	Measurable?
	Obtainable from models	Models
	Potentially from models	Models?

There can be large differences between properties of logs within a stem, leading to a number of different assortments. A typical situation will be for example, one first section for solid wood products (one or more logs possible to buck), one section mainly aimed for fibre products and the remainder aimed for energy. The knowledge of properties at a tree level (all related quality parameters) allows to know properties of a stem (related quality parameters), which in returns allows to identify the most appropriate cuts and logs for bucking (according to orders, and destinations, of clients).

Finally, activities along the supply chain from harvesting to delivery to industries may affect raw material quality. For instance, harvesting can generate cracks and splits, debarking and damage from aggressive feed rollers. Furthermore lead time and handling, storage and transportation may lead to contamination by dirt and non-wood elements as well as damage, drying out, insects and fungi. Therefore a summary table (Table 18) of these activities is also provided. It will be useful for the work in WP5000.

Table 27. Characterisation of tree/log parameters reflecting industrial requirements

Wood properties on individual tree/log level	Solid wood WP 3100 Level of imp.	Fibre WP 3200 Level of imp.	Bio energy WP 3300 Level of imp.	Source of data	
				Measurable	Models
Height of tree	3	3	0	Measurable	
Geographical coordinates (X, Y, Z)	3	3	3	Measurable	
Crown volume	2	2	1	Measurable	Models
Crown diameter	2	2	0	Measurable	Models
Taper	3	2	0	Measurable	Models
Diameter of branches	3	1	1	Measurable?	Models
Number of branches	3	1	1	Measurable?	Models?
Internodes lengths	2	1	0	Measurable?	Models
Knot cluster	2	1	0	Measurable?	
Knot diameter	2	2	0	Measurable?	Models
Number of knots	2	2	0	Measurable?	Models?
Species	3	3	3	Measurable?	Models
Diameter, at breast height (dbh)	3	3	2	Measurable	Models
Volume (total)	3	3	3		Models
Volume of logs (> dm 7 cm)	3	3	3		Models
Age	3	2	0	Measurable	Models
Log assortments	3	3	3		Models
Crown ratio	3	2	0		Models
Height of the first living branch	2	1	0	Measurable?	Models
Sweep (crooks)	3	2	0	Measurable?	
Ovality	3	2	0	Measurable?	Models?
Bumpiness at surface	3	2	0	Measurable?	Models?
Bole scar	2	2	0	Measurable?	Models?
Ash content	0	1	3		Models?
Heavy metal content	0	3	3		Models?
Sound knots	2	1	0		Models
Dead knots	2	1	0	Measurable?	Models
Rotten knots	2	1	0		Models?
Steep splay knots	2	1	0	Measurable?	Models?
Basic density	2	3	1		Models
Green density at felling	1	3	1		Models
Reaction wood	2	0	0		Models?
Discoloration	2	3	1		Models?
Callus, scar	2	2	1		
Shakes	1	1	0		Models?
Annual growth	1	3	0	Measurable	Models
Spiral grain	3	1	0	Measurable	Models?
Pitch pockets	1	1	0	Measurable	Models?
Damage by insects	2	3	1	Measurable	Models?
Damage by fire	2	3	1	Measurable	Models?
Dry matter content	1	3	3		Models
Moisture content	2	3	3		Models
Bark thickness	2	3	2	Measurable	Models
Fibre wall thickness	0	3	0		Models
Fibre width	0	3	0		Models
Fibre length	0	3	0		Models

Table 28. Activities affecting the quality of wood (harvesting, forwarding, piling, loading, transport, unloading, handling)

Activities affecting Wood properties	Solid wood WP 3100 level of importance	Fibre WP 3200 level of importance	Bio energy WP 3300 level of importance
Harvesting			
Cracks/splits	3	1	0
Feeding rolls, spike damage	3	2	0
Unintentional debarking	2	2	0
Marking logs	3	3	0
Sorting	3	3	2
Date of felling/bucking	2	3	1
Information flow	3	3	2
Forwarding			
Drying out after bucking, before forwarding	2	3	3
Unintentional mixing of assortments	3	3	2
Dirt/contamination of stems/logs	2	3	3
Pile requirements	3	3	2
Marking piles	3	3	0
Information flow	3	3	2
Stockpiling			
Storage time at roadside /plat./indus.	3	3	3
Stock conditions (under cover, etc.)	3	3	3
Air temperature and relative humidity	2	3	2
Green weights	3	3	0
Predicted/measured rate of drying	2	3	1
Field stock/accuracy	3	3	1
Lead times	2	2	2
Information flow	3	3	2
Transport to industry			
Transport conditions	2	2	2
Bark loss from handling/ transp.	2	2	0
Flow accuracy	1	3	1
Date of transportation	1	3	1
Lead time	2	3	2
Predicted/measured rate of drying	1	3	1
Information flow	3	3	2

Legend		
	High importance	3
	Medium importance	2
	Low importance	1
	Not identified	0

8. Industrial requirements on quantity

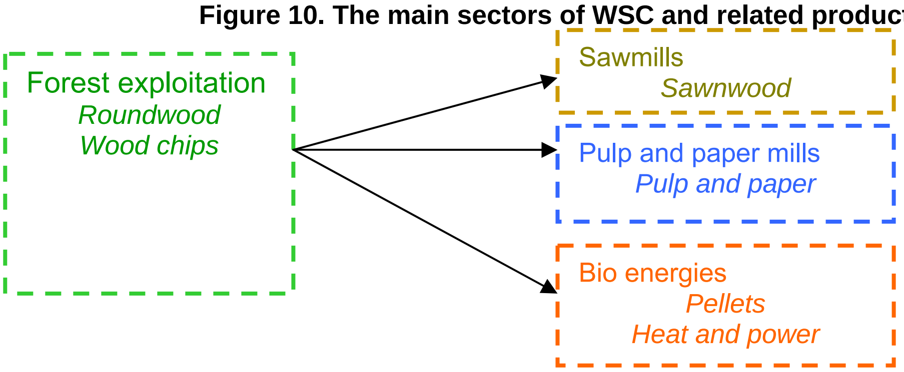
In the WSC several quantity measures are used to scale the amount of wood (volumes, weight, energy content), depending on habits of actors in production sectors. For comparability and a common representation of quantities in the WSC, several conversion factors are developed.
Above the requirements of industrial sectors on raw material quality, it is necessary to estimate their requirements on wood quantities, current and to come within 5 to 10 years. The quality requirements are different between sectors. The more sectors, presenting the highest requirements of wood qualities, are expected to increase in future, the more technologies (like remote sensing) identifying wood qualities are attractive.

8.1 Multiple quantity measures in the WSC

8.1.1 The main quantitative measures

Under the scope of D3.1 they are four sectors in the WSC producing different products (Figure 10.). The connection between sectors is strong where outputs of forest exploitation are inputs of sawmill, pulp/paper mills and bio energy units (by-products are not considered), having their own products.

Figure 10. The main sectors of WSC and related products



The most of time different quantitative measures are applied within and among sectors. The main quantity measures used in general are summarized in table 29.

Table 29. The main quantity measures in WSC according to input/output wood

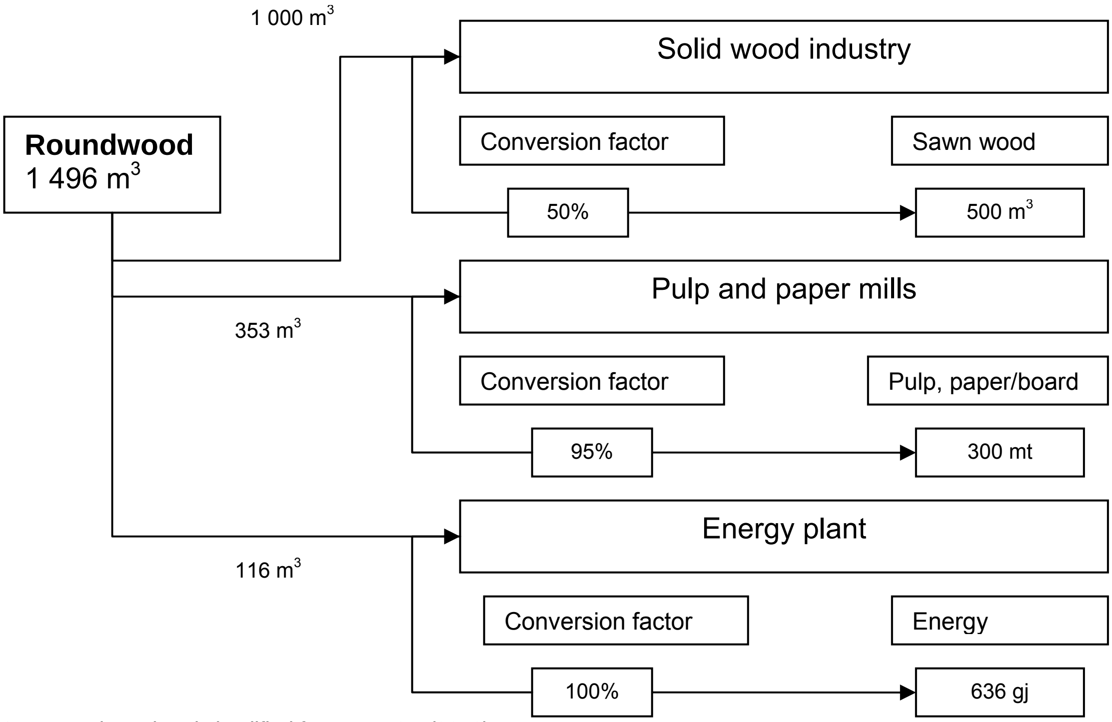
Input wood				**Output products from wood basis**			
	Volumetric measurements	Weight	Energy content	Volumetric measurements	Weight	Energy content	
Round wood	1. Cubic volume (over or under bark) 2. Stocked measure (including wood, bark and void)	1. Fresh or air dry weight (depending on wood density, moisture content, bark content)		1. Cubic metric volume 2. Square meter	1. Weight (depending on basic density, moisture content and shrinkage)		Sawn wood
Wood chips	1. Cubic volume (depending on wood density, moisture content and compaction)	1. Oven dry or fresh weight (depending on wood density, moisture content and compaction)	1. Energy content: net calorific value 2. Energy quantity (Wh);		1. Weight (depending on moisture content)		Pulp and paper
				1. Solid m^3 or loose m^3 (bulk m^3 – depending on the grades of chips, compaction)	1. Weight (depending on moisture content)	1. Energy content: net calorific value 2. Energy quantity (gj, Wh, toe);	Bark, pellets, Heat and power

Sources: UNECE (2008), UNECE (2010)

8.1.2 The main conversion factors

In order to link and compare the wood quantities of inputs and of outputs within and between sectors (e.g. wood harvested and used in different industrial processes), the conversation factors are developed (e.g. evaluation of round wood volumes consumed as inputs from the observed final product quantities) (UNECE, 2010, UNECE, 2008). The conversion factors are more or less accurate (depending on regional/national levels, type of raw material, efficiency of industrial processes, etc.) but they are widely used and necessary to ensure comparability of quantitative measurements (converting in a common unit). An example of wood balance (wood input – wood product output) is provided in Figure 11.

Figure 11. Wood material flows and conversion factors in WSC, UNECE countries



Source: adapted and simplified from UNECE (2010)

8.2 Current situation and future needs

8.2.1 The current levels of productions

Production levels of WSC sectors are unevenly distributed among EU countries. In general production of sawn wood absorbs the main part of round wood removals (table 30).

Table 30. Production levels 2008 in several European countries (2)

	Round wood removals (in Mm3)	Sawn wood (in Mm3)	Wood pulp (Mm.t., air dry weight)	Paper and board (in M m.t.)	Removals of wood fuels (in Mm3)	Primary energy from wood (1) (in Mtoe)
Austria	21,8	12	2	5,1	5	3,7
Finland	50,8	9,9	11,6	13,3	5,5	7,2
France	58,4	9,6	2,2	9,4	28,9	8,5
Germany	64,6	23	2,9	22,8	7,1	9,8
Poland	34,4	4	1,1	3,1	3,8	2,8
Sweden	69	17,6	12,2	12,4	5,9	8,4

Source: UNECE (2009), except for primary energy production EuObserv'ER (2009)

(1) Primary energy production of solid biofuels, in 2008 (including fuel wood, by products as black liquor, etc.)
(2) Consumption, exports and import levels are not represented in the table.

8.2.2 The future trends of production: UNECE, EFSOS forecasts

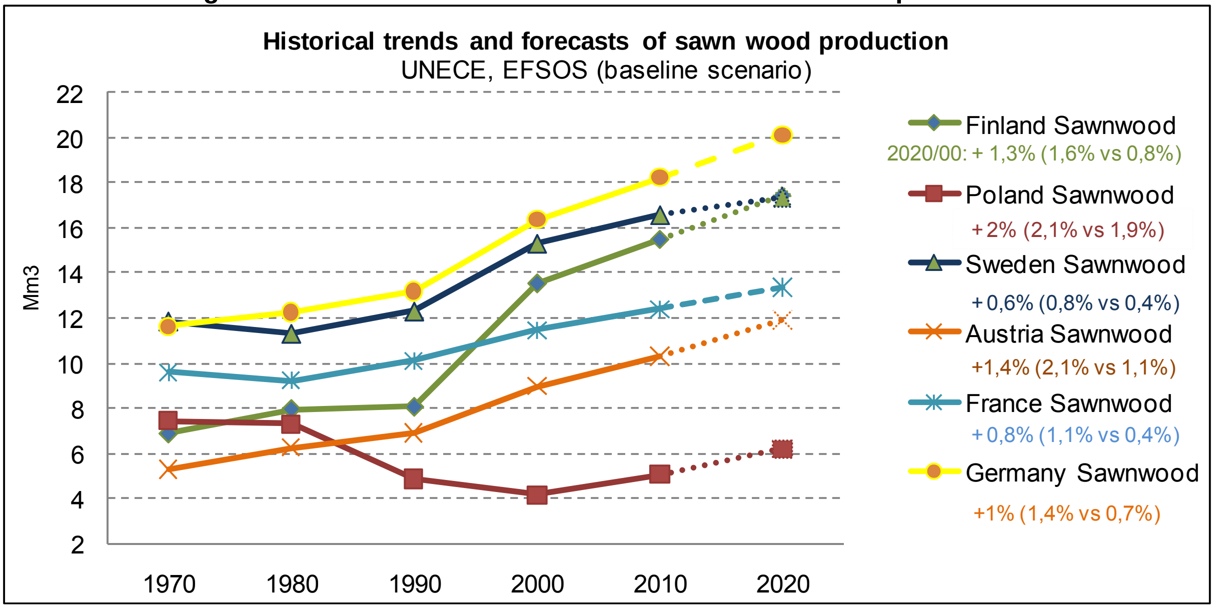
Future trends of productions, at 5 to 10 years to come, are important to identify in order to represent the major levels of demand among sectors in the WSC, and consequently of flows of wood material (quantities and qualities). The sectors have different quality requirements on raw material. The more the demand of sectors with the highest requirements of quality proprieties increases in the future, the more identification of wood quality properties is relevant, and therefore the use of new technologies allowing it (e.g. remote sensor).

An assessment of future trends of production is a difficult, resource and time consuming task. In the literature, there is a limited number of references. This is particularly true at the European level, whereas at national levels more studies can be found but not always comparable.

The most recent extended study, driven by UNECE (European Forest Sector Outlook Study, EFSOS, 2005), establishes outlooks of productions of wood material uses (sawn wood and pulp production) at 2020. Three scenarios are elaborated (conservation, baseline, and integration scenarios).

For production of sawn wood, the major increase is forecasted in Poland (+2% per annum between 2000 and 2020, baseline scenario), while the highest level of production is expected to remain in Germany (20 M m^3, in 2020).

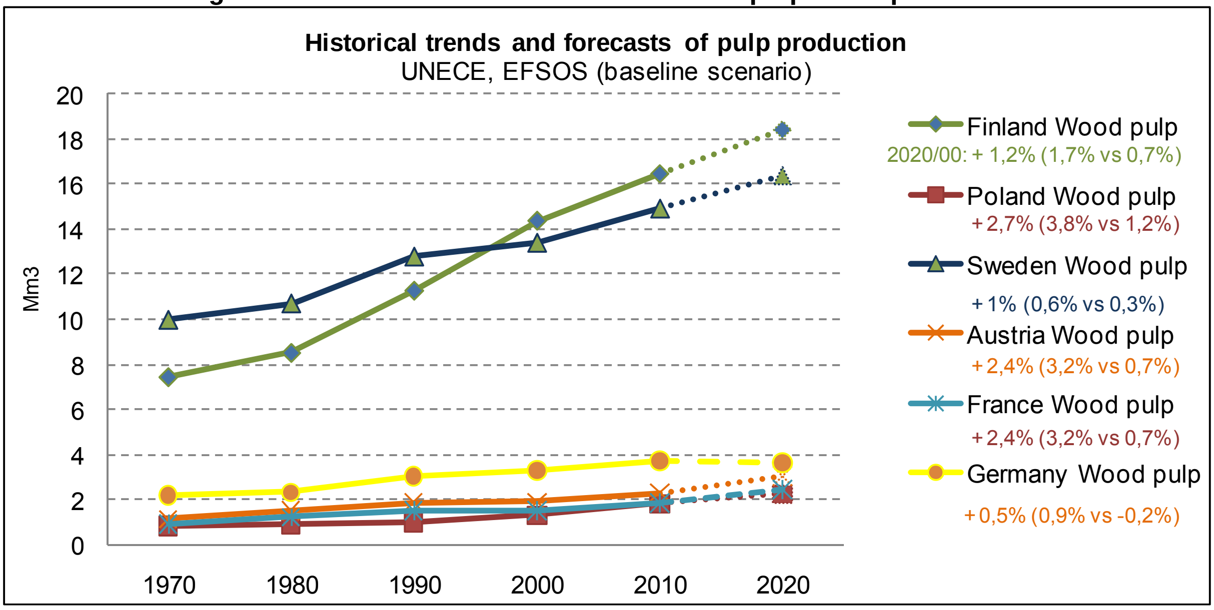
Figure 12. Historical trends and forecasts of sawn wood production



Source: UNECE, EFSOS, 2005
Legend: between brackets are reported projections of "integration" and "conservation" scenarios.

For production of wood pulp, the major increase is also forecasted in Poland (+ 2,7% per annum between 2000 and 2020, baseline scenario), while the highest level of production is expected to remain in Finland (18 Mm^3, in 2020).

Figure 13. Historical trends and forecasts of pulp wood production



Source: UNECE, EFSOS, 2005
Legend: between brackets are reported projections of "integration" and "conservation" scenarios.

The use of wood as bio fuel for energy generation is expected to increase. The EU's Renewable Energy Directive (Directive 2009/28/EC) sets up ambitious national targets for renewables (of which wood) in order to reach a share of 20% in the EU's overall energy mix at 2020. In respect to the Directive, the Member States are required to draw up national renewable action plans by June 2010, setting out measures on how they plan to meet their targets and trajectories. Actions and trajectories for the use of wood should be specified. But by the end of June, only two Member States provided their action plans, which therefore can not be used in D3.1 to draw up outlooks. A forecast of demand of wood for energy production, consistent with approach used in EFSOS, is provided by Hetsch (2008). For production of energy from wood, reflecting the requirements defined by national energy policy objectives, the major increase is forecasted in Germany (+ 150% in 2020 compared to 2000, baseline scenario), while the highest level would remain in France (94 Mm^3).

Table 31. Wood required in 2020 to fulfil energy policy targets (in Mm^3)

	2005	2020
Austria	18	26 (20)
Finland	36	48 (36)
France	55	94 (70)
Germany	32	82 (62)
Poland	23	49 (37)
Sweden	44	52 (40)

Source: Hetsch (2008); Legend: between brackets are reported projections of an alternative scenario "75 % scenario in 2020", considering a decreasing importance of wood energy among RES in 2020 compared to levels in 2005.

In sum, considering the total of future projections of sectors' productions (demand), and wood supply from forests and by products (supply), a shortage of wood resources is estimated at 145 Mm^3 for six countries in 2020 (table 32).

Table 32. Forecasted wood demand vs. wood supply in 2020 (3)

	Total wood supply (1) (Mm^3)	Total wood demand (2) (Mm^3)	Difference (Mm^3)
2005	565	541	+ 24
2020	576	721	- 145

Source: UNECE (2007)
(1) Supply direct from forest and in direct from by-products (EFSOS forecasts)
(2) Demand covering EFSOS projection (sawn wood and pulp) and energy policy objectives
(3) Includes: Austria, Finland, France, Germany, Poland and Sweden.

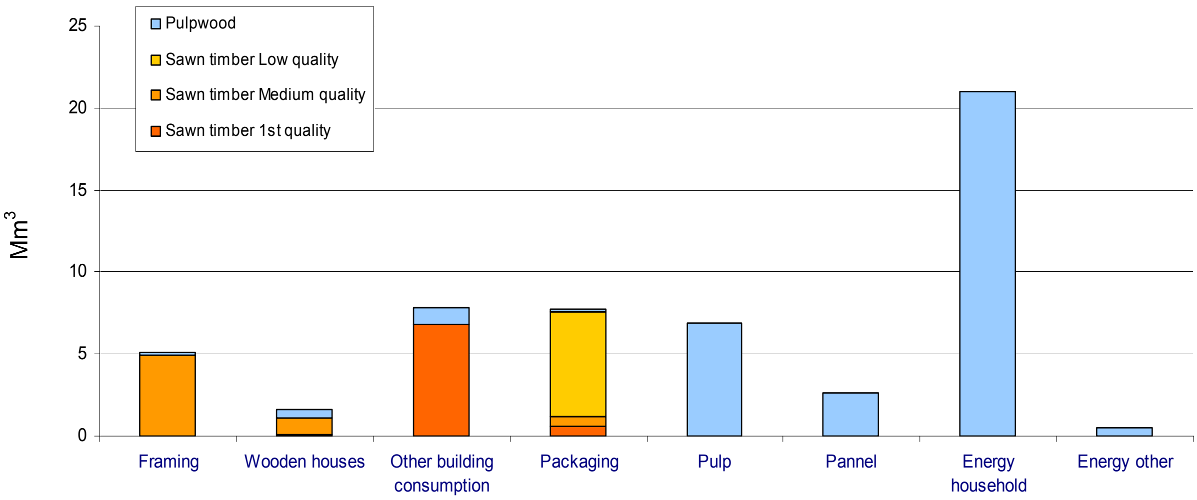
8.2.3 The future trends of production: experts' opinion

In forecast of future trends, the EFSOS study does not translate production levels on raw material specifications (in terms of species and qualities of wood). To fill the gap, in France, experts having a particular knowledge of WSC were consulted. They were asked to estimate and quantify the most plausible outcomes of wood consumption, depending on types of products and raw material used, by 2020.

As the start, the experts identified actual consumption of wood products (data 2006), depending on the wood uses (type of products) and types of wood consumed in their production (qualities and volumes of consumption of equivalent round wood, estimated at 52 Mm^3). The main use of "pulp wood"[3] is in energy generation, by households, and in pulp production (Figure 14). The sawn wood of the highest quality is mainly used in other building products, while the sawn wood of medium quality is mainly used in framing and wood houses construction and the lowest quality in packaging.

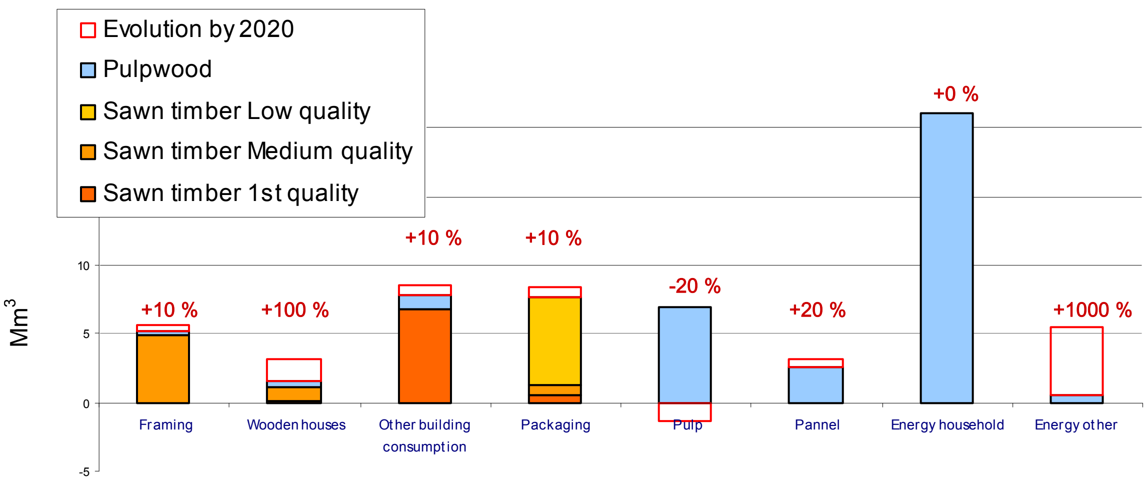
[3] Pulp wood refers to: "*Round wood that will be used for the production of pulp, particleboard or fibreboard. It includes: round wood (with or without bark) that will be used for these purposes in its round form or as split wood or wood chips made directly (i.e. in the forest) from round wood" (*UNECE).

Figure 14. Consumption of wood in France 2006 according to the wood uses and types



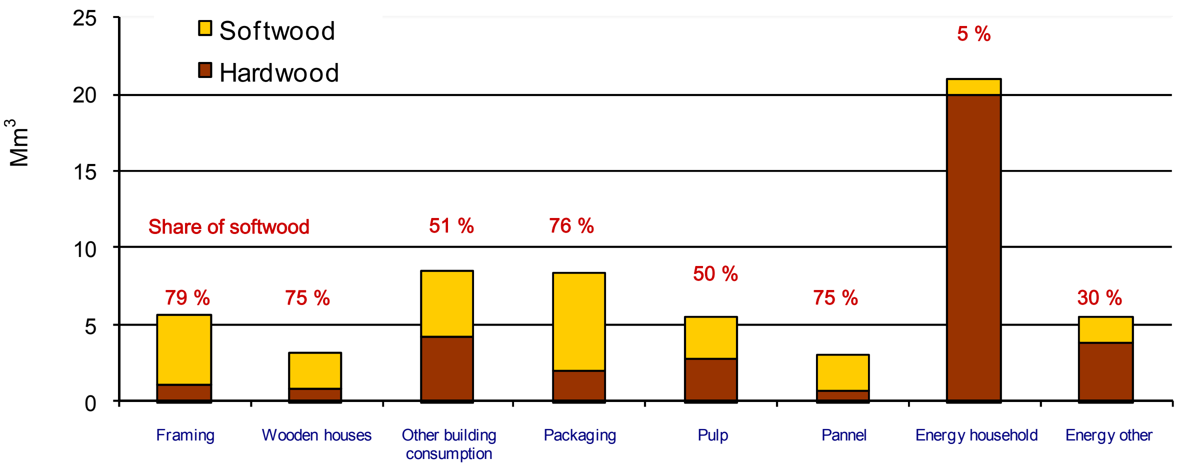
In France, a general trend of increase in wood consumption is expected, reaching 61 M m^3 in 2020 (figure 15). However the evolution is different according to the wood uses: while the volume of wood consumed in other energy productions (industrial and collective uses) is expected to increase (by 1000%) as well as in wooden houses (by 100%), the wood consumption in pulp production is expected to decrease (by -20%). Assuming the distribution of wood qualities by uses constant (2005), the future French production will consume more pulpwood (low quality wood for energy and panels productions), and more sawn wood of medium (for framing, wooden houses) and high quality (for other building consumptions). The driving forces behind this evolution are an increase of wood volumes used in construction sector and the energy policies in favour of renewables (and wood use). These two forces increase the demand of wood products and thereafter pull the forest wood exploitation. At the moment around 60% of annual increment of the French forests is exploited. Up to 2020 it is not forecasted to face shortage of wood raw material, considering only annual increment without considering other issues (environmental impact, willingness of forest owners to sell and exploit the wood, etc.).

Figure 15. Forecast of wood consumption in France by 2020 according to wood uses and types



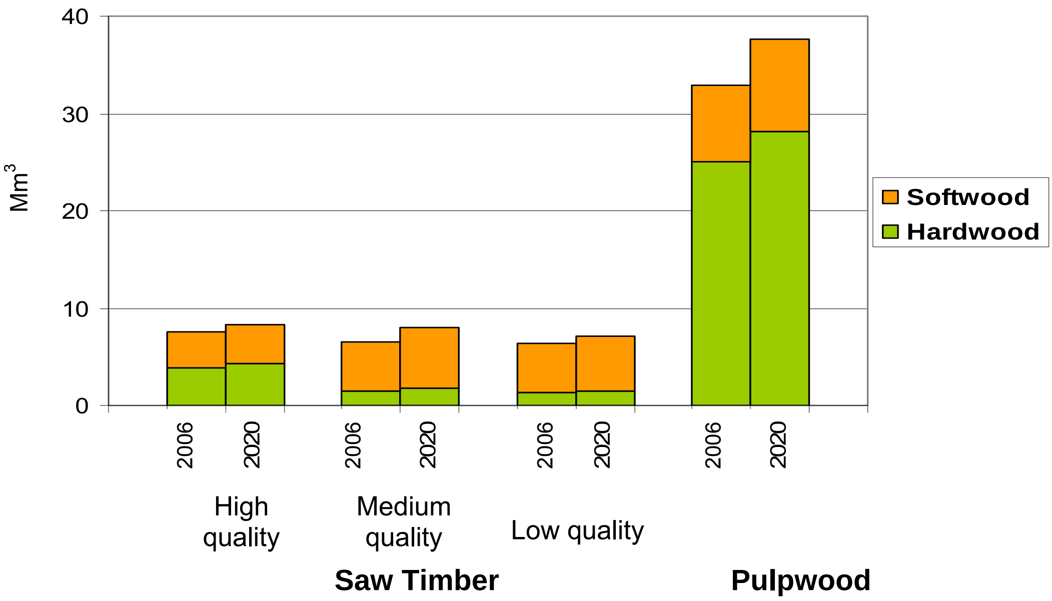
In 2020, the highest volumes of softwood is expected to be employed in packaging, framing and other building products, while those of hardwood in energy use (figure 16).

Figure 16. Forecast of wood consumption in France by 2020 according to species and uses



Compared to 2006, the round wood consumption is expected to increase, where the highest increase is expected for round wood of medium quality (for sawing), mainly from softwood species (figure 17). The pulpwood is expected to remain dominated by hardwood species.

Figure 17. Forecasts of round wood consumption in France in 2020 according to species and types



9. Matching the stakeholders' requirements

Wood markets and wood-based industries have been subject to structural changes in recent years. Studies indicate that rising demand for wood products and for bio-energy may lead to increasing competition between different actors in the forest based sector.
FlexWood has been set up to develop new concepts for meeting market demands within a flexible wood value chain. As an initial step the perceptions of key actors in the forest sector in the EU are analysed to identify the most recent demands and developments in the sector. In an attempt to cover the whole forestry wood chain we interview actors in different countries in the EU representing forest owners, harvesting and transport companies as well as wood-based industries. Actors are asked for their judgments on current and future trends in their business domain. As a result, the perceptions from different actors along the forest wood chain will be compared within countries and among selected European countries as well. Hence, common trends, goals and potential conflicts with regard to wood resources along the value chain can be identified.

9.1 Stakeholder analysis

Stakeholder analysis (SA) can be defined as a methodology for gaining an understanding of a system, and for assessing the impact of changes to that system, by means of identifying the key stakeholders and assessing their respective interests. Stakeholders in this sense are a group of people who share a common stake or interest in a particular issue (Grimble and Wellard, 1997). Stakeholder analysis is particularly relevant to natural resource management in case of (i) cross-cutting systems and stakeholder interests, (ii) multiple uses and users of the resource, (iii) subtractability and temporal trade-offs, (iv) multiple objectives, (v) unclear property rights, (vi) negative externalities, and (vii) untraded and non-marketed goods and services (Grimble, 1998). It shall support both an improved handling and impact assessment of policies and projects (Grimble and Wellard, 1997).
For the purpose of SA, all major stakeholder groups along the forest-wood chains were addressed in selected countries:

- forestry
- harvesting and logistics
- sawmilling industry
- wood-processing industries, panels
- pulp and paper industries
- bio-energy sector

Representatives of different parts of the forestry wood chain in selected European countries have been contacted to get their expertise in the context of this work (see Table 33). However, not all stakeholders have provided answers.

Table 33. Contributing stakeholders from selected European countries

	Austria	France	Germany	Poland	Sweden
Forestry	X	X	X	X	X
Sawmillers			X	X	X
Wood processing	X	X	X	X	
Pulp & Paper	X	X	X		X
Bio-energy	X		X		X
Logistics	X			X	X

9.2 Interviews

The aim of this subtask is to come up with a diversified but specific view of the different stakeholder interests and demands along the forestry wood chain according to their needs and expectations on the supply chain. As the qualities are precisely described in the work packages 3100, 3200 and 3300, the focus of this part is mainly on quantities. For a deeper insight on the current status of the different stakeholders along the chain a wide ranged literature study has been done to get an overview of actual challenges as well as of ongoing changes in varied parts of the European forest sector.
The procedure for setting up the interview guideline was as follows:

- Prepare information based on the following references:
  - EUROSTAT, 2008, Forest-based industries in the EU-27;
  - FAO, 2008, Forest Finance 90 – 06;
  - FAO, 2010, Country reports for forestry;
  - FSC, 2010, FSC certificate database;
  - PEFC, 2010 , PEFC Council Information Register;
  - UNECE & FAO, 2005, Country Tables from the European Forest Sector Outlook Studies;
  - UNECE, 2009, Forest Products Statistics 2004 – 2008;
  - UNECE, 2010, MCPFE indicators;
  - Mantau et al., 2007, Wood resources availability and demands – implications of renewable energy policies;
- Build hypotheses building on the prepared information;
- Ask for the strength of agreement on the hypotheses;
- Ask for judgement of instruments related to the discussed issue;
- Ask for further comments and future outlook;

The set-up is based on interviews using pre-information and formalized guidelines. In the beginning relevant data is presented. According to that, arguments have been verbalized and international and national policy instruments were selected that should be rated in order to show their impact within the scope of the discussed issue. At the end of each chapter there is always space for open statements of the stakeholders related to the particular content. Table 34 shows the structure and contents of the interview guideline.

Table 34. Structure of the interview guideline and related content

Wood mobilisation	**Forest management**	PFA limiting for forest biomass supply	Extension of PFA increasingly limiting	Climate change adaptation limiting for wood supply		
	Harvests	Balanced increment/felling sufficient for wood supply	Stronger domestic wood mobilisation feasible	Balanced harvesting ratio important to prevent over-exploitation	Salvage cuttings as strategic factor	EFSOS projections increment/felling
	Wood supply and demand	EU forestry will meet wood demand of EU industries	Wood imports more important for wood demand	Wood substitution by other materials	EFSOS projections supply/demand	
Consumption and Production	**Material and energetic use**	Positive influence of increased wood demand	Negative impact of increasing energy demand	Energy wood from short-rotation plantations	Greening trends increase wood consumption	EFSOS projections consumption
	Quantity of production	Increased roundwood production and forest sector growth	Share of roundwood production meeting sawnwood qualities	Short-rotation plantations for pulp&paper demand	Non-wood materiels/products limiting factor	EFSOS projections production
	Imports and Exports	Importance of export rate	Exports to outside/inside EU	Imports from outside/inside EU		
Socio-Economic role of the forest-based sector		Economic pressures decrease employment	Decreasing employment due to efficency gain	Labour productivity of forest sector comparable	Importance of labour costs	Development of GVA
Marketing	**Certification**	Certification important marketing instrument	Competitive advantages through certification	Certification improves public perception	One common certification scheme	
	Innovation	Role of product innovation	Imortance of process innovation	R&D budgets sufficient	Forest sector organisation important factor	
	Public and self-perception	Environmentally friendliness of business	Innovative business	Forest sector important for sustainable development		

With respect to the overall goal of giving an outlook on to the next 5 or 10 years stakeholders have been confronted with the baseline scenario projections of the European Forest Sector Outlook Studies (EFSOS) for highlighting the validity of these estimations. This scenario assumes the following developments:

- Forest products market:
  - Long-term historical relationships remain the same;
  - Constant prices and baseline economic growth projections for forecasts;
- Forest resources:

- o Bio-physical characteristics of Europe´s forests will be largely determined by existing status of forest resources.

Because policy instruments are gaining importance due to globalized strategies on forestry, energy and socio-economics, international and national instruments have been merged with main aspects of this work targeting their influences on different stages of the chain.

9.3 Results

9.3.1 Wood mobilisation

In the first part availability of wood resources and restrictions due to conservation and adaptation measures are within the scope of the questions. As background, the share of Protected Forest Areas of selected European countries, the ratio between increment and felling in each country and the supply and demand of wood in Europe are presented.
Figure18 shows the development of net increment in specific European countries over time with statistical data until 2005 and EFSOS projections for 2010 and 2020.

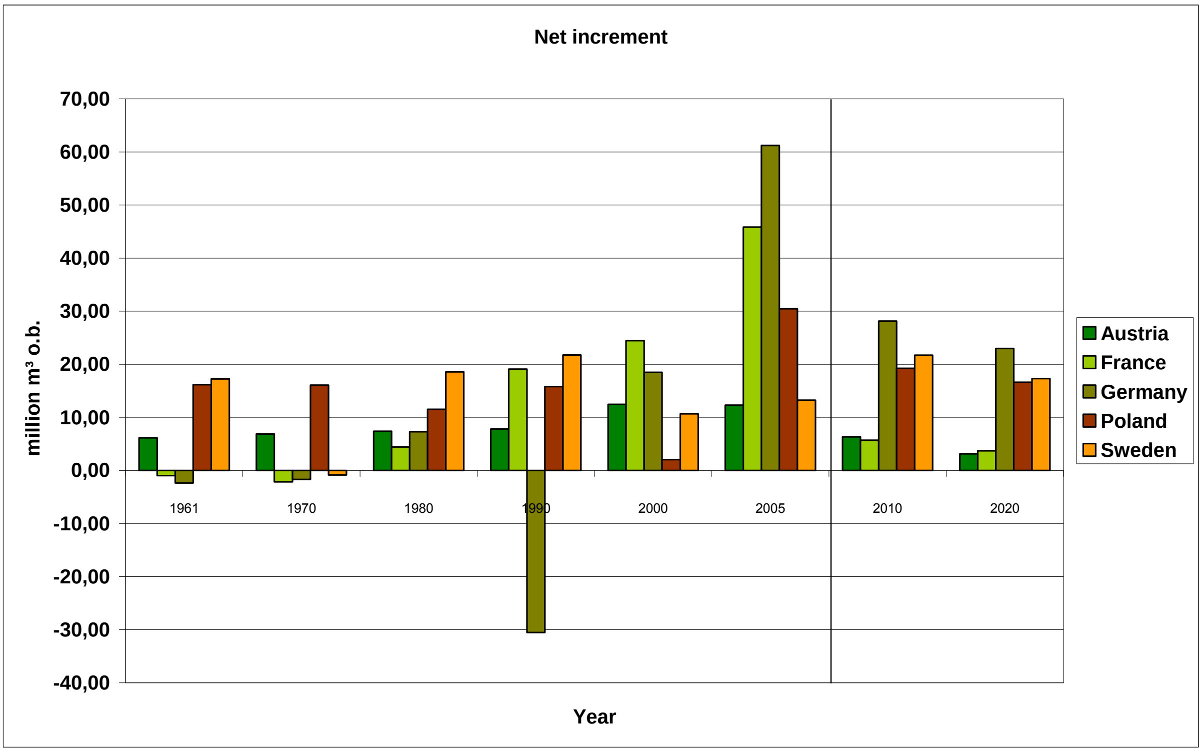


Figure 18. Net increment in specific European countries over time (UNECE & FAO, 2005 / FAO 2010)

Table 35 shows the cumulative results of the interviews as strength of agreement with regard to proposed statements (hypotheses 1-12). It is shown for different countries and different national stakeholder groups.

Table 35. Results of the interviews for specific countries and contributing stakeholder groups with regard to the chapter "Wood mobilisation" as strengths of agreement: dark green – strong agreement; light green – agreement; orange – disagreement; red – strong disagreement; grey – no opinion; white - no participants

	Forestry					Logistics					Sawmilling					Panels					Pulp&paper					Bioenergy				
Forest Management																														
1																														
2																														
3																														
Harvests																														
4																														
5																														
6																														
7																														
8																														
Wood Supply & Demand																														
9																														
10																														
11																														
12																														

Based on the interviews, the following hypotheses are put to test:

- **Forest Management**

H1 - The current area and status of protected forest areas is a limiting factor to the supply of forest biomass.
Limiting productive forest area or wood harvesting by protection measures may form a conflict for wood availability. Indeed, representatives of forestry, logistics, sawmilling, and wood processing industry show strong agreement on this statement throughout the countries. Interestingly, pulp and paper industry and the bioenergy sector slightly disagree by trend with Swedish bio-energy as principal outlier.

H2 - A further extension of protected forest areas would have negative impacts on the raw material supply of the forestry wood chain
An extension of protected forest areas (PFA) may even increase conflicts between resource utilisation and nature protection as well as pressure on wood availability. According to any further extension of these protected areas in the different countries there is strong consensus on negative impacts on raw material supply by PFA extension.

H3 - Changes in forest management as response to long-term trends such as adaptation to climate change will have negative impacts on the raw material supply of the forestry wood chain.
Management for climate change adaptation and/or mitigation may request objectives other than/additional to wood supply. Impacts on the raw material supply related to changes in forest management are perceived controversially along the whole chain. It can be assumed that there is no clear picture yet on these future adaptation needs.

- **Harvests**

H4 - For the domestic forest sector a balanced ratio of increment and felling would allow a sufficient supply of raw materials.
For resource availability it is important to estimate whether domestic wood demand could be covered hypothetically by a country's resources without over-exploitation. According to the opinions of addressed stakeholders sufficient domestic raw material supply should be feasible in all their countries (apart from Germany's panel industry).

H5 - A stronger domestic wood mobilisation by increasing harvests is not feasible due to technical or economic constraints.
Not all wood resources may be utilised to their full amount. There may constraint to technical and/or economic constraints (e.g. steep slopes, swamplands or fragmented forest ownership). According to the stakeholders, technical or economic constraints are no real limiting factor. Stronger wood mobilisation seems to be feasible in each of the countries.

H6 - The sustainability paradigm of a balanced ratio of increment and felling is an important instrument to prevent over-exploitation of forest resources.
A balanced ratio between increment and fellings is more a sustainability paradigm than a science-based advice. It may vary across stand structures, development phases and historical backgrounds. Yet, all stakeholders (except the panel industry in France) agree to the importance of a balanced ratio of increment and felling to prevent over-exploitation of forest resources.

H7 - Wood supply from salvage cuttings due to natural disturbances will be an increasing strategic factor.
Wood supply from salvage cuttings may play an increasing role in the future as natural disturbances might appear more frequently. This implies a higher uncertainty in planning and

new challenges in harvesting and trade logistics. This argumentation line is well perceived within the forestry and sawmilling sectors, but judged heterogeneously within the other businesses.

H8 - In the light of the situation in 2010 and the impacts of the financial crisis, the EFSOS scenario projections are valid estimates.
EFSOS projections in the baseline scenario indicate that the net increment will slightly decrease in each country since the fellings will increase and more wood will be harvested in the future. Most representatives agree to the validity of these estimations. Only the panel industry shows reservation.

- **Wood supply and demand**

H9 - European forestry will be able to meet the demand for wood of European forest-based industries on the long run.
In contrast to the notion that domestic supply can currently be tackled in the 5 represented countries, stakeholders from material-use branches foresee that European forestry will not be able to meet the demand for wood of European forest-based industries on the long run (except P&P in France). Bio-energy producers tend to be less distinct in this topic.

H10 - Wood imports will gain more importance to meet the raw material demand of the European forest-based industries.
Consequently, wood imports and trade – both within and from outside EU – are almost unanimously judged as increasingly important to meet the raw material demand of European forest-based industries.

H11 - In case that wood demand cannot be met sufficiently, wood will be substituted by other materials.
Substitution among materials can be seen as another form to competition. It depends on substitutability within production processes, availability of wood and alternative material, and cost of substitution. From the interviews, it becomes evident that substitution of wood may be a feasible way for the panel and the P&P industries, in case wood demand cannot be met sufficiently. All other stakeholders are dependent on this particular resource.

H12 - In the light of the situation in 2010 and the impacts of the financial crisis, the EFSOS scenario projections are valid estimates.
EFSOS projections indicate in the baseline scenario for 2010 that the total wood demand in Europe would overcome the total wood supply. This development should be more drastically in 2020, a trend upon which there is rather strong agreement. Only few stakeholders (in particular in the bio-energy branch) judge these estimations as invalid since they fear overestimated material flows underlying these projections.

9.3.2 Consumption and Production

Hypothesizing that there will be increasing demand for wood, and for energetic purposes in particular, the second chapter shows statistics for material and energetic use of wood in Europe. For instance, some studies indicate that the disposal of raw material for energy production will overcome the raw material flows that go into the production of wood-based products (see Figure19).
Also, the development of the consumption and production of roundwood, sawnwood and wood-based panels as well as of wood pulp, paper and paperboard and recovered paper are considered. Imports and exports of different wood based products complete the picture of this part of the questionnaire.

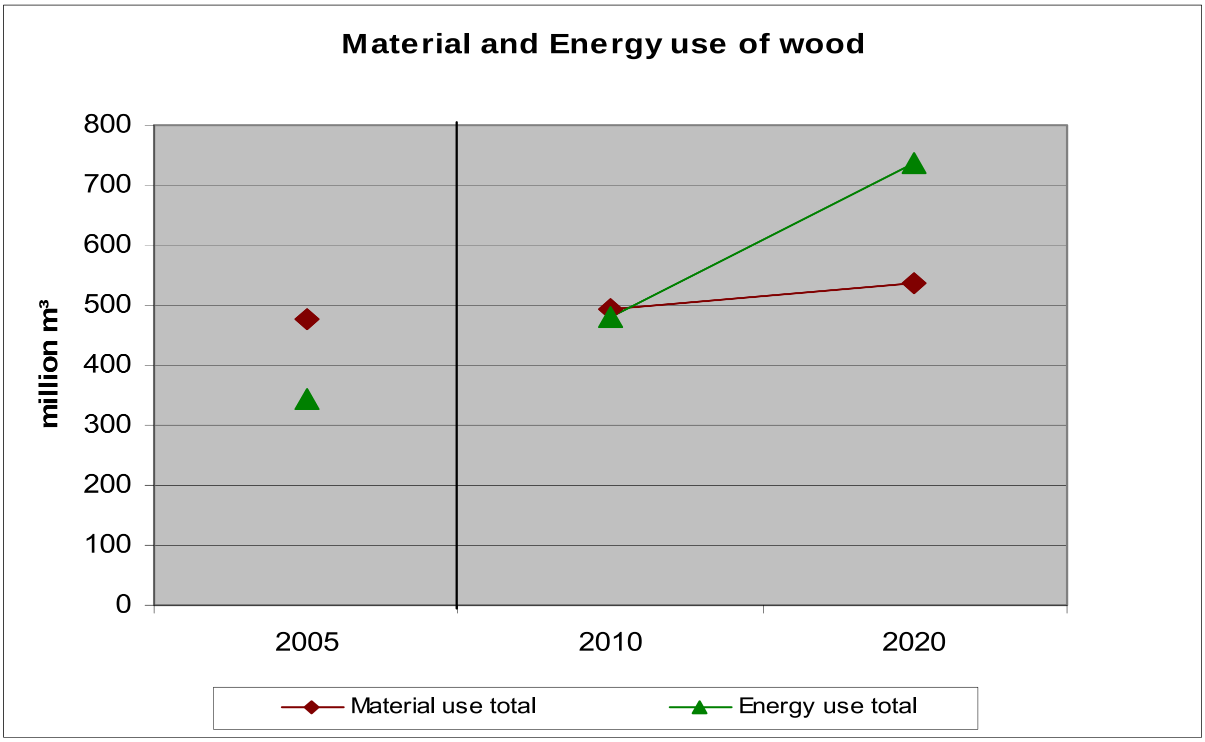


Figure 19. Material and energetic use of wood in EU27 + Norway and Switzerland (Mantau et al, 2007)

Table 36 shows the cumulative results of the interviews as strength of agreement with regard to proposed statements (hypotheses 13-25). It is shown for different countries and different national stakeholder groups.

Table 36. Results of the interviews for specific European countries and contributing stakeholder groups with regard to the chapter "Consumption and Production" as strengths of agreement: dark green – strong agreement; light green – agreement; orange – disagreement; red – strong disagreement; grey – no opinion; white - no participants

	Forestry					Logistics					Sawmilling					Panels					Pulp&paper					Bioenergy				
	AT	DE	FR	PL	SE	AT	DE	FR	PL	SE	AT	DE	FR	PL	SE	AT	DE	FR	PL	SE	AT	DE	FR	PL	SE	AT	DE	FR	PL	SE
Material and energetic use																														
13	dark green	dark green	orange	light green	light green	dark green			dark green	light green		dark green		dark green	dark green	light green	light green	dark green	orange		dark green	orange	dark green		dark green	light green	dark green			red
14	light green	light green	light green	light green	dark green	orange			dark green	light green		light green		dark green	orange	dark green	dark green	light green	light green		dark green	dark green	light green		orange	light green	orange			light green
15	orange	orange	orange	red	orange	orange			light green	orange		light green		grey	orange	light green	light green	light green	light green		dark green	light green	light green		orange	light green	dark green			orange
16	light green	light green	light green	light green	light green	light green			dark green	light green		light green		light green	dark green	dark green	light green	light green	light green		dark green	grey	light green		light green	light green	light green			light green
17	orange	light green	light green	light green	light green	light green			light green	orange		light green		light green	light green	light green	light green	light green	light green		dark green	orange	red		light green	light green	red			light green
Quantity of production																														
18	dark green	light green	dark green	light green	dark green	light green			dark green	orange		dark green		dark green	light green	dark green	light green	dark green	light green		dark green	light green	light green		light green	light green	light green			light green
19	dark green	dark green	dark green	light green	light green	dark green			light green	light green		light green		dark green	dark green		light green	light green	light green		dark green	grey	dark green		dark green	dark green	dark green			light green
20	orange	dark green	light green	orange	orange	light green			light green	light green		grey		grey	dark green	light green	light green	grey	orange		dark green	orange	light green		light green	light green	dark green			red
21	orange	orange	light green	grey	orange	orange			light green	light green		orange		orange	light green	orange	light green	grey	orange		orange	orange	light green		orange	orange	orange			orange
22	light green	light green	light green	orange	light green	orange			light green	light green		light green		light green	red	light green	light green	light green	light green		orange	grey	red		red	orange	orange			light green
Imports and exports																														
23	dark green	light green	light green	orange	dark green	dark green			light green	dark green		light green		dark green	dark green	dark green	light green	light green	light green		dark green	light green	orange		dark green	orange	light green			dark green
24	light green	dark green	light green	red	light green	grey			orange	grey		orange		light green	dark green	light green	orange	orange	light green		orange	orange	light green		light green	orange	orange			grey
25	orange	light green	grey	light green	orange	light green			light green	light green		orange		light green	light green	orange	orange	orange	light green		light green	dark green	light green		light green	orange	light green			light green

Based on the interviews, the following hypotheses are put to test:

- **Material and energetic use**

H13 - An increasing demand for forest biomass for energy production will have negative impact on the material use.
With a broadening portfolio of wood use (e.g. by emphasis of bio-energy) a stronger competition for the resource is assumed. In fact, there is strong agreement on increasing competition and that increasing forest biomass demand for energy production will have negative impact on the material-use branches. The Swedish bioenergy sector is the only strong objector to that assumption.

H14 - A general increase in demand for wood will influence the forest-based sector positively.
On the other hand, a strong role of wood-use in today's and future economies is well-perceived. There is rather stable consensus on the positive impact of a general increase in demand for wood for the forest-based sector and that wood should play a vital role in multiple use of natural resources.

H15 - Short rotation plantations for energy-wood will play an increasing role in the wood supply of forest-based industries.
One response to increasing wood demand may be the fostering of short rotation plantations for biomass production. While foresters in all 5 countries do not see any need for short rotation plantations at all, it is seen as feasible option for most of industries' stakeholders. Opinions differ within logisticians and the bioenergy sector.

H16 - Increased wood consumption will gain additional momentum due to greening trends by European consumers.
From the consumer's point of view, a greening trend has been observed in Europe during the past years. This trend is assumed to be one of the drivers of stronger use of natural resources and wood in particular. All stakeholders agree that greening trends can be held accountable for increasing wood consumption in the future.

H17 - In the light of the situation in 2010 and the impacts of the financial crisis, the EFSOS scenario projections are valid estimates.
EFSOS projections indicate in the baseline scenario that consumption of wood based products will rise further in each of the 5 countries. Stakeholders agreed to that mostly in forestry, logistics, sawmilling and panels, stronger objections are recorded for P&P (G, F) and bio-energy in Sweden.

- **Quantity of production**

H18 - An increase of domestic roundwood production is essential for the growth of the whole forest sector
Domestic roundwood production as important driver for the viability of the sector is seen as a crucial factor and is widely agreed upon.

H19 - As a general principle, a high share of roundwood production meeting sawnwood quality standards is important for the whole forest sector.
High-quality timber is assumed to create maximum value added along the forest-wood chain compared to poor assortments. There is overall agreement on this statement. A high share of roundwood production meeting sawnwood quality standards seems to be essential for the whole forest sector.

H20 - Wood imports from short-rotation plantations will play an increasing role to meet the demands of pulp and paper production.
Addressing the particular needs of the P&P industries, wood imports from outside EU may raise increasing scrutiny. Even within P&P there is no unanimous opinion, the rest of the picture remains scattered, foresters are more sceptic by trend in this point.

H21 - Non-wood raw materials and/or products will be an increasingly limiting factor for the forest-based sector.
As concerns the competition between wood and other materials/non-wood products most stakeholders do not see non-wood raw materials and/or products as limiting factor to the forest-based sector.

H22 - In the light of the situation in 2010 and the impacts of the financial crisis, the EFSOS scenario projections are valid estimates.
EFSOS projections indicate in the baseline scenario that production of wood-based products would slightly increase in each of the 5 countries. These estimations are seen mostly critical, although many stakeholders at least confirm a correct trend. For P&P industries and most of bio-energy H22 is simply invalid.

- **Import and exports**

H23 - A high export rate is important for forest-based businesses.
H23 is based on the assumption that a high export rate is an important indicator for the forest-based sector. This appears true for the whole chain apart from minor dissents.

H24 - Exports to countries outside EU will gain importance compared to intra-EU exports.
Specifying ‘exports’ to ‘exports outside EU’ creates a big difference between the countries and the branches in the chain. No general conclusion can be drawn from the opinion of the stakeholders in the 5 countries.

H25 - Imports from outside EU will gain importance compared to imports from EU countries.
Quite similar, ‘imports from outside EU’ are perceived contrastingly across countries and branches. Agreement can be found for logistics and P&P industries, rather disagreement for panel industry.

9.3.3 Socio-economic role of the forest-based sector

In this section, the forest sector is highlighted as employer and macro-economic factor. The development of employment and gross value added in the forest sector in each country over time and the development of main indicators (average personnel costs, apparent labour productivity and wage adjusted labour productivity) for forest-based industries in selected European countries build the basis for the questions in this context.
For instance, Figure20 shows that the number of persons employed in the forest-based sector in each country decreases constantly.

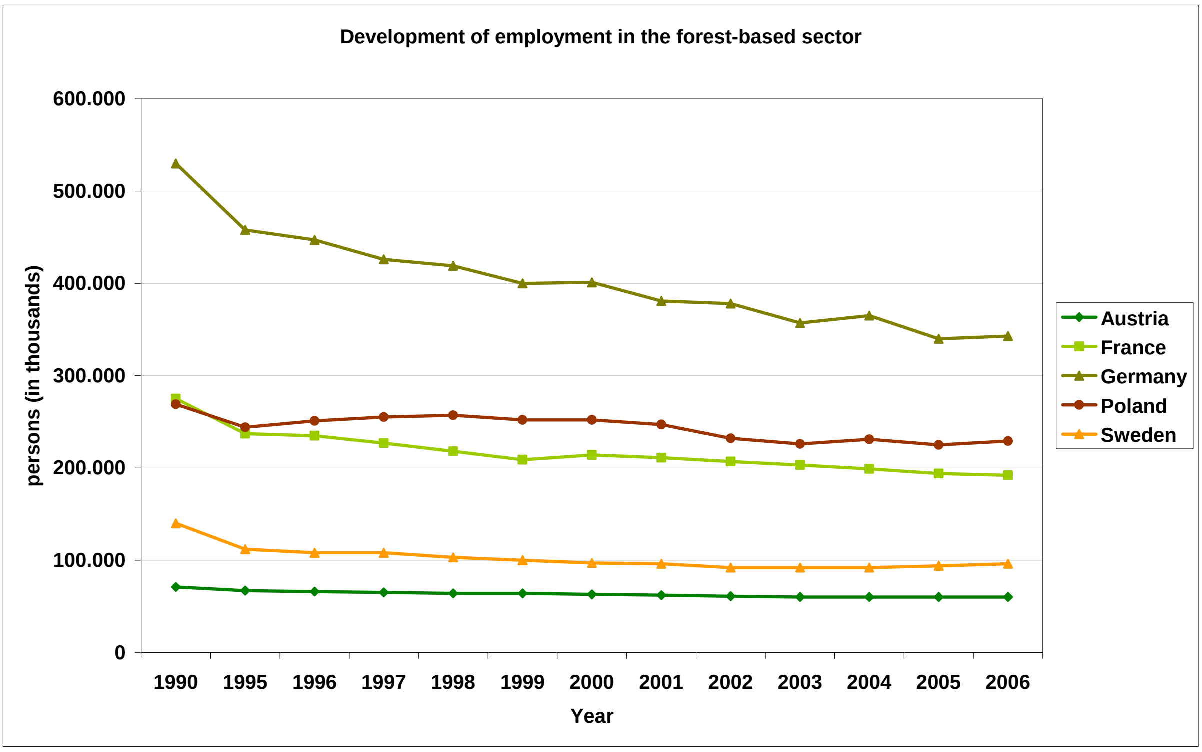


Figure 20. Development of employment in the forest-based sector in specific European countries over time (FAO, 2008)

Table 37 shows the cumulative results of the interviews as strength of agreement with regard to proposed statements (hypotheses 26-30). It is shown for different countries and different national stakeholder groups.

Table 37. Results of interviews in specific European countries and contributing stakeholder groups with regard to the chapter "Socio-economic role of the forest sector" as strengths of agreement: dark green – strong agreement; light green – agreement; orange – disagreement; red – strong disagreement; grey – no opinion; white - no participants

	Forestry					Logistics					Sawmilling					Panels					Pulp&paper					Bioenergy				
	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪
Socio-economic role of the forest sector																														
26																														
27																														
28																														
29																														
30																														

Based on the interviews, the following hypotheses are put to test:

H26 - Economic pressures are mainly responsible for decreasing employment in the forest sector.
Experiencing decreasing employment in the forest-based sector, one reason could be that economic pressure leads to personnel reduction, an argument upon which high agreement among stakeholders can be found.

H27 - Decreasing employment in the forest-based sector is a consequence of increased efficiency.
On the other hand, also increasing efficiency in production processes may lead to less employment compared to the amount of goods produced. However, no clear trends – neither for countries nor for branches - can be identified from stakeholders' opinions.

H28 - Labour productivity within the forest sector is currently comparable with the productivity in other sectors.
Perceiving labour productivity as competitiveness factor and relating it to other sectors we find that labour productivity in the forest-based sector is estimated as comparatively low by Polish stakeholders. In all other countries, no distinct differences and no competitive disadvantages are assumed, maybe also due to absence of comparative data of other sectors in these interviews.

H29 - Compared to costs for raw material, energy, and other operating costs labour costs are of high importance in the forest-based sector.
The share of labour costs is predominantly correlated with the branches. Whereas labour costs are important cost factors in forestry and logistics, this statement is not valid for more intensive industries such panels and P&P.

H30 - Gross Value-Added of the forest sector in my country will further increase in the next 5 years.
In line with a stronger trend of natural resource use and greening trends, GVA created in the forest-based sector is believed to rise again. Stakeholders from logistics show some more reservation towards this hypothesis.

9.3.4 Marketing

Forest certification is an instrument to promote wood and wood products from sustainable forest management and chains of custody. The FSC and PEFC certification schemes are discussed as well as aspects of product and process innovation. Public and self-perception cover the last topic of interest.
As an example, Figure21 shows current statistical data regarding FSC and PEFC certification schemes in selected European countries.

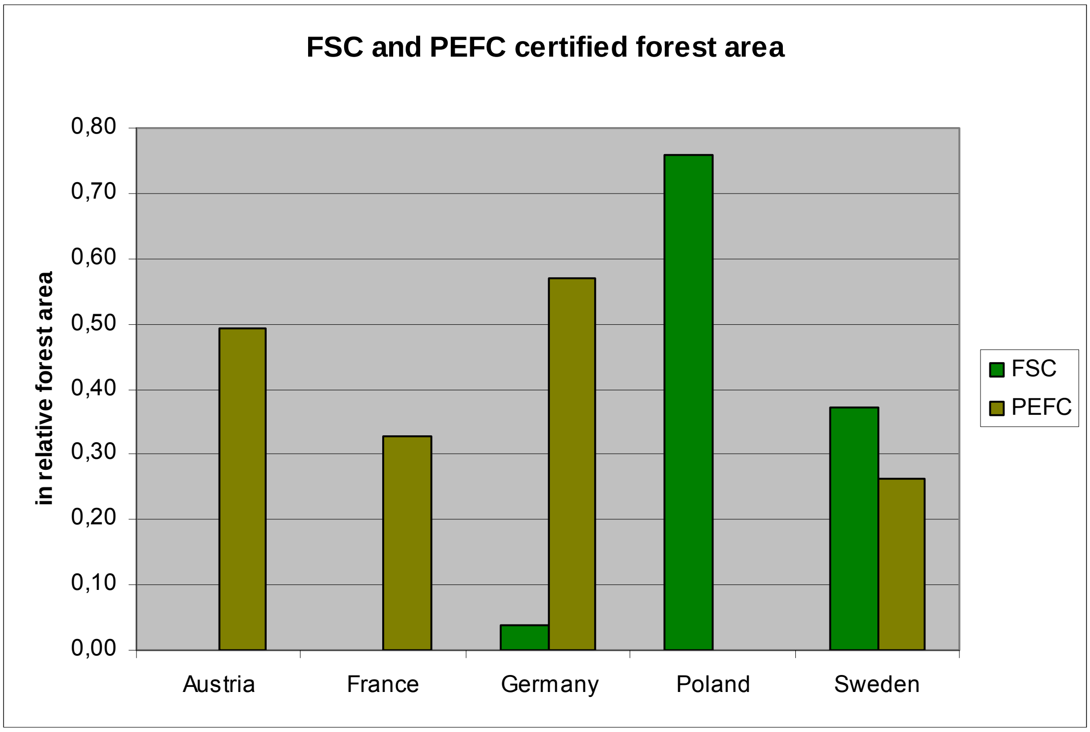


Figure 21. FSC and PEFC certified forest area in different European countries 2010 (FSC, 2010 / PEFC, 2010).

Table 38 shows the cumulative results of the interviews as strength of agreement with regard to proposed statements (hypotheses 31-41). It is shown for different countries and different national stakeholder groups.

Table 38. Results of interviews for specific European countries and contributing stakeholder groups with regard to the chapter "Marketing" as strengths of agreement: dark green – strong agreement; light green – agreement; orange – disagreement; red – strong disagreement; grey – no opinion; white - no participants

	Forestry					Logistics					Sawmilling					Panels					Pulp&paper					Bioenergy				
	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪	🇦🇹	🇩🇪	🇫🇷	🇵🇱	🇸🇪
Certification																														
31	light green	light green	dark green	light green	light green	light green			light green	light green		red		dark green	light green	orange	light green	light green	light green		dark green	orange	dark green		light green	light green	dark green			light green
32	orange	light green	orange	light green	light green	light green			orange	light green		orange		light green	light green	light green	orange	grey	light green		light green	orange	light green		light green	light green	orange			light green
33	light green	light green	dark green	light green	light green	light green			dark green	light green		orange		light green	light green	orange	light green	light green	light green		dark green	orange	light green		light green	light green	light green			light green
34	orange	light green	orange	orange	dark green	light green			light green	light green		light green		dark green	orange	light green	light green	grey	light green		dark green	dark green	light green		orange	orange	orange			light green
Innovation																														
35	dark green	dark green	dark green	light green	dark green	light green			light green	light green		dark green		orange	light green	light green	light green	dark green	light green		dark green	light green	dark green		light green	dark green	light green			dark green
36	dark green	light green	dark green	light green	light green	light green			light green	light green		dark green		grey	dark green	light green	light green	dark green	light green		dark green	light green	dark green		dark green	dark green	dark green			light green
37	orange	red	red	light green	orange	red			orange	orange		red		orange	grey	light green	orange	grey	orange		light green	light green	orange		grey	red	grey			orange
38	dark green	red	light green	orange	light green	light green			orange	light green		orange		dark green	dark green	light green	dark green	light green	orange		dark green	light green	light green		dark green	dark green	dark green			light green
Public and self-perception																														
39	light green	light green	light green	light green	light green	dark green			orange	orange		red		light green	grey	light green	light green	orange	light green		light green	orange	red		grey	dark green	dark green			light green
40	orange	orange	light green	orange	light green	orange			orange	light green		red		orange	grey	orange	light green	orange	orange		orange	orange	red		grey	orange	dark green			light green
41	dark green	dark green	dark green	light green	dark green	dark green			light green	dark green		dark green		dark green	dark green	dark green	dark green	dark green	light green		dark green	light green	dark green		dark green	dark green	light green			dark green

Based on the interviews, the following hypotheses are put to test:

- **Certification**

H31 - Forest certification is an important instrument to foster marketing of wood-based products in general.
Forest certification is a market-based instrument to grant sustainable forest management and chain of custodies for selling 'green' products. However, representatives of the Austrian panel industry and the German sawmilling and pulp and paper industry do not strong trust in certification while all other stakeholders judge forest certification as an important instrument to foster marketing of wood-based products in general.

H32 - Forest certification generates competitive advantages within the wood-based business.
As whether certification provides competitive advantages or if it is a prerequisite for the (Western) timber market is not totally clarified. German stakeholders (except foresters) are particularly sceptic towards competitive advantages by forest certification, as well as Austrian foresters and Polish logisticians. For others, there is rather support for this argument.

H33 - Forest certification will help to improve the public perception of the forest sector in Europe.
Even if it is of direct advantage, forest certification may help to improve the public perception of the forest-based sector. Indeed, there is a strong notion on this kind of positive effects among the addressed stakeholders. Almost everyone thinks that forest certification will help to improve the public perception of the forest sector in Europe. Only German sawmillers and pulp and paper representatives as well as Austrian panel industry members disagree.

H34 - The European forest sector should concentrate on one common certification scheme.
When addressing a unified certification scheme to overcome discrepancies between the two major systems, more than half of the interviewed persons agreed. Yet, most representatives from forestry and bio-energy disagree. It is imaginable that such a vision is simply judged as unrealistic.

- **Innovation**

H35 - Product innovation will play a major role for the future of the forest-based sector
Innovation as source for improvement, flexibility, and renewal could be a driving force for maintaining competitiveness within the forest-based sector, among sectors, and on the global market. Product innovation addresses new assortments, new components, and new products. According to the stakeholders, product innovation will definitely play a major role for the future of the forest-based sector.

H36 - Process innovation in the production will be essential to remain competitive forest-based sector.
In addition, process innovation is aspired to make production process more efficient, more effective, or higher in quality. Again, there is overall agreement among the stakeholders that process innovation will be key for the viability of the sector.

H37 - Research & Development budgets in the forest-based sector are sufficient compared to competing sectors.
R&D should be one of the main drivers to facilitate innovation, R&D budgets form one indicator towards that. Overall, R&D budgets are judged as comparatively low with regard to competing sectors. The situation is perceived slightly more optimistic by the P&P industry.

H38 - The organisation of the forest-based sector (e.g. associations, platforms) in my country is an important factor to support innovation, Research & Development.
Organisation of the sector is assumed as an important factor for exchange, supporting innovation and R & D, representation, and lobbying. In fact, Polish stakeholders are sceptic about the role of their associations and the degree of their organisation. Also, Germany (forestry, sawmilling) is critical about the role of organisation within the sector.

- **Public and self-perception**

H39 – The forest-based sector (and its sub-sectors) is perceived as environmentally friendly by the customers.
Representatives of forestry and the bioenergy sector do believe that they are perceived as environmentally friendly by the customers. In logistics, the sawmilling and the pulp and paper industry good reputation related to environmental friendliness is rather doubted.

H40 - The forest-based sector (and its sub-sectors) is perceived as innovative by the customers.
Concerning innovation, the bio-energy branch is more convinced than others that they are perceived as innovative by the customers. Otherwise, innovation does not seem to be one the selling points of the forest-based sector.

H41 - The forest-based sector is an important player for sustainable development.
The self-image of the forest-based sector is being an important player for sustainable development in Europe. There is strong agreement along the chain in each of the countries.

9.4 Synthesis of findings

The interviews and stakeholder analysis aimed at clarifying the opinions of high-level stakeholders in 5 countries with regard to the topics (i) wood mobilisation, (ii) consumption and production, (iii) socio-economic role of the forest-based sector, and (iv) marketing. Besides judgments of formulated hypotheses, the impacts of policy instruments and open comments by the stakeholders were of core interest.
Concerning **Wood Mobilisation**, it can be stated that in all countries stakeholders are advocating for a stronger use of their national wood resources. They mostly see large potential for wood harvest without questioning any sustainability paradigm. However, stronger wood mobilisation will evoke conflicts and constraints. It is perceived that the amount of protected forest areas may become a limiting factor to wood supply, hence the concept of multi-functionality may be put to question (e.g. within Natura 2000 regions). On the other hand, structural problems such as fragmented forest ownership and inactive forest owners constitute hampering factors to a more effective wood mobilisation. As a response, measures for public awareness rising, public relations inside and outside the forestry-wood chain, and support from public authorities to better reach forest owners are strongly recommended.
Among the policy instruments, (a) the EU Biomass Action Plan (and national action plans), (b) Natura 2000, and (c) the Convention on Biological Diversity have been estimated as particularly important both as driver (a) and limiting factors (b, c). It has to be pointed out that national implementation means (e.g., National Biomass Action Plans, Forest Law, Climate Program, Nature Protection Law) are considered of prior importance by the stakeholders.

With regards to **Consumption and Production**, a potential conflict between material use and energetic use of wood was addressed. There is a notion that energetic use is overly fostered by range of policy instruments with a strong impact on the use of the resource (e.g. EU Climate Change Programme, EU Renewable Energy Roadmap, EU Strategy for Biofuels). This may lead to shortage in wood supply and increasing competition within the wood supply chain. As a consequence, most stakeholders doubt that the EU wood production can sufficiently supply the industries and foreseen increasing importance of imports to the EU and from short rotation plantations. Counter- strategies could be seen in a stronger cascadic use of wood; high-quality wood to improve the value-added along the chain, fostering the material use (e.g., raising public awareness- greening trends, new building standards), and use wood-waste for energetic purposes. Still, there is currently no general consensus for this kind of wood use cycle.

The **Socio-economic role of the forest sector** is characterized by decreasing employment and substantial losses due to the recent financial crisis. On the other hand, bio-energy industry experienced a boom during the past years. In general, stakeholders are rather optimistic towards future development of the forest-based sector and the gross-value added therein. In the wake of stronger use of natural resources and greening trends in the society stakeholders mostly expect an increasingly important role of the forest-based sector and a stable role of the sector as employer. What is needed therefore is a balanced system of policy instruments (e.g., subsidies, taxes) and a secured raw material supply. The role of the forest-sector as key driver of rural development is still not sufficiently acknowledged.

At last, **Marketing** was touched in order to look at certification, innovation, and perception of the forest-based sector. Certification is considered as a valuable instrument by most of the stakeholders, although it does not seem to create substantial additional income. It is seen as an important pre-requisite for presence on international markets and moreover a tool to raise public awareness of wood and increase public perception of the forest-based sector (e.g., advantages of wood, carbon storage). According to the stakeholders, there is still room for improvement concerning the visibility of wood from sustainable production. Although there two competing system (FSC, PEFC), double certification seems to be a common phenomenon. If this improves credibility of certified wood, may be discussed.
As a further point, product and process innovation are seen as crucial for the further development of the forest-based sector. This goes in line with the need for increased R&D budgets and strong vertical and horizontal organisation within the sector. It appears that Eastern European still need to be stronger organised and integrated in European associations.
There is overall consensus among the stakeholders that the forest-based sector will be a key sector for supporting sustainable development in Europe. Therefore, an appropriate political framework is requested as well a standardised form of information. With regard to sustainability reporting and forest resource assessments, there is still a vast conglomerate of definitions, units and scales which is hampering factor for any information-based decision-making for and within the forest-based sector.

10. Conclusion

This deliverable identifies the profiles of demand on wood raw material of three industrial sectors (sawing, pulp/paper and energy productions) within the WSC. These profiles are strongly related to particularities of each production site, and as such are difficult to extract. Therefore the results of this delineable are to be seen as representing the typical, general characteristics of industrial demands that can be expect in average situation. The industrial requirements on properties of wood raw material are determined by sector specifications, by products made and by processes/equipments used.

There exist several key quality properties of wood raw material for each industrial sector. The industrial requirements are characterised per wood properties at stand level and at individual tree (log) level. Sometimes these properties are shared among sectors (e.g. species), but most of time their relative importance vary (e.g. age). Typical requirements related to the wood raw material quality of sawmills are higher than for bio-energy producers. Beside the native wood properties, there are several activities along the supply chain from harvesting to delivery to industries that affect the quality of wood (e.g. harvesting, forwarding, stocking). In general in bio-energy production the impact of these activities are more important then the native wood material properties (e.g. grades, moisture content, contamination with other materials, …). In future it is expected that importance of raw material quality will increase for sectors.

Regarding the quantities of wood raw material, the major consumption of round wood is realised by sawmills, although the level vary among countries. While, the forecast of future trends are a difficult task, it is reasonable to expect that productions of sawmills and bio-energies will increase at the horizon 2020. Therefore the more the demand of sawmills (having with the highest requirements of wood qualities) increases in the future, the more identification of wood quality properties at the beginning of supply chain is relevant, and make the use of remote sensing technologies attractive. Similarly, the more the demand of bio-energies (representing high requirements on activities of supply chain) increases in the future the more efficiency of logistics and material supply is relevant.

A stakeholder analyses reveals that there is a potential conflict between material and energy use of wood. The support for RES may lead to shortage of wood and increase in competition within the supply chain. Here also the remote sensing technologies, and logistics, can improve the efficiency of the wood use and as such improve the visibility of the forest based sectors in the sustainable development of Europe.

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