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## **BioNorm II**

**Pre-normative research on solid biofuels for improved European standards**

**SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT**

**PRIORITY [6-1] – Sustainable energy systems**



### **DIIL.6 Critical Control Points**

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## Abstract

The development of European Standards (EN) is a precondition to expand the market for solid biofuels and a very important step to fulfil the political and environmental goals of the European Union.

The aim of the BioNorm II project is to carry out pre-normative research in the field of solid biofuels in close collaboration with the work of CEN TC 335 "Solid Biofuels". This includes the development of an overall quality assurance system for solid biofuels, their characterization and corpus of legislation.

In WP III the work focuses on the development of a Quality Management System in order to guarantee a defined biofuel quality. Based on the results of the former BioNorm project where a Quality Assurance and Quality Control System were developed WP III now concentrates on the Quality Policy including also Quality Planning and Quality Improvement.

A major aim of WP III is the development of a "Procedure for Quality Planning" which will give an overview about relevant quality measures within the supply chains of different biofuels. The following biofuels: wood pellets, wood chips, hog fuel, straw and olive residues should cover the most common and also new and potential biofuels. Therefore relevant information about end-user requirements, quality influencing factors, Critical Control Points, appropriate test methods and the description of the supply chains is needed which was compiled by four national teams. As it is important to regard experience from practice the required information was attained with the help of a poll. The national teams therefore interviewed end-user and boiler producers, fuel producers and fuel distributors.

This report is the summary of all the information gathered in the first project year by the international project partners and describes following scopes:

- national teams and the allotted fuels;
- objectives of the task;
- the methodology (poll);
- the description of the single fuel supply chain;
- and the CCP's.

This report is the basis for the Guideline describing the procedure for quality planning (including CCPs, the most appropriate test methods, the costs, necessary arrangements for provision, transport and storage etc.)

**List of Abbreviations**

a	Annus, year
BEP	Break even point
CCPs	Critical Control Points
CHP	Combined heat and power plant
kg	Kilo grams
kW	Kilo Watt
MW	Mega Watt
NO <sub>x</sub>	Nitrogen oxides
t	Ton
WP	Work Package

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## Table of Contents

<b>1</b>	<b>INTRODUCTION AND OBJECTIVES.....</b>	<b>7</b>
<b>2</b>	<b>METHODS .....</b>	<b>7</b>
<b>3</b>	<b>SUPPLY CHAIN AND CRITICAL CONTROL POINTS .....</b>	<b>9</b>
<b>4</b>	<b>RESULTS OF WOOD PELLETS.....</b>	<b>10</b>
4.1	Supply chain of wood pellets .....	10
4.2	Critical Control Points within the supply of wood pellets .....	11
<b>5</b>	<b>RESULTS OF WOOD CHIPS.....</b>	<b>14</b>
5.1	Supply chain of wood chips .....	14
5.1.1	Supply chain of wood chips from virgin wood (The Netherlands).....	16
5.2	Critical Control Points within the supply of wood chips .....	16
5.2.1	Critical Control Points within the supply of wood chips from virgin wood (The Netherlands)	18
<b>6</b>	<b>RESULTS OF HOG FUEL FROM LOGGING RESIDUES .....</b>	<b>19</b>
6.1	Supply chain of hog fuel from logging residues .....	19
6.2	Critical Control Points within the supply of hog fuel from logging residues.....	20
<b>7</b>	<b>RESULTS OF HOG FUEL FROM WASTE WOOD .....</b>	<b>21</b>
7.1	Supply chain of hog fuel from waste wood.....	21
7.2	Critical Control Points within the supply of hog fuel from waste wood.....	21
<b>8</b>	<b>RESULTS OF OLIVE RESIDUES.....</b>	<b>22</b>
8.1	Supply chain of olive residues .....	22
8.2	Critical Control Points within the supply of olive residues .....	23
<b>9</b>	<b>RESULTS OF STRAW .....</b>	<b>25</b>
9.1	Supply chain of straw .....	25
9.2	Critical Control Points within the supply of straw.....	25
<b>10</b>	<b>SUMMARY .....</b>	<b>27</b>
<b>11</b>	<b>LITERATURE .....</b>	<b>27</b>

## 1 Introduction and Objectives

In future the amount of solid biofuels contributing to heat generation shall be increased. In order to use available biomass potential best possible and to ensure a long term competitiveness consistent and homogenous fuel quality has to be guaranteed. Establishing a necessary Quality Management System requires supply chain analysis of solid biofuels regarding structure, requirements of and quality influencing factors within the single process steps. Objective is to identify Critical Control Points (CCPs) within the supply chains and end users devices of wood chips, wood pellets, hog fuel, olive residues and straw where requirements can be checked and quality influencing factors can be controlled. The description of the supply chain is essential and gives an overview about the single steps of fuel production and fuel use.

CCPs are borderlines within or between processes. Examples where CCPs are likely to be recognized include places where relevant properties can be most easily assessed and places that offer the greatest potential for interventions in processes. The following question will be answered by the supply chain analyses: Where are these specifications mainly influenced and determined? Critical Control Points are to be determined and therefore the following points are of interest and were investigated.

- point(s) at which raw materials are collected/purchased;
- point(s) at which raw materials are pre-processed and loaded for delivery to the next point in the chain;
- during (interim) storage (before and after the production process)
- during production process and between processes
- within the premises of the final supplier;
- points at which the condition of the material is (or can be) changed deliberately;
- point at which the final product is loaded for delivery;
- point(s) of delivery at the end users' premises.

It is important to analyse each biofuel separately due to it's specific characteristics regarding market use and experience on the one hand as well as biofuel properties and supply chain structure on the other hand. The procedure will result in an overview about relevant points within the supply chains of wood chips, wood pellets, hog fuel, olive residues and straw where there is the possibility to measure and influence the fuel specifications.

## 2 Methods

For the evaluation of requirements and the description of the different supply chains it was decided to collect relevant data with the help of a poll. To get an overview about the current situation within the supply chains different actors, mainly end user, were interviewed. Also boiler producers were interviewed in order to provide an overview about current boiler technique and specification on biofuels from their point of view. Additional interviews with fuel producers and fuel distributors and also information from other projects and literature should complete the data collection.

End-users like power plant operators or boiler owners who use biofuels for combustion purpose can deliver insight into effectively used technique, combustible biofuels and to which standard the fuel quality complies. In addition to this information the interviewees were asked about logistic issues, storage management, quality improvement devices like sieves, etc.

For the realisation of the poll questionnaires considering the chosen biofuels, wood pellets, wood chips, straw, hog fuel and olive residues were developed for boiler producer and for end-user. They

were tested by some of the interviewees. After this first test-run the two types of questionnaires for different solid biofuels were adapted. For harmonisation and optimisation, the questionnaires were exchanged between the different workgroups.

Depending on the amount of biofuel needed per year, the end-users were divided into three different groups of small, medium and large scale users. Within the different types of biofuel the classification of small, medium and large scale user varies. The type of questions for small, medium and large scale itself was divided into general questions and questions in terms of quality of the biofuel. Examples are given below:

General questions contain following topics:

- used amount of biofuel,
- kind of biofuel used  
(e.g. forest wood or wood from landscape management, olive residues or olive kernels etc.),
- boiler output,
- kind of boiler technique used,
- desired fuel quality according to boiler design,
- delivery of fuel,
- storage of fuel, existing quality
- controls on site etc.

Questions in terms of quality contain following topics:

- using of standardised fuel,
- knowledge about standards,
- agreements in terms of fuel quality with producer/distributor,
- determination of agreements within contract for delivery,
- delivered fuel quality,
- delivered documents,
- lack of quality,
- proceeding in case of complaints,
- amount of complaints,
- potential for improvement from end-user point of view etc.

For the development of the questionnaires for boiler producer, the questions from the end-user questionnaires were adapted. The main focus herewith was the boiler technique and occurred problems due to insufficient fuel quality which may result for example in problems with the

- combustion technique,
- feeding system,
- furnace chamber,
- flue gas cleaning etc.

After developing the questionnaires contact data of boiler producer and end user were collected. In case of end users this was partly difficult depending on the current use of particular solid biofuels on the energy market.

Wood pellets and wood chips for example are widely used in Austria and Germany as well as straw in Denmark. The use of olive residues in comparison is under development at the moment. The research for contact data of boiler producers was difficult only for olive residues as there is no real producer market yet.

The interviews with end users for wood pellets, wood chips and hog fuel were performed by phone, email and fax, those for straw and olive residues were additionally performed face to face in Denmark and Spain. The difficulty in Spain was based on the language barrier so that a translator was needed. Interviews with boiler producers were mainly performed by phone with exception of one which was performed face to face during the visit in Spain.

To get more input about the current situation within the supply of solid biofuels it was decided to additionally distribute the questionnaires to end user and boiler producer with the help of the BioNorm II homepage and through the members of the national mirror committees of CEN TC 335 “Solid Biofuels”.

After collecting and analyzing the results from the poll existing (pre-)standards have been analyzed for further information regarding supply chain related properties. Thereupon a table for each biofuel was prepared where the respective Critical Control Point(s) for the single steps of the supply chain are specified. The results for the single biofuels are added in the following chapter.

The following table shows the summarized number of performed interviews as well as other sources of information like earlier project works and references from literature.

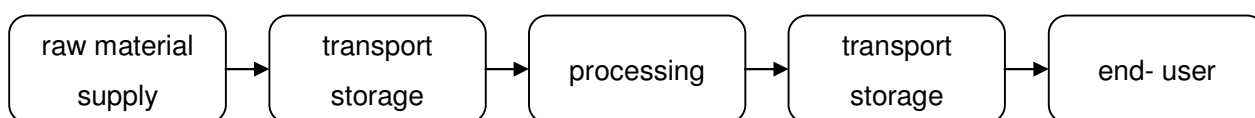
**Table 1** Number of performed interviews during the first project period

	end user	boiler producer	others (e.g. fuel producer, fuel distributor)
performed interviews	45	17	7
data from earlier project works	2	1	4
data from literature			2

### 3 Supply chain and Critical Control Points

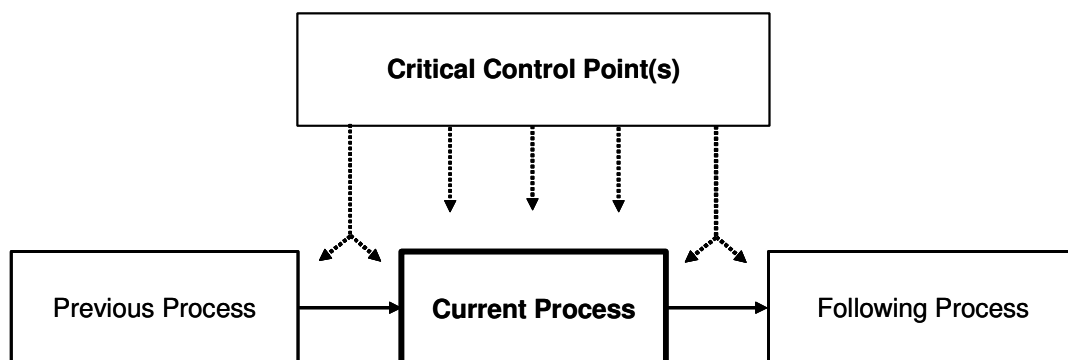
Within the focus of the supply chain analyses were wood pellets, wood chips, hog fuel, straw and olive residues. Different requests and use of these biofuels on the market causes different experiences in handling regarding quality requirements. The range of experiences with the biofuels therefore varies from long experienced (like e.g. wood pellets) to short experienced (like e.g. olive residues).

It was found that the requirements for fuel quality can be summarized to general aspects. First of all a biofuel is needed which causes no problems and difficulties during combustion and which is therefore easy to handle. The aim of this project is the pre-normative work on biofuels not on combustion technique so this necessarily requires a biofuel which corresponds to the needs of the respective combustion unit. For this reason fuel producer have to be informed about the combustion units’ quality requirements and have to deliver that quality consistently. In this context it is not necessarily important to refer to a standardized biofuel but to agree on special quality requirements between all actors in a supply chain concerning different fuel parameters like moisture, impurities, ash content, mechanical durability etc.



**Illustration 1** General description of a supply chain for solid biofuels

Although the current situations within the supply chains seem completely different general quality influencing factors are often similar within the different sorts of solid biofuels and include factors like storage, transport, processing of raw material and final product as well as selection and collection of raw material. In principal quality influencing factors can be generalized to the single process steps, depending on the respective biofuel with varying focus.



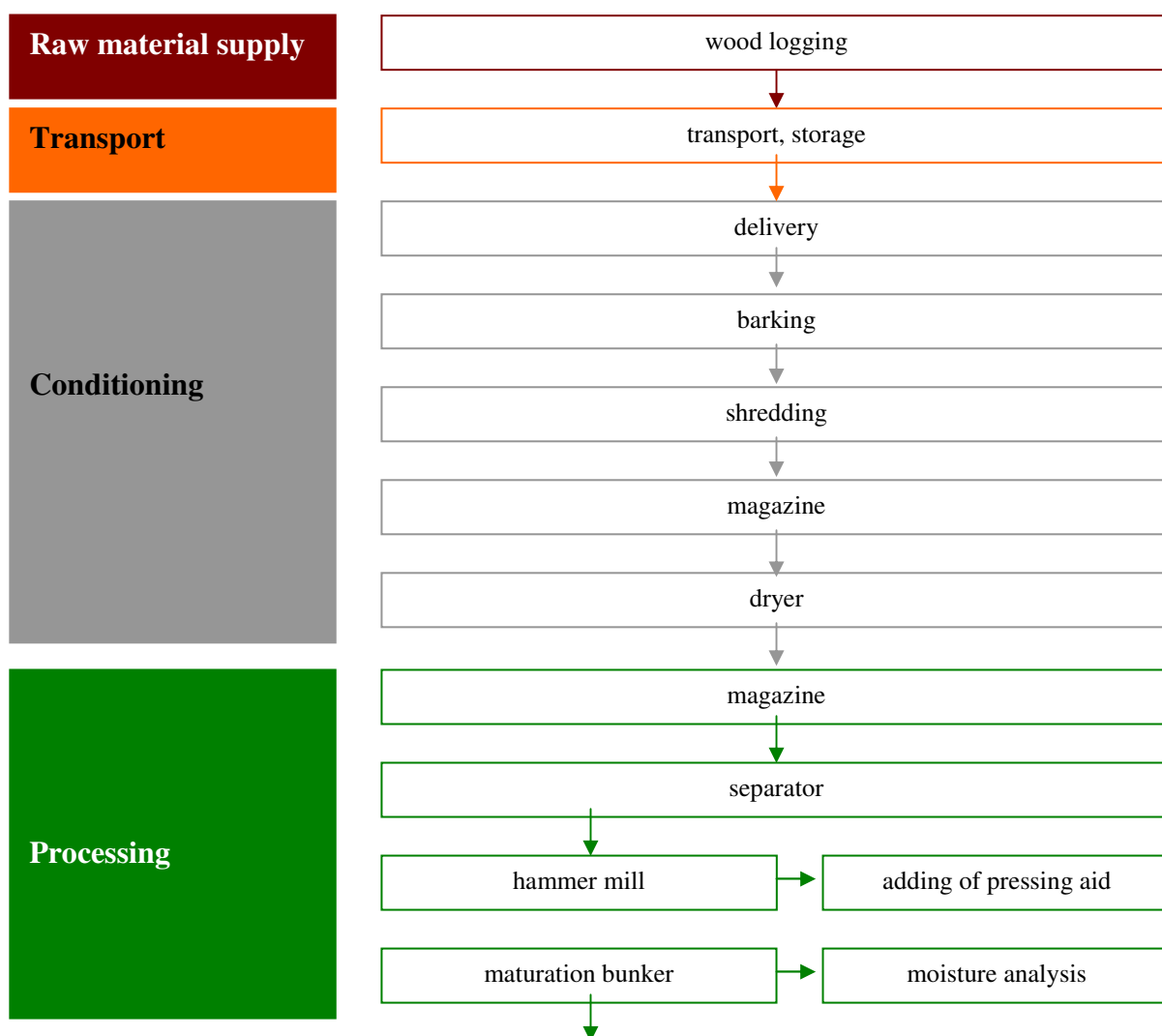
**Illustration 2** Possible positions of Critical Control Points within the single steps of a supply chain [2]

The CCPs for the respective biofuel supply chain which derive from the analyses of end-user requirements and quality influencing factors are described closer within the following chapters. Also information from the previous BioNorm project has been taken into consideration.

## 4 Results of wood pellets

### 4.1 Supply chain of wood pellets

The structure of a typical wood pellets supply chain is demonstrated within illustration 3.



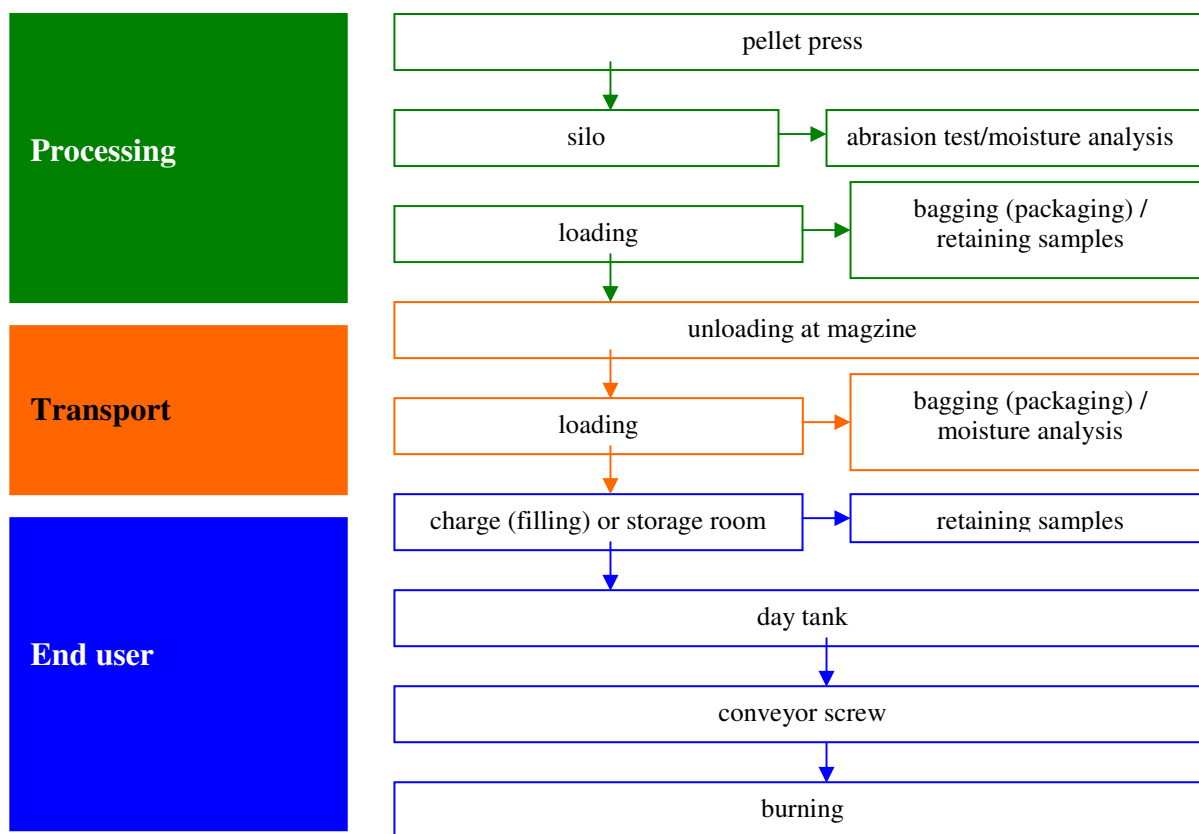


Illustration 3 Structure of the wood pellets supply chain

## 4.2 Critical Control Points within the supply of wood pellets

The existing quality standards for wood pellets like described within *DINplus* or *ÖNORM*°M 7135 are nearly satisfying. Parameters that influence the ash melting point and their consequences on the performance of the boiler have to be regarded within an adapted quality standard also.

A lot of small and medium end users trust to a certificate for a quality according to the demanded standards. In general quality controls to the quality delivered aren't applied, as there is a label the material is certified to according to *ÖNORM* or *DINplus*. Also very often it is not known that differences in the quality exist or that special parameters can be checked. Small and medium scale user require the delivery of an unproblematic wood pellet charge which is causing no problems during combustion and which is therefore unproblematic in handling. As soon as the combustion unit is not working properly differences in pellet quality reveal and result in reclamation about the delivered pellet quality. Hence a progress starts finding out if the combustion problems result from unsuitable pellet quality or if the heating and supply system hasn't been adjusted correctly.

Large scale end users normally purchase industrial products and define their respective standards in cooperation with the supplier. As a result these industrial standards differ from end user to end user. Large scale end users normally have an own quality management which requires on-site testing of the product when it is delivered. If the quality is not fulfilling the quality requirements, the delivery will be send back without unloading.

Although less than 10% of end users don't name problems with the delivered fuel quality occurring deviations refer to situations where the quality demanded in *DINplus* or *ÖNORM* M 7135 is not fulfilled. Although the existing quality management seems already successful, improvements can be performed. These improvements should be chosen advisedly to ensure an economic quality management (BEP) which doesn't cause rising product prices due to inadequate quality measures.

Improvements should be chosen in a way to guarantee constant product prices or a reduction of, because the wood pellet price is the main reason for end users using wood pellets for the heat supply.

Within the former BioNorm project several CCPs have been identified which not all refer to the wood pellet production itself. Therefore the existing CCPs referring to the wood pellet production have been carefully checked and put in a concrete form within BioNorm II. The CCPs within the remaining steps of supply chain like logging, transport, trader etc. have been added as well. In general two different kinds of CCPs have been identified:

1. CCPs between two different steps of the supply chain (quality check at the delivery from one actor to another).
2. CCPs within one step of the supply chain (quality check at a certain production step)

In the following table the CCPs referring to a single step/process within the fuel supply are named as well as the respective controls that have to be performed at the respective CCP.

**Table 2 Relevant Critical Control Points within the supply chain of wood pellets**

step within the supply chain	process step	CCPs	checking of
raw material supply	wood logging	X	kind of wood silicates impurities condition date and place of next logging
transport	transport, storage		moisture aging impurities fungi
conditioning	delivery	X	moisture colour impurities derivation condition bark
	barking		pureness of wood
conditioning	shredding		dimensions moisture bark colour condition
	magazine		impurities colour heating up of filling
	dryer	X	moisture

step within the supply chain	process step	CCPs	checking of
production	magazine		moisture impurities heating up of filling
	separator		functionality
	hammer mill	X	particle size needed energy
	adding of pressing aid		balancing starch
	maturation bunker	X	residence time
	analysing moisture		moisture before press
	pellet press	X	geometry of pressing duct geometry of koller temperature of koller electricity needed by press
	silo	X	temperature before silo sieving of fines before silo
	abrasion test	X	calibration
	moisture analysis	X	calibration
	loading	X	formation of dust truck: impurities truck: moisture truck: old load humidity absorption
	bagging (packaging)	X	fines crusher
retaining samples		identification representative storage	
trader	unloading at magazine	X	material inside moisture fines low injection pressure
trader	loading	X	formation of dust truck: impurities truck: moisture truck: old load humidity absorption
	bagging (packaging)	X	fines crusher
	retaining samples		

step within the supply chain	process step	CCPs	checking of
end- user	charging (filling) of storage room	X	material inside moisture fines injection pressure
	retaining samples		
	day tank		moisture fines
	conveyor screw		moisture fines
	burning		temperature slagging ash content

## 5 Results of wood chips

### 5.1 Supply chain of wood chips

Raw material for wood chips mainly consists of woody residues and used wood which is not chemically treated. Also wood from landscape management is suitable for the further processing to wood chips. As an alternative to woody residues and landscape management wood short rotation plantations for the cultivation of willow and poplar are becoming more and more important. At the moment short rotation plantations however are still under construction and are not commercially operated. Typical biofuel producer are actors within agriculture, forestry and timber industry as well as companies in the sector of waste management processing used wood.

The supply chain of wood chips is relatively manageable as for the processing itself just a chipping machine is needed. Due to the little technical expenditures wood chips can be produced much cheaper than e.g. wood pellets. Besides that wood chips can be produced where the raw material arises so that the raw material doesn't necessarily have to be transported to the production unit. That's why lots of small scale as well as self producers exist within the supply of wood chips.

In Germany the wood chips production is not committed to a quality standard, although the pre-CEN/TS 14961 has been published in spring 2005. The processing of used wood however is subjected to separate conditions which are set within the German Waste Wood Ordinance.

The raw material is provided by harvesting or coppice maintenance actions and in dependence of the respective harvesting technique directly chipped or picked up, collected and stored at a central place for seasoning. Supplying raw material can happen with either coupled (harvesting, picking up, remove of branches, chipping one step) or decoupled (several steps from harvest to chipping) processes which offer several possibilities to influence and control the wood chips quality.

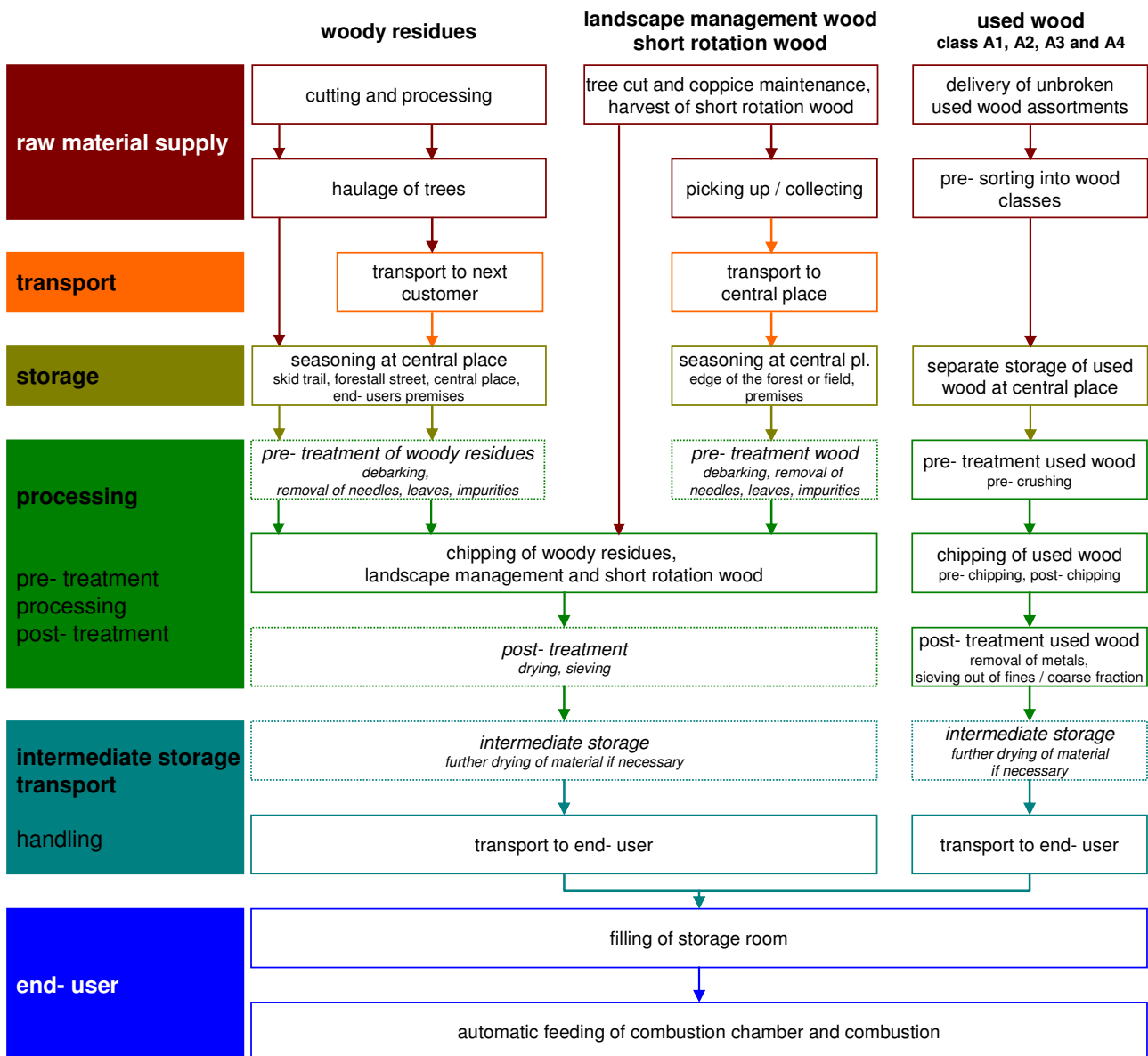
The central place for seasoning can be situated at different places as for example skid trail or forest street, edge of the forest or field or at the respective premises of producers or already end-users. Before chipping the raw material it might be useful to pre-treat the respective wood assortments depending on to what degree needles, leaves or impurities exist which influence the produced wood chips quality. As far as the raw material is chipped directly after harvesting this method is hardly meaningful. In that case existing fines and coarse fractions can be separated after the chipping step by post-treatment with the help of sieves.

The delivery of wood chips can happen “just in time” what means that wood chips are directly chipped in the transportation unit which delivers the biofuel to the end user. Post- treatment processes like sieving or drying are not necessarily possible within that kind of delivery. As far as wood chips are not delivered “just in time” they are stored in an intermediate storage. In that context further post- treatment processes like sieving and/or drying can be performed due to the interruption of the supply chain.

Dependant on the distance to cover from producer to end- user the delivery of wood chips happens with tractor and trailer, walking floor trucks or dump trailers. Bigger distances in general are covered by transportation on train or ship where appropriate containers for bulk materials are used.

Within the wood chips production mostly one actor covers the whole supply chain from raw material supply to delivery to the end- user. The instruction of subcontractors usually happens when production peaks have to be covered or required technique can’t be provided by the producer itself. Process steps carried out by subcontractors can vary between transports, chipping, sieving or delivery.

The structure of a typical wood chips supply chain is demonstrated within illustration 4.



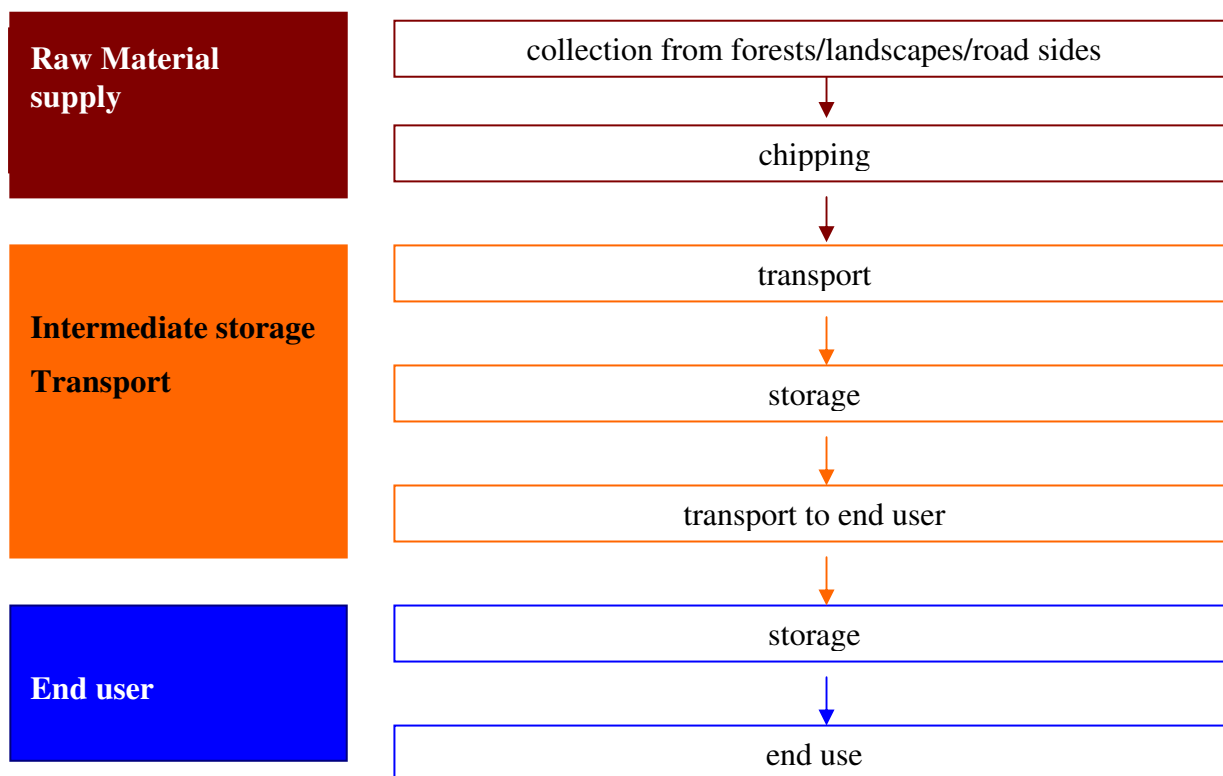
**Illustration 4** Structure of the wood chips supply chain. Broken lines mark a process step which is not necessarily applied

### 5.1.1 Supply chain of wood chips from virgin wood (The Netherlands)

Wood chips in the Netherlands are typically produced from chipping woody residues (branches, treetops, thinnings) that result from maintenance of forests/landscapes/road sides.

Typical production volumes of the green maintenance companies in the Netherlands are over 10,000 tons per year.

The structure of a typical supply chain of wood chips produced from virgin wood is demonstrated within illustration 5.



**Illustration 5** Structure of the supply chain of wood chips from virgin wood

Wood chips are typically cut with relatively sharp knives to form chips with sharp edges. The fuel is typically used in grate and fluid bed combustion furnaces of varying sizes, varying from approx 100 kW<sub>th</sub> grate furnaces to several hundreds of MW<sub>th</sub> fluidised bed furnaces. In the Netherlands there are 4 relatively large combustion units burning wood chips, and several with smaller capacities. Bruins and Kwast is one of the companies that both produces and sells wood chips from virgin wood.

## 5.2 Critical Control Points within the supply of wood chips

The end user of a solid biofuel is dependant on reliable boiler technology as well as on reliable fuel quality in order to be satisfied with the combustion of solid biofuels. In Germany not necessarily a standard for wood chips is requested but a consistent and homogenous fuel quality. If at all a standard is regarded this is the Austrian standard for wood chips ÖNORM M 7133 as the pre-CEN/TS<sup>o</sup>14961 is rarely applied at the moment. Nevertheless the ÖNORM M 7133 serves more as an orientation than obligation in Germany. Other standards for wood chips exist in Sweden and Finland but aren't applied within Germany.

In general arrangements regarding the wood chips quality are made directly and verbally with the fuel producer. However the agreed fuel quality is often not delivered. Most of the problems refer to an unsuitable moisture content and dimension (amount of fines and/or coarse fraction too high) as well as impurities like sand, stones, plastics etc. If these three parameters differ from the quality required further problems with parameters like ash content, bulk density, amount of bark etc. result. This again causes difficulties during the combustion of wood chips concerning e.g. the feeding system, combustion chamber as well as flue gas emissions.

That's why special attention is directed to process steps resp. Critical Control Points (CCPs) at which impurities, moisture and dimensions of wood chips can be influenced. These are steps within the supply chain where the physical- mechanical and chemical properties of wood chips are influenced by transport and/or handling, storage and processing. Critical Control Points can therefore be regarded under two different aspects:

1. Handling of solid biofuel (e.g. piling, pre- and post treatment, storage)
2. Choice of technical devices like chipper, storage buildings, transport unit, sieves etc.

In the following table the CCPs referring to a single step/process within the fuel supply are named as well as the respective controls that have to be performed at the respective CCP.

**Table 3 Relevant Critical Control Points within the supply chain of wood chips**

step within the supply chain	process step	CCPs	checking of
supply of raw material	cutting of trees	X	kind of wood trunk / branch diameter condition impurities
	delivery of used wood	X	used wood class impurities condition
	forest haulage of trees	X	impurities
	pick-up / collecting of tree-cuts and short rotation wood	X	impurities
	pre-screening of used wood	X	condition of used wood used wood able to classify (A1 to A4) impurities
transport	transport to central place transport to next customer		
(temporary) storage	piling of trees at central place	X	moisture of wood moisture of environment loss of material storage according to piling instructions impurities
	storage of used wood on the producers premises	X	separate storage of different used wood classes correct sorting of used wood classes impurities moisture of wood moisture of environment

step within the supply chain	process step	CCPs	checking of
processing	pre-treatment of the material	X	amount of needles and leaves at branches impurities length of trunks /branches homogeneity of used wood classes
	chipping of raw material	X	selection of chipping technique (quality of chipper) settings of chipper
	post- treatment of wood chips	X	impurities amount of fines and coarse fraction moisture amount of bark
transport/handling	charging of the transportation unit	X	cleanliness of the transportation unit moisture particle size impurities amount of bark bulk density creation of dust
	transport to end- user transport to storage building transport to next customer		
(temporary) storage	filling of the storage building emptying of the storage	X	cleanliness of the storage room aeration of storage room moisture particle size impurities amount of bark bulk density creation of dust
delivery to end- user	charging of storage room	X	cleanliness of the storage room aeration of storage room moisture particle size impurities amount of bark bulk density creation of dust
	adding screw		moisture fines and coarse fraction impurities
	burning		temperature slagging ash content

### 5.2.1 Critical Control Points within the supply of wood chips from virgin wood (The Netherlands)

The most important fuel characteristics with the end user are dry matter, moisture, and ash content. The Dutch classification standard NTA 8003 describes the important parameters.

**Table 4 Relevant Critical Control Points within the supply chain of wood chips**

step within the supply chain	process step	CCPs	checking of
collection from forests/landscapes/road sides	reception at waste processing company	X	impurities (sand, leaves)

step within the supply chain	process step	CCPs	checking of
processing	chipping	X	particle size, impurities (sand, leaves)
transport		X	
fuel storage	raw material storage unprotected,	X	moisture content, impurities (sand, leaves)
	power plant storage under roof	X	
transport/fuel delivery	trucks (walking floor, containers), ship (bulk), train (containers)	X	checks of compliance with producers' product sheets, visual control of contaminants, random sampling and analysis of moisture, ash

## 6 Results of hog fuel from logging residues

### 6.1 Supply chain of hog fuel from logging residues

Hog fuel is produced from logging residues in connection with round wood harvesting. The harvester operator is responsible for piling up the logging residues and the forwarder takes care of the forest haulage of the residues. Logging residues are crushed by a truck-mounted crusher at the road side directly into the truck.

The truck driver transports the fuel to the end-user, takes samples for moisture content measurement and weighs the load. The end-user carries out the analysis of moisture content and informs the supplier of the results. Typical production volumes of the green maintenance companies in the Netherlands are over 10,000 tons per year.

The structure of a typical supply chain of hog fuel from logging residues is demonstrated within illustration 6.

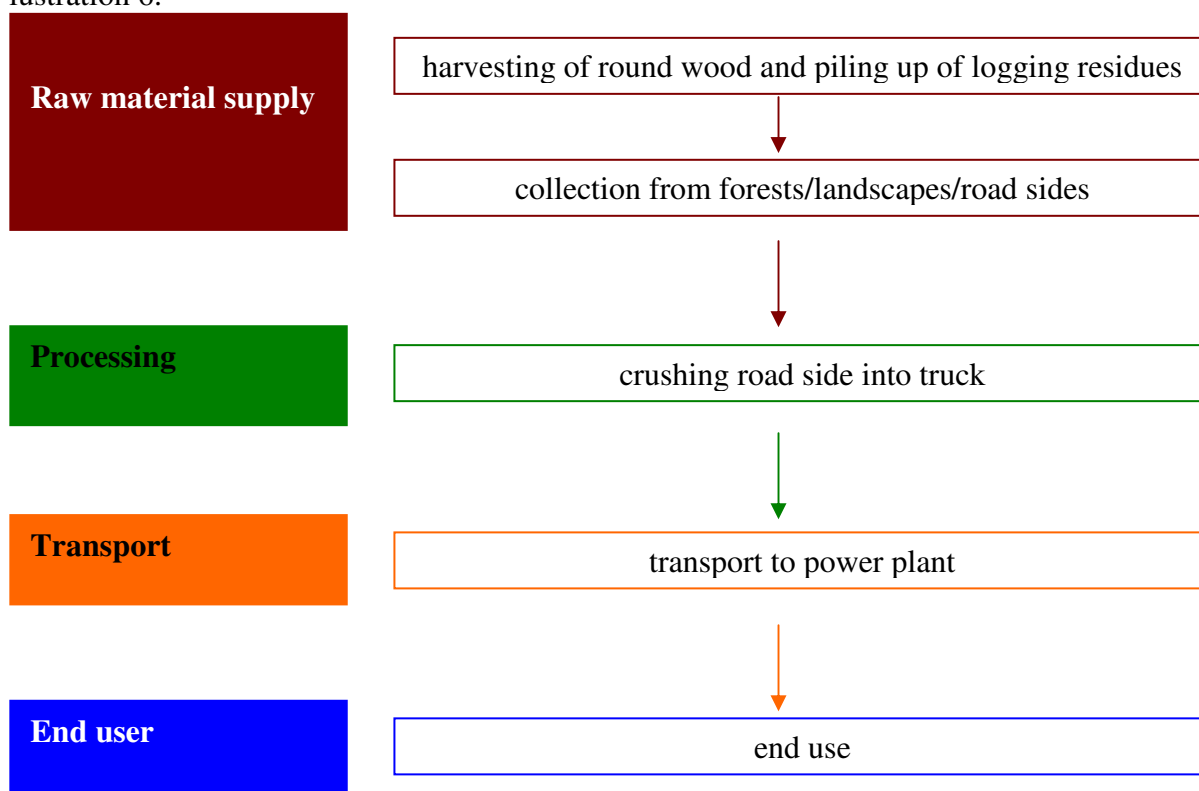


Illustration 6 Structure of the supply chain of hog fuel from logging residues

Logging residues are typically cut using a shredder. The fuel is typically used in somewhat larger grate and fluid bed combustion furnaces of sizes exceeding approx 5 MW<sub>th</sub>.

## 6.2 Critical Control Points within the supply of hog fuel from logging residues

The most important fuel characteristics with the end user are dry matter, moisture, and ash content. Annex B4 of CEN/TS 15234:2005 (E) describes the CCP's.

**Table 5 Relevant Critical Control Points within the supply chain of hog fuel**

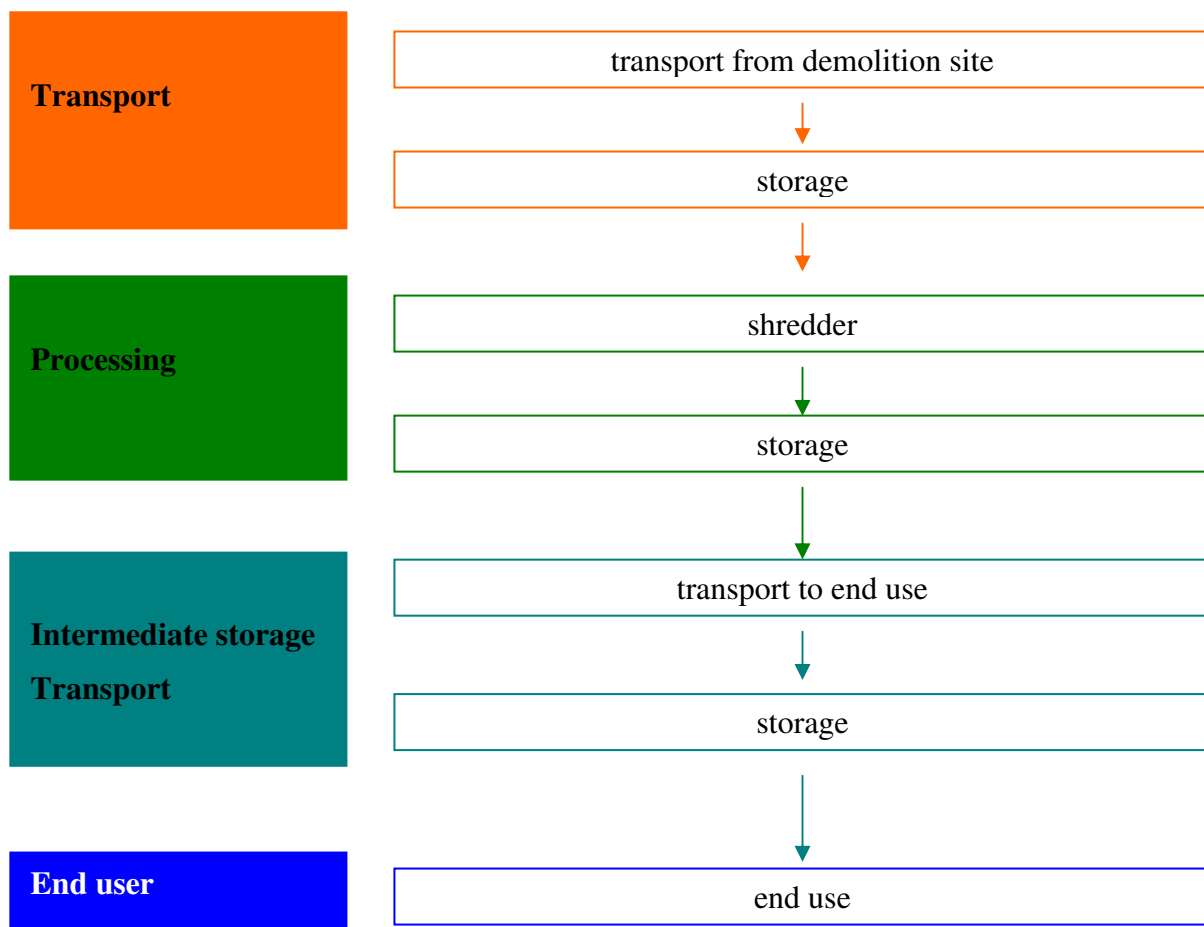
step within the supply chain	process step	CCPs	checking of
supply of raw material	piling of logging residues in a heap in the stand	X	impurities (sand, leaves)
transport	forest haulage of logging residues	X	particle size, impurities (sand, leaves)
fuel storage	storage of logging residues at the road side	X	ground conditions, weather conditions
processing	crushing of logging residues	X	moisture content, impurities (sand, leaves)
transport	transport to the plant	X	checks of compliance with producers' product sheets, visual control of contaminants, random sampling and analysis of moisture, ash

## 7 Results of hog fuel from waste wood

### 7.1 Supply chain of hog fuel from waste wood

Hog fuel from used wood becomes available with waste recycling companies as a by-product from building demolition activities. Typical production volumes of the waste recycling companies in the Netherlands are over 10,000 tons per year.

The structure of a typical supply chain of hog fuel produced from waste wood is demonstrated within illustration 7.



**Illustration 7** Structure of the supply chain of hog fuel from waste wood

In contrast to wood chips that are typically cut with relatively sharp knives, hog fuel is typically cut with relatively blunt tools using a shredder. The fuel is used in both dedicated small boilers and larger multifuel combustion furnaces, varying from approx 5 MW<sub>th</sub> grate furnaces to approx 80 MW<sub>th</sub> grate, fluidised bed and cofiring facilities. In the Netherlands there are currently 8 units that burn hog fuel from waste wood. Bruins and Kwast is one of the waste processing companies that both collects and burns hog fuel from waste wood for energy production.

### 7.2 Critical Control Points within the supply of hog fuel from waste wood

The most important fuel characteristics with the end user are particle size, moisture content, ash content, nitrogen content (due to NO<sub>x</sub> formation) and concentrations of contaminants. The Dutch classification standard NTA 8003 describes the important parameters.

**Table 6** Relevant Critical Control Points within the supply chain of hog fuel from waste wood

step within the supply chain	process step	CCPs	checking of
transport from demolition site	reception at waste processing company	X	visual control of contaminants, random sampling and analysis of moisture, ash
processing	shredder	X	particle size
fuel storage	raw material storage unprotected,	X	
	power plant storage under roof	X	
transport/fuel delivery	trucks (walking floor, containers), ship (bulk), train (containers)	X	checks of compliance with producers' product sheets, visual control of contaminants, random sampling and analysis of moisture, ash

## 8 Results of olive residues

### 8.1 Supply chain of olive residues

The first harvest of olives is possible about seven years after the planting of olive trees and takes place in Spain between mid-October and mid-March. 75 percent of the harvested olives transform into waste material (kernels, leaves, brunches etc.) after the oil-production and can be used as fuel.

The global acreage of olive trees is about 8,6 millions ha and the amount of the global harvested olives is about 17,3 millions tons/a. The annual output in Spain is about 4,5 millions tons of olives and the market in Spain is still growing.

Although in Spain no kind of standards or laws for olive residues combustion yet exists, olive residues are used as fuel for many years. The combustion takes place in small units (2-4 t fuel/a) as well as in large heating plants (>100.000 t fuel/a).

The smaller a combustion unit is, the better the fuel quality should be. In Spain the end user differs between olive kernels and olive residues. Olive residues contain skin, pulp and kernels.

Olive kernels can be combusted e.g. in adapted combustion units for wood chips but the olive residues can just be combusted in large power plants (higher ash-content, higher potassium content etc.). There are no standards, labels, guidelines or certificates for olive-fuels in Spain but the end users know by experience about the most important quality criterions to avoid combustion problems; the moisture content and the pureness of kernels (no skin or pulp)

Too high content of moisture can cause problems during the combustion, so usually the end user is storing the fuel after the heating period for the next period and the fuel can dry during the summer time. If an end user needs fuel immediately, the fuel can be wet, because of the missing drying time. Additionally fuel can get wet because of fuel storage outside or transport in open trucks uncared of the weather.

For a short time it is difficult for small scale users to get olive kernels with high fuel quality, because of a new competition: pellets producer start to produce pellets out of olive residues.

The structure of a typical olive residues supply chain is demonstrated within illustration 9.

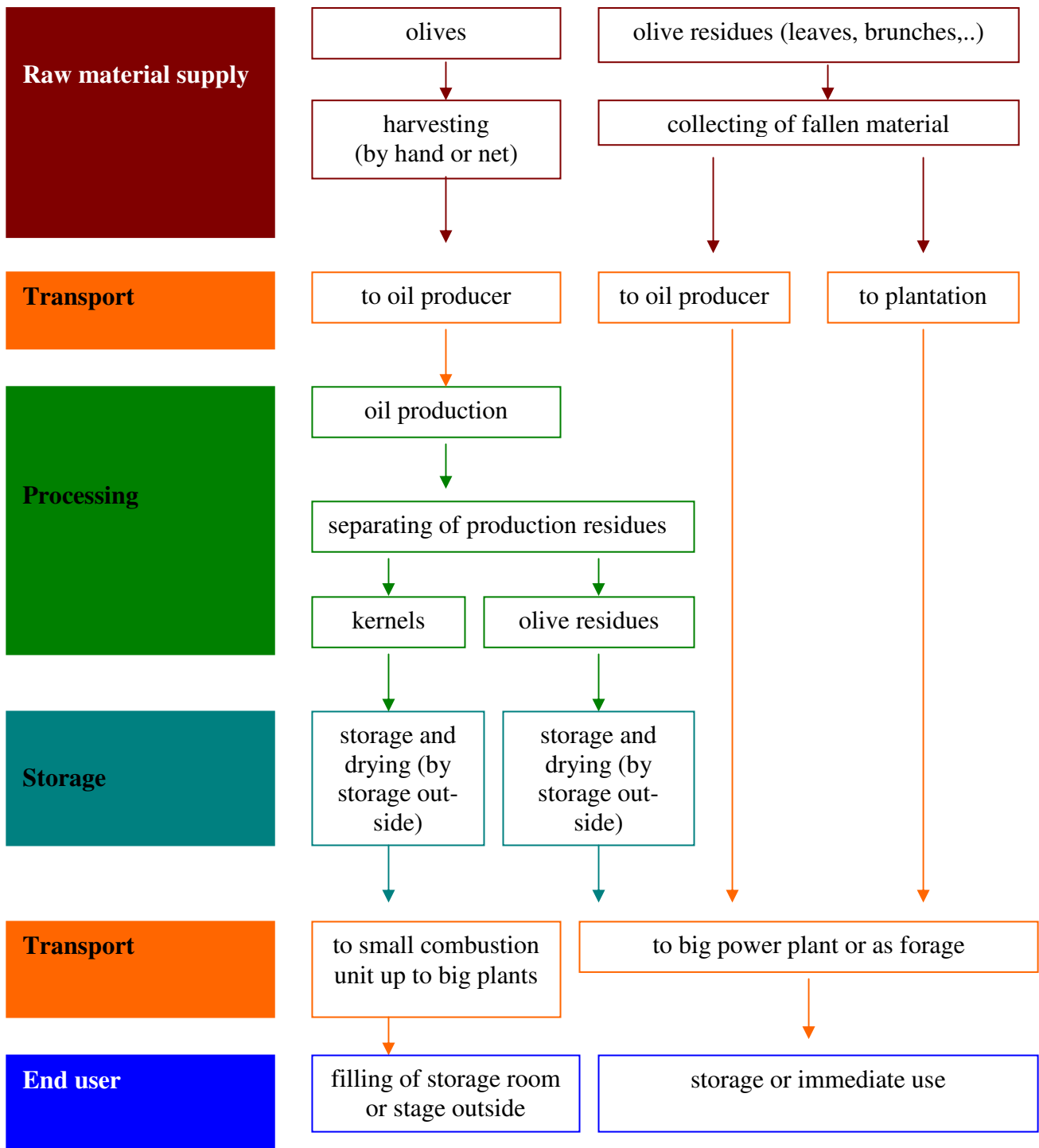


Illustration 8 Structure of the supply chain of olive residues

### 8.2 Critical Control Points within the supply of olive residues

The difference between olive residues and olive kernels is very important and the following CCPs were determined for olive kernels, because it is the most common form of olive-fuel. The most important CCPs are the storage of olive kernels, because the storage is normally not roofed and not concreted. The contamination of the fuel by earth or sand is possible because of the storage conditions and can cause problems like slagging during the combustion. The second very important CCP is the pureness of the fuel. Any kind of impurity with other olive residues has an effect on the ash content, the potassium content and other fuel parameter.

The moisture content is also a very important fuel parameter, because olive residues have up to 40% water content and small scale units can't guarantee an efficient combustion with such a wet fuel.

**Table 7 Relevant Critical Control Points within the supply chain of olive kernels**

step within the supply chain	process step	CCPs	checking of
raw material supply	harvesting	X	impurities
transport	loading	X	truck: impurities truck: old load
	transport usually in open trucks	X	impurities
storage	storage outside	X	impurities
processing	oil production		
	separation of production residues	X	pureness of kernels
	storage outside	X	moisture aging impurities pureness of kernels
storage/conditioning	drying (usually outside)	X	moisture aging impurities
transport	loading	X	truck: impurities truck: moisture truck: old load
	transport usually in open trucks	X	impurities moisture
end- user	charging (filling) of storage room	X	material inside moisture fines
	conveyor screw		moisture fines
	burning		temperature slagging ash content

## 9 Results of straw

### 9.1 Supply chain of straw

The description of the supply chain gives an overview about the single steps of straw production and straw use for big bales used in CHP and power plants.

The structure of a typical straw supply chain is compiled in illustration 10.

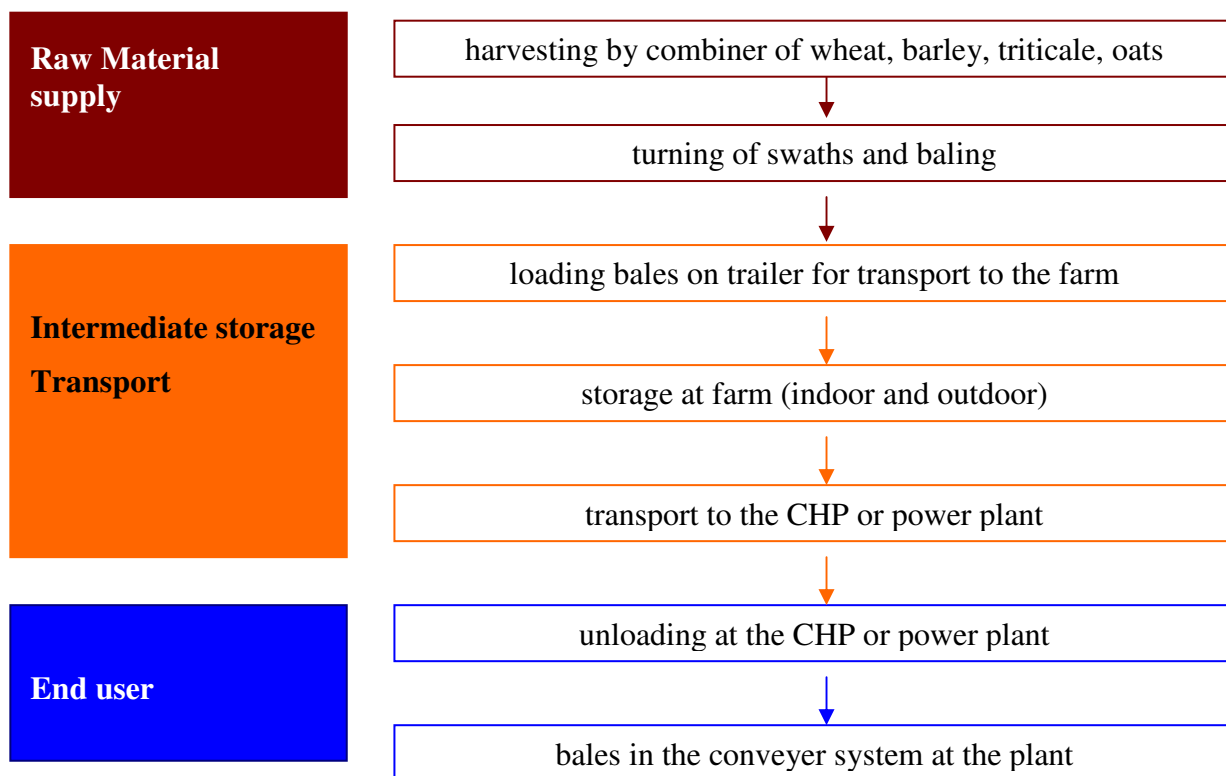


Illustration 9 Structure of the supply chain of straw

### 9.2 Critical Control Points within the supply of straw

Large-scale straw handling for energy purposes has in Denmark developed into an independent discipline in agriculture in which particularly large farms and machine pools make investments. The big bale 120x130x240 cm is the only type accepted by the district heating, CHP and power plants. The weight is around 500 kg, and new balers can make bales up to 700 kg. 1 million tons is used every year in power plants, CHP plants and District Heating plants. No standards are used, but the conditions for delivery, moisture, weight and dimensions are carefully described in the contracts between the farmers and the end users. The chosen points are typical CCPs as these points are the “points of no return” if a high straw quality shall be maintained.

**Table 8** Relevant Critical Control Points within the supply chain of straw

step within the supply chain	process step	CCPs	checking of
harvesting of wheat, barley, triticale, oats	harvest with combiner		kind of straw type, moisture
turning of swaths and baling	producing straw bales	X	moisture impurities fungi and mould dimensions
loading bales in the field	bales on trailer for transport to the farm		moisture impurities fungi and mould
storing at the farm	indoor storing	X	moisture fire risk
	outdoor storing	X	tarpaulin cover by outdoor storing
transport to the CHP or power plant	tractor with front and loader loads 24 bales at a truck. The straw is covered with net to prevent loss in streets	X	moisture impurities fungi and mould
unloading at the CHP or power plant	a crane on the plant is equipped with grip hooks that can lift 12 bales (one layer) at a time off the truck. By means of microwaves that are sent through the bales from one grip hook to the other one, and by means of a weighing cell between grip hooks and crane, the average water content and the weight are being measured and recorded by a computer.	X	moisture weight fungi and mould dimensions fire risk
bales in the conveyer system at the plant	crane puts the bales on the conveyer belt		
	the strings are automatically removed.		removal of strings
	straw cutter (scarifying) hammer mill screw conveyer to the boiler		knives impurities (stones, iron) fire risk

## 10 Summary

To ensure and guarantee a homogenous biofuel quality it is necessary to establish a Quality Management System within the fuel supply chain. At the beginning the quality influencing factors within the single process steps have to be found and the Critical Control Points have to be defined.

CCPs are borderlines within or between processes where the greatest potential for interventions in processes exists and relevant properties like fuel specification can be most easily assessed.

During the collection of data it was important to analyse each biofuel separately due to their specific characteristics regarding market use and experience on the one hand as well as biofuel properties and supply chain structure on the other hand. All analysed fuels are very common but with different provenance, history, processing and standards, nevertheless there are some identical Critical Control Points for all fuels.

Contamination of fuels is a very usual quality influencing factor. These impurities can be earth from not concreted outdoor storage places or contamination of fuel during harvesting, charging and transport. The reasons for contamination can be very different, but the effects during the use of these fuels are usually the same. Impurities are normally mineral compositions and influence predominantly the fuel parameters ash content and ash melting behaviour.

Another quality influencing factor which is similar for all evaluated fuels is the moisture content. The size of the end user (small scale user or power plant) is not that relevant, because each type of combustion has a limit for moisture content. Some power plants may use fuels up to about 60% moisture and some small boilers may be limited by up to about 10% moisture. The control of the moisture content is needed for both combustion dimensions. Furthermore the moisture content is the most changeable parameter, because it varies already with the variation of air moisture, and within each supply chain process steps exist where the fuels are exposed to the weather.

Beside of the similar CCPs there are also some special and fuel specific CCPs like packaging or pressing aids. These differences are results of the very different process steps and end user requirements for each fuel.

The evaluation of the CCPs is an essential step to define the appropriate test methods and draw a guideline “Procedure for quality planning”.

## 11 Literature

- [1] preCEN/TS 15234 Solid Biofuels – Fuel Quality Assurance, CEN/TC 335, WG2, 2005
- [2] preCEN/TR 15569 Solid Biofuels – A Guide for a Quality Assurance System, CEN/TC 335, WG2, 2006
- [3] DIN*plus* Standard
- [4] ÖNORM M 7133 Chipped wood for energetic purposes- Requirements and test specifications
- [5] ÖNORM M 7135 Compressed wood or compressed bark in natural state-Pellets and briquettes- Requirements and test specification
- [6] preCEN/TS14961 Solid Biofuels – Fuel specifications and classes
- [7] NTA 8003 Standards and classes