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Pre-normative research on solid biofuels for improved European standards

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PRIORITY [6-1] – Sustainable energy systems

Task IV.1 – Supply chain based properties, Task 1

Feedback on prEN 14961 standards from industry and workshops

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Preface

The BioNorm II project consortium is a team of 25 experienced partners from 11 European countries (many partners are also active members of TC 335) and the Institute for Energy and Environment (IE) is the coordinator of this project that runs 3 years (2007 – 2009). Within the project framework 4 work packages (WP I - IV) exist in which fuel characteristics of solid biofuels and methods to test and verify them are developed:

- WP I: Sampling, sample reduction and planning
- WP II: Chemical and physical testing procedures
- WP III: Quality measures
- WP IV: Specifications of solid biofuels

The WP IV is co-ordinated by VTT and other partners are FJ-BLT, RTU, USTUTT and CERT/ISFTA.

In WP IV the total work is concentrated on the support of the European standardisation Committee by defining fuel specifications and classes of the most traded solid biofuels. Thus supply chain related fuel properties as well as combustion and fuel handling related fuel properties have to be analysed and determined for each specific biofuel (e. g. wood chips, pellets, briquettes etc.). This pre-normative work is continuation of the results of the first BioNorm project.

This report is summary of the company interviews carried out during 2007 and beginning of the year 2008.

Jyväskylä, April 2008

Eija Alakangas, Task leader

List of Abbreviations

P	Particle size of fuel, D and L, mm
D	Diameter, mm
L	Length, mm
M	M_{ar} =Moisture content, ar = as received, w-%
A	ash content, dry basis, w-%
$q_{,net, d}$	Net calorific value, dry basis
Q	$q_{,net, ar}$ =Net calorific value, as received, MJ/kg or kWh/kg (1 kWh/kg = 3.6 MJ/kg) used in prEN 14961 quality tables
BD	Bulk density or bale density, kg/m^3
DU	Mechanical durability of pellets, w-%
E_{ar}	Energy density, kWh/m^3
F	Fines, (< 3,15 mm), w-%
S	Sulphur, dry basis, w-%
N	Nitrogen, dry basis, w-%
Cl	Chlorine, dry basis, w-%

1 Introduction

The technical specification: Solid biofuels – Fuel specification and classes (CEN/TS 14961) was published in year 2005 and now it will be upgraded to the first full European Norm (EN) for solid biofuels in 2008. Therefore the collection of feedback from the practice, scientific institutions and other BioNorm II partners to the draft standard, its evaluation and harmonisation was the main task of WP IV. The encouraged work finished in a new draft of the prEN 14961 with the integration of more detailed specifications and for further solid biofuels. Furthermore, some modifications of existing thresholds were needed but also the extension of the prEN 14961 to multi-part standard, in which concrete fuel quality requirements for different solid biofuel products used in small-scale can be seen as a result of the feedback analysis of companies and several associations and in collaboration with the CEN/TC 335 WG 2. Also combustion tests with small-scale boilers (< 50 kW) by using the most traded solid biomass fuels (pellets, briquettes, wood logs, wood chips and olive residues). The work will also benefit the upgrading of CEN/TC 335 standards to ISO standards.

The objectives of the WP IV are:

- To clarify the specification of solid biofuels to support the upgrading of the CEN/TS 14961 (and CEN/TS 15234) to EN-standard.
- To guarantee by measurements, interviews and reviewing data the suitability of different biomass fuels for domestic consumers
- To clarify properties of biomass fuels for different supply chains
- To draft basics for conformity rules for solid biofuels

The aim of the Task IV.1 is it to define the fuel properties according by supply chain. This has to be realised based on the work already carried out within the "Fuel specification and classes" technical specification (CEN/TS 14961).

Therefore among others the following questions have to be addressed:

- Are the fuel properties defined already within the "fuel specification and classes" standard needed?
- Are additional properties needed?
- Are fewer properties needed?
- Are the classes and their variations (i.e. property width) for the different important properties defined within the existing "fuel specification and classes" technical specification justified?
- Which fractions or blends of used wood need more detailed specifications and limitations, e.g. impurities, chemical composition that they can be safely used in different type of combustion units?
- If not: How could they be arranged to meet the need of industry and consumers in a better way?

Descriptions of companies participating in the BioNormII task IV.1 are listed in the Table 1. Comments were also collected from different associations: Österreichischer Kachelofenverband" (Austrian tiled stove association), Finnish Pellet Energy Association, the European Fireplace Association, the German Energy Pellet Association, HKI which represents the interests of the producers of domestic heating and cooking appliances (more than 70 manufacturers of domestic heating and cooking appliances), BDH represents the interest of 69 companies from the sector of building services engineering with focus on heating engineering, association of the German sawmill industry, German Chimney Sweeper Association, association for trade and production of firewood with around 80 members from economy and politics and Institute for firewood technology with focus on drying and moisture determination of firewood.

Table 1. Description of the companies involved in the case studies.

Company code	Traded forms of solid biofuels	Size of company (number of employers, turnover etc.)	Annual production of solid biofuels (amount/unit)
A	Olive residue cakes	5 million €, 10 permanent staff + 2-4 employees for harvesting time	5 000 tons
B	Wood chips from landscape management woody biomass, waste wood, stem wood, logging residues, bark, by-products and residues from wood processing industries	Turnover n/a, 60 employees	300 000 bulk m³
C	Wood chips and hog fuel from logging residue and stumps, agrobiomass bales, pellets, sawdust, bark, cutter chips	Turnover 660 Million €, 1 828 employees	4.2 TWh wood fuels for power plants and heating plants and raw material for pellets. Pellet production 550 000 tonnes and total trading 612 000 tons. Agrobiomass is grown on 14 000 hectares and 42 GWh delivered.
D	Wood pellets produced from different types of sawdust supplied by wood processing industries (fir, poplar, pine and small quantities of beech).	8 employees	12 000 tonnes
E	Wood chips or hog fuel from logging residue chips, stem wood, stumps, sawdust, bark, cutter chips, used wood, retailer of pellets and briquettes	Turnover for whole company 555 Million €, 9 500 employees	Subsidiary process 5 TWh wood fuels (6 million loose m^3)
F	Wood pellet and briquette producer from sawmill residues (spruce)	1 500 employees	120 000 tonnes
G	Wood briquettes chemically untreated wood with and without bark	1.4 million €, 22 employees	1 800 tonnes
H	Wood chips from small coniferous trees and logging residues	350 wood chips producers (farmers)	12 000 – 15 000 bulk m^3 of year to 12 heating plants
I	Wood pellets without additives and from chemically untreated wood residues	2.8 million EUR, 60 employees	30 000 tonnes
J	Wood briquettes from chemically untreated production residues	Turnover n/a, 200 employees	1 800 tons

Feedback to general classification of prEN14961

1.1 General classification

The following solid biofuels are included in the prEN 14961:

- products from agriculture and forestry,
- vegetable waste from agriculture and forestry,
- vegetable waste from the food processing industry,
- wood waste, with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating, and which includes in particular such wood waste originated from construction and demolition waste
- fibrous vegetable waste from virgin pulp production and from production of paper from pulp, and
- cork waste.

For the avoidance of doubt, demolition wood is not included in the scope. Demolition wood is "used wood arising from demolition of buildings or civil engineering installations" (prEN 14588).

The classification of solid biofuels is based on their origin and source (Table 1 in prEN14961). The fuel production chain shall be unambiguously traceable back over the whole supply chain. The solid biofuels are divided to the following sub-categories for classification:

- Woody biomass
- Herbaceous biomass
- Fruit biomass
- Blends and mixtures

The quality classification in the table form was prepared only for the most important commercial biofuels (=traded form) like briquettes, pellets, wood chips, hog fuel, wood logs, sawdust, bark, cutter chips, straw bales, energy grain and fruit seed. Additionally, a general table was compiled for other biofuels.

The quality classification for briquettes and pellets comprises those produced from wood and also from other biomass materials. Both small-scale and large-scale consumers are considered in the quality classification. The classification is flexible, and hence the producer or the consumer may select from each property class the classification that corresponds to the produced or desired fuel quality. This so-called "free classification" does not bind different characteristics with each other. An advantage of this classification is that the producer and the consumer may agree upon characteristics case-by-case.

The most significant characteristics are decisive, normative, and shall be given in the fuel specification. These characteristics vary for different traded form, while the most significant characteristics for all biofuels are moisture content (M), particle size/dimensions (P or D/L) and ash content (A). For example, the average moisture content of fuels is given as a value after the symbol (e.g. M20), which means that the average moisture content of the fuel shall be ≤20 w-%. Some characteristics, e.g., bulk density, are voluntary, informative. The nitrogen content and chlorine content is normative only for chemically treated biomass. Chemical treatment is defined as any treatment except air, water and heat. It is not necessary to measure characteristics, but typical values of different fuels concerned may be used. These are given in an informative Annex B in prEN14961.

The prEN14961 – Part 1 includes also wood waste, if it not containing halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating. One aim of the project was clarify which fractions of wood waste can be defined as solid biofuel. VTT has collected together with partners and some company's information on different type of wood waste. The classification of the used wood and chemically treated biomass should be divided to different sub-classes e.g. A, B, C and D. This kind of classification is used in German, Austria and the Netherlands. VTT has made a report of the different classifications systems for used wood (Wiik et al, 2008) and made a proposal for classification for chemically treated wood industry by-products and residues and used wood. The company E will start testing this classification in their used wood business.

The proposal for the classification is presented in the App. 1. Figure 1 clarifies the classification. Wood waste in classes A and B is solid biofuel as defined, with given restrictions (do not contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating). Wood waste in class C falls under the Waste Incineration Directive (WID) 2000/76/EC, and is solid recovered fuel. Wood waste in class D includes preservatives and shall be disposed according to the Hazardous Waste Incineration Directive (94/67/EC).

Wood waste under solid biomass fuels (prEN 14961-Part 1):

Class A (natural wood, only mechanically treated)

- Chemically untreated by-products or residues from forest and wood processing industry (1.2.1)
- Chemically untreated used wood (1.3.1)

Class B (Coated, lacquered or otherwise chemically treated and coating does not contain halogenated organic compounds (for example PVC) and preservatives, no demolition wood)

- Chemically treated by-products and residues from forest and wood processing industry (1.2.2)
- Chemically treated used wood (1.3.2)

Company E is proposing that used wood classified in classes B and C should be incinerated in plants with boiler capacity of 50 MW_{th} or more. Company E is also proposing that used wood classified in C the compounds listed in Table 1 should be analysed.

Table 2. Analysis of compounds, if used wood is classified as used wood - Class C.

Compound	**Method to be used**
Chlorine, Cl	CEN/TS 15289
Arsenic, As	SFS-EN ISO 15586
Cadmium, Cd	SFS-EN ISO 15586
Chromium, Cr	SFS-EN ISO 11885
Copper, Cu	SFS-EN ISO 11885
Mercury, Hg	SFS-EN 1483
Lead, Pb	SFS-EN ISO 15586
Vanadium, V	SFS-EN ISO 15586
Zinc, Zn	SFS-EN ISO 11885

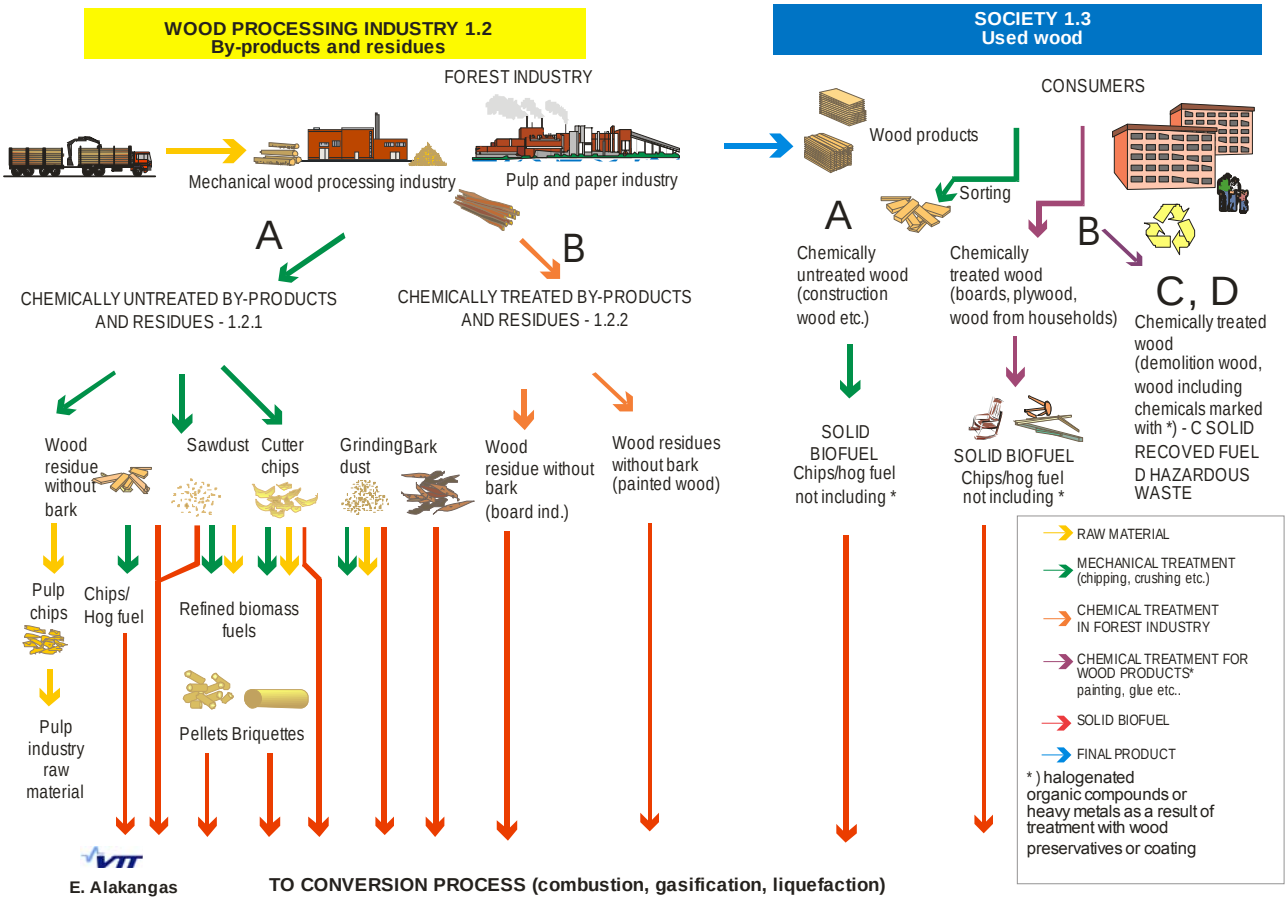


Figure 1. Proposal for the classification of chemically treated wood industry by-products and residues and used wood.

1.2 Feedback to classification table

Question: Is woody biomass from private households and other non-public maintenance processes (e.g. residues from trimming of trees, bushes and hedges that are collected at municipal recycling centres) included under landscape management woody biomass in Table 1 of prEN 14961-1? A common definition of landscape management woody biomass is woody biomass originating from the maintenance of public parks and gardens only.

Proposal: Definition of landscape management woody biomass and, if necessary, additional class for woody biomass from private households and other non-public maintenance processes in prEN 14961-1.

Question: Class 1.1 in table 1 of prEN 14961-1 is labelled “forest and plantation wood”. Isn’t this labelling insufficient with regard to class 1.1.7 “landscape management woody biomass”? Can landscape management woody biomass necessarily be classified as forest and plantation wood? Moreover, landscape management woody biomass (including woody biomass from private households and other non-public maintenance processes collected at municipal recycling centres) is one of the most important sources for company B. However, the significance of this source is not represented by the labelling of class 1.1.

Proposal: The labelling of class 1.1 in table 1 of prEN 14961-1 should be completed at least by the term “landscape management woody biomass”.

Question: Why is there no class 1.1.8 “Blends and mixtures” in table 1 of prEN 14961-1 as under each sub-class (1.1.x.5)? Class 1.4 implies blends and mixtures of all kind of woody biomass

including wood processing industry by-products and residues as well as used wood. Company B mainly blends different forest woods and landscape management woody biomass, i.e. only biomass from class 1.1.

Proposal: Add class 1.1.8 "Blends and mixtures" in Table 1 of prEN 14961-1. Furthermore, blends should be clearly stated according to the classification of origin and sources (e.g. 75 % 1.1.7 / 25 % 1.1.3).

2 Feedback to different traded forms

2.1 Briquettes

At the moment there are around 10 active wood briquettes producers in Latvia. Brief introduction about the wood briquettes production typical for Latvian wood briquettes producers is given below:

- Briquettes are made from conifer and from foliage tree. There is one company who makes briquettes from alder.
- There is cooperation between briquette producers and mill, and also with suppliers, who carry raw material from mills to production Company.
- There are requirements for raw material suppliers to chose best raw material are used visual characters and experience.
- Trading principles are tones.
- Products are distributed to local market and also abroad.
- All requirements depend from clients. Most of the clients come from Scandinavian countries therefore the Scandinavian standards are used for quality definition.
- Companies distribute their production by themselves.
- Most of production is exported.

Company G states that most of the dimensions listed in prEN 14961 to classify quality of the briquettes, are not important. Only density is important and depends on technique, which is used in briquetting. They report that informative properties should be stated as normative except chlorine, because it is not important and amount of it is negligible. There is needed only one parameter for dimensions D80 and L200; they do not produce briquettes with other sizes. There should not be parameter M15 and M20 for moisture. Parameter could be M07 where moisture content is less then 7% because that is moisture content in their production. Ash content in briquettes is 1% so parameter A3.0, A6.0, A10.0 is unnecessary for their products.

Table 3. Properties of briquettes for company G.

Property	Actual value	Property class according to prEN-14961-3
Dimensions	D ≤70 mm, L ≤150-180 mm	D80, L200
Moisture	M ≤ 7%	M10
Ash	A ≤ 1%	A1.5
Sulphur	-	-
Additives	not used	no additives used
Nitrogen	-	-

Company J produces wood briquettes from residues, which arises from the production of glued wood. The glued wood production comprises the production of wooden beams and their glue junction to formwork girders for timber constructions.

The residues are made up to 99 % of chemically untreated spruce wood and result from different production steps. The production process of wood briquettes is schematically described in Figure 2.

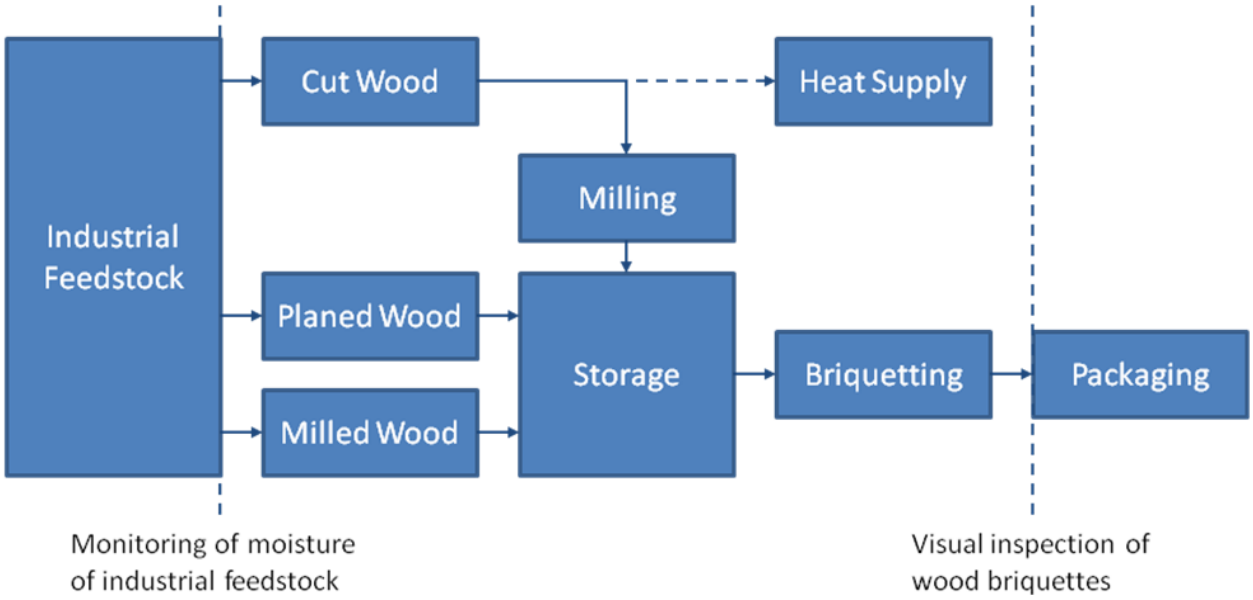


Figure 2. Production scheme for wood briquettes, company J.

The residues can be classified as follows:

- Cut wood
- Planed wood
- Milled wood

Planed and milled wood are directly collected in storage silos for the use in the briquetting system whereas cut wood can optionally be used in the company-owned heat supply station. If cut wood is used for the production of briquettes, it is further processed in a hammer mill and stored in another silo. For the briquetting system, a compactor with a forming pressure of 300 bars is used.

The quality of the produced wood briquettes is controlled by visual inspections. Furthermore, the moisture of the raw material for the production of glued wood and, hence, for the production of wood briquettes is regularly monitored since it may not exceed 13w-%. Briquettes are collected either in pallet cages for the further packaging in plastic bags at 15 kg or in big bags at 450 kg as shown in Figure 3.


Figure 3. Wood briquettes plastic bags and in big bags for company J.

In Table 3, the main properties of the wood briquettes from production residues according to Table 4 of prEN 14961-1 are listed.

Table 4. Properties of wood briquettes from production residues, company J.

Property	**Mean values**	**Property class according to table 5 of prEN 14961-1**
Origin	residues of chemically untreated spruce wood	1.2.1.1
Dimensions, D and L	160 mm cross cut and 200 mm length	D125+ L200
Moisture, M	9.5 w-% as received	M10
Ash, A	0.22 w-% of dry basis	A0.5
Net calorific value, Q	17.52 MJ/kg as received	Q16.5
Particle density, DE	minimum 1.0 kg/dm³	DE1.0

The above properties are in line with the requirements for briquette quality A as determined in Table 1 of prEN 14961-3.

Question: Shouldn't the property classes for particle density DE in table 3 of prEN 14961-1 be defined as "≥" instead of "≤" (compare with table 1 of prEN 14961-3)? If you have a particle density of DE1.0, than you should expect having at least a particle density of 1.0 kg/dm³, i.e. 1.0 kg/dm³ or better and higher, respectively.

Proposal: Replace "≤" by "≥" in the definitions of the property classes for particle density DE in Table 3 of prEN 14961-1.

Question: What is meant with "A" and "B" in table 1 of prEN 14961-3? Only a closer look at the whole table reveals different briquette qualities and which of them is the better one.

Proposal: Choose more meaningful names for the different briquette qualities in table 1 of prEN 14961-3, e.g. "premium" and "standard" instead of "A" and "B", so that you can differentiate on the first view.

Comment: Disarrangement/mistakes in property classes for net calorific value Q (double entries) in Table 3 of prEN 14961-1. Furthermore, Table 1 of prEN 14961-3 states a net calorific value of Q16.5, which is missing in Table 3 of prEN 14961-1

Comment: Mistake concerning the maximum amount of additives, either in footnote b to Table 3 of prEN 14961-1 (20 w-%) or in footnote a to table 1 of prEN 14961-3 (2.0 w-%).

Figure 4. Wood briquette produced by Company J.

The Austrian standardization committee ON-K 241: Solid Biofuels has prepared drafts for wood pellets, wood-bark pellets and briquettes in the course of a revision of the national standard for biofuels ÖNORM M7135. Furthermore the experts tried to adapt the central information of the fuel specifications and classes for solid biofuels prEN 14961-Part 1 (Table 5).

Table 5. Proposal for wood briquette product standard (prEN 14961-Part 3) from Austrian experts.

	Origin: According to CEN/TS 14961, Table 1		1.2.1.1
	Traded form: According to CEN/TS 14961, Table 2		Briquettes
Normative	**Parameter**	**Category according to CEN/TS 14961**	**Threshold value**
	Diameter, mm	d50, D60, D80,D100,D125	40 ≤ D ≤ 125 mm
	Length, mm	L50, L100, L200,L300,L400	≤ 400 mm
	Moisture[2]	M10	≤ 10 %
	Ash[3]	A0.5	≤ 0,5 %
	Net calorific value as dry basis [3]	Q18	≥ 18,0 MJ/kg
	Particle density	DE 1,0	≥ 1,0 kg/dm^3
	Sulphur[3]	S0.02	≤0,02 %
	Nitrogen[3]	N0.2	≤ 0,2%
	Chlorine[3]	Cl0.01	≤ 0.01 %
	Additives[3,4]	-	< 2.0 %
	Chromium[5]	Cr	≤ 8
	Copper[5]	Cu	≤ 5
	Arsenic[5]	Ar	≤ 0,4
	Cadmium[5]	Cd	≤ 0,5
	Lead[5]	Pb	≤ 5
	Zinc[5]	Zn	≤ 50
	Mercury[5]	Hg	≤ 0,05
	[1]Minimum 95% per weight [2]w-% as received [3]w-% of dry basis [4]Type and amount to be stated [5]mg/kg dry basis		

2.2 Pellets

VTT organised on 15 November 2007 a workshop together with Finnish Pellet Energy Association on pellets standards. The participants were pellet producers (e.g. Company C) and equipment manufacturers or retailers. Some of the companies were international companies. In this workshop the proposal of the pellet product standard (prEN14961-1) was discussed and the proposal for product standards based on the discussions is presented in Table 7. Also existing international standard (SS, ÖNORM, DIN and Italian standard) were presented and discussed. The main conclusions from the workshop are following:

1. Raw material is mainly chemically untreated wood from wood processing industry, but in the future there will be shortage of this raw material and also small amounts of grinding dust from furniture, floor or other industry will be used. It is proposed that at least 97w-% of raw material should be chemically untreated, in order to be stated as chemically untreated material. This figure is based on the accuracy of the measurement.
2. Maximum length of the pellets; for pneumatic conveyors especially in pellet stoves the maximum length should not exceed 40 mm.
3. Size of fine particles; according the durability standard for pellets the fine particles are defined particle smaller than 3,15 mm. In the pellets particle size the minimum length is 5 mm. should we define fine particle less than 5 mm instead of 3,15 mm?
4. The durability of pellets in class A; This class is mainly targeted for stoves (packaged) pellets, and then it would be easier to ignite the pellets, if they are softer (mechanical durability DU96.5).
5. Additional properties; e.g. heavy metals and ash melting behaviour. For clean woody biomass heavy metal content is not a problem, for chemically treated biomass the nitrogen and chlorine content should be normative.

Table 6. Specification of wood pellets, company C

Property classes	Results	Property class according to pr EN 14961-2 wood pellets for domestic consumers table 1
Origin	Spruce wood (saw mill)	1.2.1.1 (without bark)
Dimension (D and L)	D 8 mm, L 5 – 40 mm	D08
Moisture M	8.7 %	M10
Ash, A	0,3 (815°C),	A0.5
Net calorific value (dry basis) as received	18.96 MJ/kg 17.1 MJ/kg 4.75 kWh/kg	Q16.5
Bulk density	620 kg/m³	BD600
Additives	0.4 w-% natural starch	0.4%w-% natural starch
Sulphur, S	<0.02	S0.02
Nitrogen, N	0.15	N0.15
Fines, w-%	0.09 w-%	F1.0

Table 7. Wood pellets for domestic use, proposal from the workshop

	Property	**A (package)**	**B (package/bulk)**	**C (package/bulk)**
Normative	Origin and source	1.2.1.1 and 1.2.2.1(without bark)	1.2.1.1 and 1.2.2.1 (without bark)	1.2.1.1, 1.2.1.2 and 1.2.2.1
	Diameter, D and length L [a)], mm	D6 ± 1,0 mm; L 5 - 40mm D8 ± 1,0 mm; L 5 - 40mm	D6 ± 1,0 mm; L 5 - 40mm D8 ± 1,0 mm; L 5 - 40mm	D6 ± 1,0 mm; L 5 - 40mm D8 ± 1,0 mm; L 5 - 40mm
	Moisture, M (w-%)	M10 ≤ 10 %	M10 ≤ 10 %	M10 ≤ 10 %
	Ash, A, (w-% dry basis)	A0.5 ≤ 0.5 %	A0.5 ≤ 0.5 %	A1.0 ≤ 1.0 %
	Mechanical durability, DU (w-% after testing)	DU96.5 ≥ 96,5 %	DU97.5 ≥ 97,5 %	DU95.0 ≥ 95,0 %
	Amount of fines at factory gate [b)], F (w-%,)	F1.0 ≤ 1,0 %	F2.0 ≤ 2,0 %	F3.0 ≤ 3,0 %
	Additives, (w-%) [c)]	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated
	Net calorific value as received, Q (MJ/kg or kWh/kg)	Q16.5 Q4.6 [kWh/kg]	Q16.5 Q4.6 [kWh/kg]	Q16.5 Q4.6 [kWh/kg]
	Bulk density, BD (kg/loose m^3)	BD625 ≥ 625	BD625 ≥ 625	BD600 ≥ 600
Normative /informative	Nitrogen [d)] N, (w-% dry basis)	N0.3 ≤0,3 %	N0.3 ≤0,3 %	N0.5 ≤0,5 %
	Sulphur [d)], S (w-% dry basis)	S0.02 ≤0,05 %	S0.04 ≤0,05 %	S0.05 ≤0,05 %
	Chlorine [d)], Cl (w-% dry basis)	Cl 0.05 ≤0,05 %	Cl 0.05 ≤0,05 %	Cl 0.05 ≤0,05 %
	Ash melting behaviour, DT (°C)	AM 1 300	AM 1 300	AM 1 150
	[a)] Amount of pellets longer than 40 mm can be 2,5 w-% and maximum length is 45 mm. [b)] Amount of fines (< 3,15 mm) at factory at last possible place when packing or loading. [c)] Maximum amount of additives can be 2,0 w-% of pressing mass. **[d)]** Nitrogen, chlorine and sulphur listed Table 1 are normative only, if raw material is chemically treated woody biomass			

The company C is proposing that dimensions could possibly be informed by stating the weight of 1000 pellets (dry basis). This method is used for grains and now under testing also for wood pellets.

Company F is an Austrian saw mill with 5 production locations in and around Austria. It has nearly 1500 employees and the core products are timber, structural glued laminated timber as well as medium density fiberboards. Beside these products it produces wood pellets and briquettes from saw mill residues with an annual production capacity of 120.000 t. These raw materials arise mostly in their own production and are mainly based on spruce wood. The wood pellets are produced according to the ÖNORM M 7135 and the DIN 51731 (DINplus) standards and are available in 600 to 1000 kg big-bags, 15 kg bags or in bulk form.

Figure 5. Wood pellets in big bags, 15 kg bags and in bulk form, company F.

The wood pellets and the whole production chain are subject to a permanent quality control by their own and an accredited inspection authority. So a constant fuel quality could be guaranteed. A permanent control by an accredited inspection authority is required by the ÖNORM M 7135. For the certification of a product with the label "ÖNORM certified product" a neutral third-party confirmation is needed. This neutral third-party could be a governmental or governmentally authorized and accredited inspection authority. The external monitoring has to be carried out once a year by an authorized institution and has to be done unannounced und for every single production location. Beside the external control, the company F has a self monitoring system, which corresponds to the in-house quality assurance. The producer is obligated to carry out the self monitoring by a qualified employee once a week. The results have to be documented and controlled in the line of the external monitoring by the inspection authority.

The sawdust gets collected directly at the saw mill and transported into a storage silo until the next stage of production. In the next step the moisture content and particle size of the sawdust are controlled. If the raw material does not meet the requested requirements, it is necessary to grind and dry it. Before the sawdust is pressed into pellets, it is mixed up with additive for a good compound. After the compression the wood pellets are cooled down and filled into the respective packages, big bags, 15 kg bags or stored in silos until the delivery with tank trucks. The critical parameters in the wood pellets production chain are the moisture content, the particle size, the content of additives, and the temperature at the pellet press and die pressure.

Company F produces wood pellets of the quality stated in Table 8.

Table 8. Specification of company F product

Property classes	Results	Property class according to pr EN 14961-2 wood pellets for domestic consumers table 1
Origin 	Spruce wood (saw mill)	1.2.1.1 (without bark)
Dimension (D and L)	D 6 mm, L 5 – 30 mm	D06
Moisture M	6.4 %	M10
Ash, A	0,19 (815°C), 0,35 (550°C)	A0.5
Net calorific value (dry basis) as received	19,02 MJ/kg 17,6 MJ/kg	 Q16.5
Bulk density	642 kg/m³	BD625

All Austrian wood pellet producers manufacture their wood pellets according to the two standards ÖNORM M 7135 and DIN 51731 (DINplus). This standards are very detailed and therefore treasured and in a great demand in their major distribution countries. So the Austrian wood pellet producers are not interested in changes and do not find the time beside their day-to-day business. The Austrian wood pellet producers know that the currently existing national standards will exist and will be in demand in the future. Furthermore because of the detailed and strict regulation and prescriptive limits, they know that they do not have to make many modifications in the production chain for new product standards.

The comments and feedbacks for prEN14961 are from experts of the Austrian standardization committee ON-K 241: Solid Biofuels. The committee includes representatives of several biofuel producers as well as researchers and agents of public authorities. The duties and responsibilities of the ON-K 241 are the standardization of solid biofuels in regard to the terminology, characteristics, requirements, transport, logistic, storage, quality assurance and test methods. This group of experts acts as mirror committee for the CEN TC 335: Solid Biofuels.

Comment: The Austrian standardization committee ON-K 241 has the opinion, that trade form A and trade form B should be unite as one trade form. There should not be any qualitative differentiations (mechanical durability, amount of fines and content of sulphur and chlorine) between pellets in bags (packaged) and bulk form and therefore a separation in form A and from B do not make sense. A differentiation could confuse the end consumer.

Comment: Separate specifications for pure wood pellets and wood –bark pellets were recommended by the ON-K 241. This two traded forms should only differ in the origin and source (consequential in ash and chemical parameters), but not as to mechanical durability, amount of fines or bulk density.

Comment: Origin and source: For the traded form A/B the raw material 1.2.2.1 should be cancelled, because these are chemical treated sources.

Comments: The ash content for wood-bark pellets should be raised from 1% to 1.5 %.

Comment: The mechanical durability should be the same for all traded forms and the limit value should be at 98 %.

Comment: The amount of fines should be limited to maximum 1% in all traded forms. (Note: after the last screening before delivery/ at the factory gate)

Comment: The property class bulk density is not necessary, but if it is part of the new specification, the Austrian standards committee would recommend a limit value of 625 kg/m³ for all traded forms.

Comment: Nitrogen, sulphur, chlorine and the seven heavy metals of the current DIN 51731 (arsenic, cadmium, chromium, copper, mercury, lead, zinc) should be binding normative parameters. The limit values should be geared to the Austrian recommendation for wood and wood-bark pellets.

Comments: Limit values for nitrogen should be lowered to 0.2 %. Tests at the FJ-BLT boiler test bench with modern wood pellet boilers have shown that nitrogen content over 0.2 % could exceed the Austrian emission limits. Furthermore nitrogen content higher than 0.2% at pure wood pellets mostly correlates with impurities with nitrogenous glues.

Beside the draft of a product standard for pure wood pellets and wood briquettes for domestic consumers the ON-K 241 has made a proposal for specific wood-bark pellets. This pellets form should be up to the technical requirements of the pure wood pellets (Mechanical durability, amount of fines, diameter…). The difference is only in the origin and source, wood and an amount of natural bark of 8 – 15%, which has an effect on the chemical ingredients as well as on the content of ash. To have a clear discrimination for the end consumer between this two traded forms, the Austrian recommendation is, to create two separate product standards (documents). For example trade form A for pure wood pellets (packaged and bulk) and trade form B for wood-bark pellets (packaged and bulk).

Table 9 and 10 presents the Austrian proposal for product standard for pellets for household consumers.

Table 9. Product standard for wood pellet for domestic consumers- Specifications (Austrian proposal according to the last draft of the new version on ÖNORM M713).

	Origin: According to CEN/TS 14961, Table 1		1.2.1.1
	Traded form: According to CEN/TS 14961, Table 2		Pellets
Normative	**Parameter**	**Category according to CEN/TS 14961**	**Threshold value**
	Diameter, mm	D 06	6 ± 1 mm
		D 08	8 ± 1 mm
		D 10	10 ± 1 mm
	Length, mm		5 – 40 mm [1] maximum length ≤ 45
	Moisture[2]	M10	≤ 10 %
	Ash[3]	A0.5	≤ 0,5 %
	Net calorific value as dry basis [3]	Q18	≥ 18,0 MJ/kg
	Mechanical durability	DU98,0	≥ 98,0 %
	Amount of fines [4]	F1.0	≤ 1,0 %
	Sulphur[3]	S0.02	≤0,02 %
	Nitrogen[3]	N0.2	≤ 0,2%
	Chlorine[3]	Cl0.01	≤ 0.01 %
	Additives[3,5]	-	< 2.0 %
	Chromium[6]	Cr	≤ 8
	Copper[6]	Cu	≤ 5
	Arsenic[6]	Ar	≤ 0,4
	Cadmium[6]	Cd	≤ 0,5
	Lead[6]	Pb	≤ 5
	Zinc[6]	Zn	≤ 50
	Mercury[6]	Hg	≤ 0,05
	[1]Minimum 95% per weight [2]w-% as received [3]w-% of dry basis [4]w-% < 3,15 mm after production at factory gate [5]Type and amount to be stated [6]mg/kg dry basis		

Table 10. Product standard for wood-bark pellet for domestic consumers- Austrian proposal

	Origin: According to CEN/TS 14961, Table 1		1.1.1 1.1.2 1.1.3 1.2.1.1 1.2.1.2
	Traded form: According to CEN/TS 14961, Table 2		Pellets
Normative	**Parameter**	**Category according to CEN/TS 14961**	**Threshold value**
	Diameter, mm	D 06	6 ± 1 mm
		D 08	8 ± 1 mm
		D 10	10 ± 1 mm
	Length, mm		5 – 40 mm [1] maximum length ≤ 45
	Moisture[2]	M10	≤ 10 %
	Ash[3]	A1.5	≤ 1,5 %
	Net calorific value as dry basis [3]	Q18	≥ 18,0 MJ/kg
	Mechanical durability	DU98,0	≥ 98,0 %
	Amount of fines [4]	F1.0	≤ 1,0 %
	Sulphur[3]	S0.02	≤0,04 %
	Nitrogen[3]	N0.2	≤ 0,30%
	Chlorine[3]	Cl0.01	≤ 0.02 %
	Additives[3,5]	-	< 2.0 %
	Chromium[6]	Cr	≤ 8
	Copper[6]	Cu	≤ 5
	Arsenic[6]	Ar	≤ 0,4
	Cadmium[6]	Cd	≤ 0,5
	Lead[6]	Pb	≤ 5
	Zinc[6]	Zn	≤ 100
	Mercury[6]	Hg	≤ 0,05
	[1]Minimum 95% per weight [2]w-% as received [3]w-% of dry basis [4]w-% < 3,15 mm after production at factory gate [5]Type and amount to be stated [6]mg/kg dry basis		

University of Stuttgart has collected comments from the different manufacturers.

Comment: Manufacturers of pellet firings would appreciate an ash content of maximum 0.3w-% for high quality pellets. Commercial branded pellets with a good quality throughout show a maximum ash content of 0.3w-%. Higher ash contents would raise the frequency of cleaning and maintenance. Tests revealed twice as often cleaning and maintenance after a doubling of the ash content.

Comment: There is a big problem with sintering and slagging of pellets. However, there are no approved criteria yet to solve this issue. One reason might be pellets that are too short causing too high temperatures in the combustion chamber. Another theory refers to certain eutectics of SiO_2 and potassium salts which lower the melting point of SiO_2.

Comment: Additives should be clearly defined and limited since there are sintering and slagging problems with certain approved additives, e.g. silicate containing pressing aids like potato starch (compare with above comment).

Comment: The distinction of two quality grades in prEN 14961-2 with regard to packaged and bulk material (A and B) is very theoretical and will lead to the validity of the more stringent thresholds in the market. Furthermore, it is not feasible to operate separate production processes for packaged and bulk material. Hence, two quality grades (A and C) for both packaged and bulk material are enough to properly take the market demand and the common practice into account.

Comment: The limitation for the production of wood pellets determined in prEN 14961-2 is irreproducible. At least, the list of sources should be extended by "1.1.3 stem wood" and "1.1.4 logging residues", but also further sources are possible. In general, prEN 14961-2 should be open for all woody biomass in compliance with the determined thresholds, except for chemically treated woody biomass. The latter is not acceptable in any way for the production of wood pellets of high quality. See also footnote d of Table 1 of prEN 14961-2.

Comment: In addition to the maximum length of pellets determined in ÖNORM M 7135 and DINplus, respectively, prEN 14961-2 also determines a minimum length of 5 mm. Furthermore, the maximum amount of fines ≤ 3.15 mm is determined. Hence, there is a gap in the definition for the fraction $3.15 \leq L \leq 5$ mm. At least, the maximum share for the fraction $3.15 \leq L \leq 5$ mm should be determined. However, a fixed minimum length of 5 mm could be problematic especially for quality grade C in prEN 14961-2 with a diameter of 8 mm. Furthermore it should be stressed that these thresholds are valid for the production process only. A minimum length of 5 mm cannot be guaranteed after transportation.

Comment: In ÖNORM M 7135 and DINplus, respectively, 20 w-% of the pellets may have a length of $5 \times D \leq L \leq 7.5 \times D$. This limitation has been approved in practice. 10 w-% of pellets longer than 40 mm and with a maximum length of 45 mm would be still acceptable. However, in footnote b of table 1 of prEN 14961-2, the limitation is set to 2.5 w-%. This threshold is not reachable with the available technology.

Comment: The ashing temperature in CEN/TS 14775 with 550°C is lower than in ÖNORM and DINplus, respectively, with 815°C. At higher temperatures, parts of the inorganic compounds become volatile and carbonates are converted to CO_2. Therefore, the ash content at 815°C is always lower than at 550°C. The difference of the ash content between both temperatures amounts to 0.1-0.2 w-%. However, the ash content determined in prEN 14961-2 is the same as in ÖNORM and DINplus, respectively. An ash content of 0.5 w-% determined at 550°C according to prEN 14961-2 would exclude many commonly used sources as well as possible new sources for the production of wood pellets. Therefore, the threshold must be raised to 0.7w-% when using an ashing temperature of 550°C.

Comment: The maximum ash content of quality grade C should be raised to 2.0w-% in order to take the production of wood pellets from plantation wood into account.

Comment: Is there a correlation between durability (≥ 97.5w-%) and amount of fines (≤ 1 w-%) determined in prEN 14961-2? If so, where is the missing 1.5w-%?

Comment: The testing device ASAE Tumbler mentioned in CEN/TS 15210-1 is not commonly used. Only a few of them exist. The Ligno Tester should still be allowed and, moreover, recognized as a reference method to determine the mechanical durability. With regard to the Ligno process, the maximum abrasion should be set to ≤ 2.3w-%.

Comment: The maximum amount of fines should be 1.0 w-% for both quality grades A and B, if it will be further differentiate between packaged and bulk material. This threshold is no problem with regard to the available technology.

Comment: Concretion of the mass basis for additives. Is it on dry basis? Furthermore, additives should be clearly defined.

Comment: Compared to the determination of the ash content at 550°C (see above comment), the nitrogen content of maximum 0.3w-% determined in prEN 14961-2 is similarly challenging. With regard to the raw material basis for wood pellets, this threshold must be raised to 0.6w-% for quality grades A and B and to 0.8w-% for quality grade C. The value of 0.3w-% was temporarily used to identify waste wood. Nowadays, there are more precise methods for the identification of waste wood.

Comment: The thresholds for sulphur and chlorine should be consistently set to 0.05w-% for all quality grades.

Comment: With the determination of origin and source of the raw material in prEN 14961-2 it is guaranteed, that only chemically untreated wood with a small amount of minerals is used for the production of wood pellets. Within the variation range of chemically untreated wood, it is not reasonable to determine the ash melting behaviour by a specific temperature. Furthermore, it is not feasible to control this property in the production process.

Comment: Add footnote d from Table 4 of prEN 14961-1 to footnotes of Table 1 of prEN 14961-2.

Comment: Year or production should also be stated in quality declaration.

The collection of requested information and the compilation of the feedback from company D were accomplished according to pr EN 14961-Part 1 and 2. A summary of the feedback from case company D concerning its product, i.e. wood pellets, is presented in Table 11, as well.

Origin and sources

The product of Company D is specified by origin and source into woody biomass and classified into blends and mixture -1.4- subgroup. Aiming to specify even more its origin, the pellets are made from chemically untreated wood residues without bark that are intentionally mixed to form these densified forms.

Traded form

This type of solid biofuel is traded in the form of densified material with cylindrical shape and broken ends, known as pellets.

Properties

As the normative and informative properties as concerned, Table 4 of prEN14961 is used for their specification. Some of them were evaluated using CERTH/ISFTA's laboratory equipments while

for other properties (i.e. mechanical durability) samples of pellets were sent to laboratories abroad (FJ-BLT) in order to get the relevant information.

Diameter (D) and Length (L)

Regarding the dimensions (mm), the fuel producer reported that the class D06 describes better its product. In particular, he stated that the diameter of pellets is close to 6 mm whereas the relative length ranges from 10 to 30 mm.

Moisture, M

In CEN specifications for pellets, there are two moisture classes. The interviewee commented that it is required a lower threshold and, thus, suggested the new moisture class M08. He considered the new class is more applicable for his product, since the moisture content in these is 7 – 8w-% a.r.

Ash, A

According to the specifications of properties for pellets, the respondent's product belongs to the category of A2.0. He, also, underlined that there are enough classes to describe the pellets derived from the majority of wood-based origin materials.

Mechanical Durability, DU

The physical quality of pellets is mainly described by its mechanical durability, meaning their resistance towards shocks and friction. The knowledge of this quality parameter is determinant since it affects the way of transportation, the storage conditions and the handling behaviour. According to the results obtained by FJ-BLT, the class of DU97.5 describes better the pellets. Despite the very good quality of pellets and the significance of this property, the producer expressed the opinion that mechanical durability should be reported as informative.

Amount of fines, F

Even if the company does not possess the proper equipment for measuring this property, they consider that the amount of fines lay below the limit of 1.0w-%. Indeed, taking into account the collection of those particles sizing less than 3 mm and their re-feeding to the press machine, it verified his statement. Otherwise, F1.0 is the class that better describes this product.

Additives

Pellets were not subjected to chemical treatments, according to the producer. Therefore, no additives were used and the respondent did not commend on this.

Bulk density, BD

The trading principle that follows the company is the mass basis. However, wood pellets present as bulk density the value of 650 kg per m^3 loose. In any case, the trading principle (mass or volume) should be reported as a normative property. Consequently, they are stated as a category of BD700.

Net calorific value, Q

The wood pellets of case company D should be classified into class Q16.5, since the heating value of these is Q=17.1 MJ/kg.

Sulphur, S

According to the sulphur content, pellets of company D are classified into the last class of S0.2+. However, the producer claim that is able to reach lower limits with a change in the proportion of each initial material into blend.

Nitrogen, N

The respondent underlined that correctly the nitrogen is reported as an informative property. As this characteristic is concerned, the pellets are categorised into class N2.0.

Chlorine, Cl

As regards this property, wood pellets present a low Chlorine content (0.16%-dry basis). Thus, the product can be categorised into class Cl0.02.

CERTH/ISFTA representatives tried to comment on each of the following questions according to the instruction template by VTT and the producer's responses.

Question: Are there enough property classes?

Comment: The pellets' producer considers that there are more than enough classes of properties. However, he pointed out that new classes should be introduced into moisture and heating value, particularly.

Question: What properties are not included?

Comment: The responded stated that CEN specifications include the majority of the necessary properties categorised either as normative or informative, that could present satisfactorily the quality characteristics of biofuels. Nevertheless, he underlined that more information about the ash melting behaviour of pellets is necessary to be included in the standards. This property has great significance in slagging and fouling phenomena. Especially, in the case that market actors are extended to end-users for large-scale applications apart from domestic consumers.

Question: Are there too many property classes? What properties are unnecessary?

Comment: The interviewee opposed to the view of exaggerated number of property classes or unnecessary properties. Instead, he acknowledged every consumer's right to being well-informed about the product or the producer to form a competitive and of high quality commercial material.

Question: Are the properties correctly classified as normative/informative? Which classes should be adjusted?

Comment: In general, the company's representatives consider that the separation between normative and informative properties is reasonable. However, they commented on the mechanical durability that it should belong to informative properties only.

Question: Are the threshold values suitable / reasonable with respect to the product?

Comment: The respondent found suitable threshold values from the specification table with respect to the product. Exception to this constitutes the moisture and calorific value where lower and higher thresholds, correspondingly, should be added in order to describe better his product.

Other comments/questions/proposals:

Comment: Fuel producer stated that the lack of national standards impels him to adopt the specifications of properties for pellets produced in Italy. Besides that is the country of his main market actors. However, he expressed the intention to use CEN standards adjusting the production line and using the recommended quality control process.

Table 11. Specification of properties for wood pellets, Company D according prEN 14961-1(Table 4)

Traded form	**Wood pellets**	
Producer information	Case company D	
Origin and source according to prEN14961	1.4 Blends which origin is classified into sub-group 1.2.1.1 Chemically untreated wood residues without bark	
Description of the biofuel	It is the densified form of intentionally mixed by-products of wood processing industry	
Traded form	Pellets	
Chemical treatment	No	
Normative	Specification of dimensions: D=6mm, L<30mm	D06
	Moisture: 7.2%-a.r	M 10
	Ash: 1.9%-d.b	A2.0
	Mechanical durability: 98,0%	DU 97.5
	Amount of fines: 1.0 %	F 1.0
	Bulk density as received: 650 kg/m^3	BD650
	Net calorific value as received, 17.1 MJ/kg)	Q16.5
Normative or Informative	Sulphur: 0.5%-d.b	S0.20+
	Nitrogen 1.7%-d.b	N2.0
	Chlorine: 0.016%-d.b	Cl0.02
Suitability for use	Can be used in domestic heating appliances and small-scale applications.	
Other comments	Energy density: 3.1 MWh/m^3 or 71 kWh/package Size of package: 15 kg	

The company I is mostly concentrated on standards and requirements what their clients request. They produce enough high quality for their consumers. Where biggest consumers make their own analysis of products and if product standards are not high enough they will not buy it. It seems like producers do not fully understand the need of parameters. There is no need to add sulphur and nitrogen properties in prEN 14961 because they do not use additives in their production. There could be specification of properties for pellets with additives and another one for pellets without additives.

Company I considers that there is not possible to make higher standard as in prEN 14961. Company use only one size D08 for produced pellets it means that other parameters are unnecessary for them. There is no need for M15 and M20 in normative for moisture. Parameter for moisture could be M08≤8.0% because moisture content in their production is 6 – 8 %. Amount of fines varies from 1 to 3 percent. There should be added new parameter F3.0≤3.0%.

Table 12. Properties of pellets for company I.

Property	Actual property	Property class according to pr EN 14961-1 wood pellets
Origin	Woody biomass	1.1
Dimensions	D≤8 and 5≤ L 5-50 mm	D08
Moisture	M≤ 6-8%	M10
Sulphur	not stated	
Amount of fines	F ≤1 – 3 %	F 1.0, F2.0, F2.0+
Additives	not used	
Nitrogen	not stated	

2.3 Wood chips and hog fuel

Company B produced wood chips mainly from landscape management woody biomass and waste wood. The wide variety of biomass for the production of wood chips is completed by stem wood, logging residues, bark, wood residues from sawmills as well as by-products and residues from other wood processing industries.

Company B is mainly in charge of collecting and processing all these different kinds of woody biomass. For this purpose, the company maintains a large fleet and machinery which comprises amongst others 24 trucks, 17 shredders and chippers as well as 7 sieving machines.

The main pier of the quality system is based on long-time experiences in trading solid biofuels. The quality of wood chips is generally monitored by visual inspections. Further information about the properties of the wood chips is obtained by experiences with certain origins of the raw material and their seasonal differences. Moreover, wood chips are analysed every half a year by an independent laboratory and the company stays in close contact with their customers and thereby gets continuous feedback to the quality of their delivered lots. Non-conforming material goes back to the company for upgrading or composting.

In the following, the production and fuel properties of wood chips are exemplarily described for two sources, landscape management woody biomass and stem wood.

Company B collects landscape management woody biomass, including woody biomass from private households and other non-public maintenance processes (e.g. residues from trimming of trees, bushes and hedges), that is gathered at municipal recycling centres in 6 rural districts and more than 30 cities and municipalities within a radius of 200 km around the company site. The recycling centres are frequented with mobile chippers for a first on-site processing of the material. The further processing takes place at the company site including the removal of the coarse and fine fractions as well as the removal of contraries like stones, plastics and metals. In the last processing step, the material is usually blended with wood chips from other sources (e.g. wood chips from stem wood) depending on the customers' requirements.

Figure 6 shows the output of wood chips from landscape management woody biomass. Common traded dimensions of this material are 80 mm and 100 mm.

Figure 6. Wood chips from landscape management woody biomass, company B.

In Table 13, the main properties of wood chips from landscape management woody biomass according to Table 5 of prEN 14961-1 are listed.

Table 13. Properties of wood chips from landscape management woody biomass, company B

Property	**Mean values**	**Property class according to table 5 of prEN 14961-1**
Origin	Landscape management woody biomass	1.1.7
Dimensions, P	80 and 100 mm	P100
Moisture, M	37.4 - 37.6 w-% as received	M40
Ash, A	2.8 - 3.0 w-% of dry basis	A3.0
Energy density, E	611 kWh/m³ loose	E611 [kWh/m³ loose]
Bulk density, BD	218 kg/m³ loose as received	BD200

Stem wood is bought on the market and transported to the company site where it is further processed (chipping, screening and blending). Common traded dimensions of this material are 20 mm (screened) and 60 mm (unscreened). Figure 7 shows screened wood chips from stem wood.

Figure 7. Wood chips from stem wood, company B.

In Table 14, the main properties of wood chips from stem wood according to Table 5 of prEN 14961-1 are listed.

Table 14. Properties of wood chips from stem wood, company B.

Property	**Mean values**	**Property class according to table 5 of prEN 14961-1**
Origin	stem wood	1.1.3
Dimensions, P	20 and 60 mm	P63
Moisture, M	29.6 – 32.7 w-% as received	M30 – M35
Ash, A	0.5 – 0.7 w-% of dry basis	A0.5 – A0.7
Energy density, E	824 kWh/m³ loose	E824 [kWh/m³ loose]
Bulk density, BD	262 kg/m³ loose as received	BD250

Question: What are the reasons for the determined dimension classes P16, P45, P63 and P100 in Table 5 of prEN 14961-1? Company B produces a lot more dimensions depending on the customers' requirements. The dimension of wood chips is considered as a very important parameter for operation and, in this regard, the given property classes do not allow a clear classification.

Proposal: Either offer a finer graduation of the property classes or better allow a free classification in a way like Pxx.

Companies C and E are also supplying wood chips or hog fuel from different type of woody biomass to different type of clients, district heating plants and power stations. The companies work on network model, so several smaller entrepreneurs are involved in fuel supply chain (Figure 8 and Figure 9). Wood chips or hog fuel from forest wood is produced mainly from logging residues in connection with round wood harvesting. The most common method is chipping at roadside. In this method 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/chipper by a truck-mounted crusher or chipper at the road side directly into the truck. The truck driver transports the fuel to the plant, takes samples for moisture content and also weights of each the load. Usually plant carries out the analysis of moisture content and informs the fuel supplier of the results. The net calorific value as dry basis, ash content or content is analysed monthly basis by plant or supplier. The supplier and plant agreed on the quality stated in Fuel Quality Declaration, which is part of the contract. Invoicing is based on MWh´s (measured tons, moisture and net calorific value).

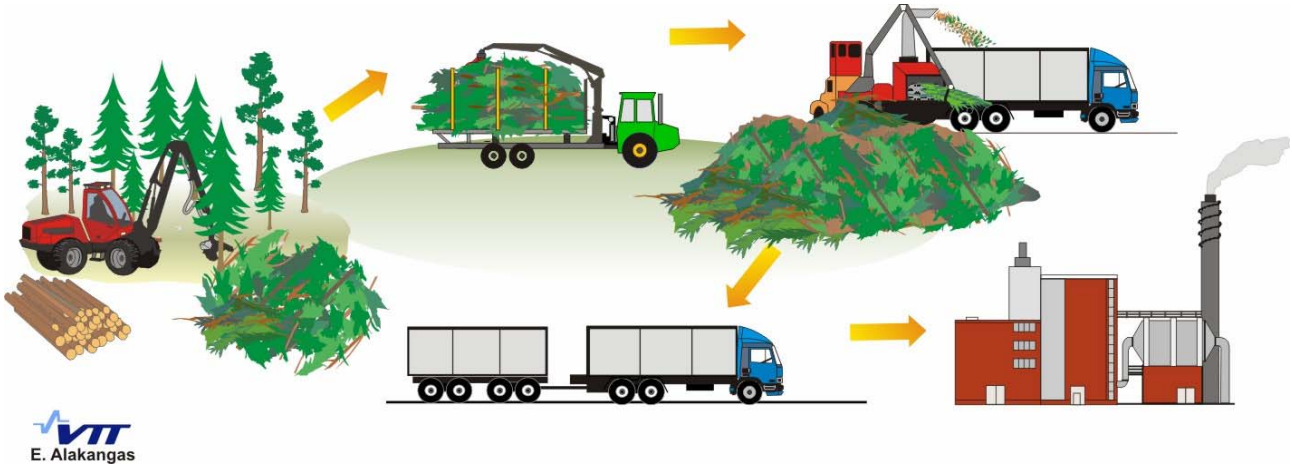


Figure 8. Logging residue supply chain – chipping at road-side most common production method, company C and E.

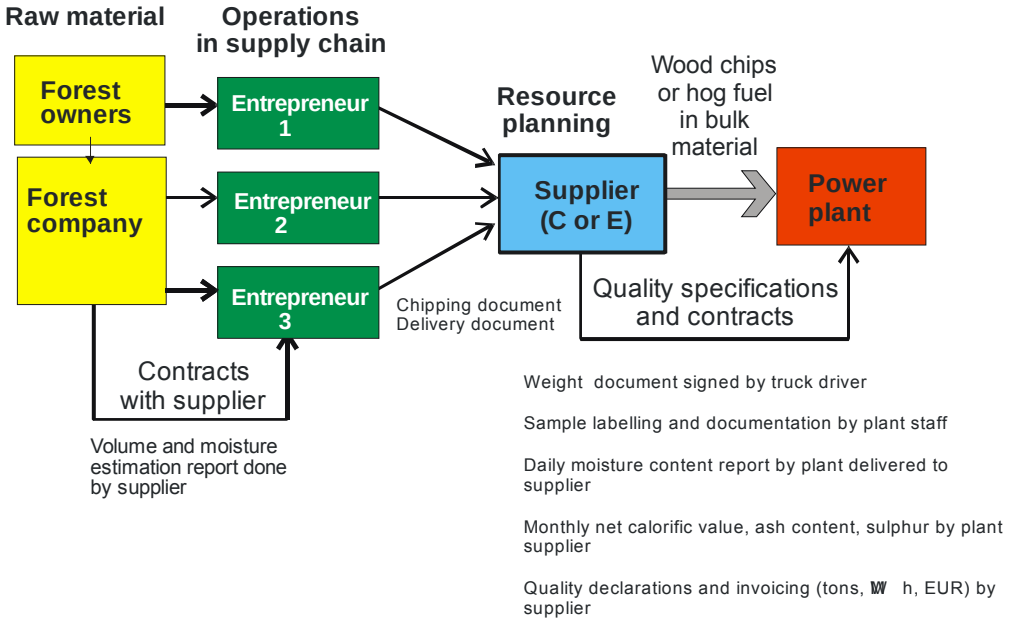


Figure 9. Fuel supply chain for wood chips and hog fuel from forest wood for company C and E.

The company C and E prefer that wood chips and hog fuel tables should be different for chemically treated woody biomass and some forest wood fractions (Figure 9), which may have higher heavy metal content e.g. short rotation forest biomass and woody biomass from landscape management. Table 15 and 16 presents the specification of hog fuel produced by company E.

Table 15. Specification of hog fuel of logging residues, Company E.

Property	**Mean values**	**Property class according to Table 6 of prEN 14961-1**
Origin	logging residues, spruce	1.1.4
Dimensions, P	55 x 20 x 15 mm	P63
Moisture, M	53 w-% as received	M55
Ash, A	-	A3.0
Net calorific value as received, Q	calculated from 19.25 MJ/kg dry basis and moisture	Q7,5
Bulk density, BD	300 kg/m³ loose as received	BD300

Table 16. Specification of hog fuel from used wood, Class B, Company E.

Property	**Mean values**	**Property class according to Table 6 of prEN 14961-1**
Origin	used wood, chemically untreated and chemically treated (Figure 11)	1.3.1 and 1.3.2.
Dimensions, P	80% < 80 mm 90% < 100 mm 100% < 150 mm	P100
Moisture, M	36,8 w-%	M40
Ash, A	0.9 w-%, dry basis	A1.0
Nitrogen, N	0,19 w-% dry basis	N0.2
Sulphur, S	<0,02 w-% dry basis	S0.02
Chlorine, Cl	0,013 w-% dry basis	Cl0,02
Net calorific value as received, Q	11,20 MJ/kg	Q11
Halogenated organic compounds	no	biomass fuel

The proposals from company C and E for wood chips and hog fuels are presented in Tables 17 and 18 based on prEN14961-Part 1 (N143). Also the particle size dimensions should be presented as a nominal top size, which refer to the particle sizes passing through (at least 95% by mass). Both companies are delivering fuel to district heating and power plants based on fluidised bed technology or grate combustion. Most of the plants are multifuel plants and can use different type of biomass fuels with varying properties.

Most important properties for wood chips and hog fuels are moisture content and particle size. Also there should not be impurities in fuel. Trade is based on energy content of fuel and moisture content sample of each load is taken and weight of load is measured (Figure 8).

Figure 10. Different kind of biomass fuels at power plant owned by company C.

Figure 11. Used wood – class B (ballets) at company E

Table 17a —Specification of properties for wood chips produced from forest and plantation wood and chemically untreated used wood - Class A)

	Master table		
	Origin: According to 6.1 and Table 1.		Woody biomass 1.1 excluding short rotation coppice 1.1.1.3, 1.1.2.3, 1.1.5.3 and landscape management wood residues 1.1.7 1.2.1 Chemically untreated wood residues 1.3.1 Chemically untreated used wood
	Traded Form		Wood chips
Normative	**Dimensions** (mm) [a]		
		Nominal top size, mm [b]	Coarse fraction max. length of particle, max 1 %, mm
	P16	P < 16 mm	> 45 mm all < 90 mm
	P45	P < 45 mm	> 63 mm
	P63	P < 63 mm	> 90 mm
	P100	P < 100 mm	> 125 mm
	Moisture, M (w-% as received)		
	M10	≤ 10 %	
	M15	≤ 15 %	
	M20	≤ 20 %	
	M25	≤ 25 %	
	M30	≤ 30 %	
	M35	≤ 35 %	
	M40	≤ 40 %	
	M45	≤ 45 %	
	M50	≤ 50 %	
	M55	≤ 55 %	
	M55+	> 55 % maximum value to be stated	
	Ash, A (w-% of dry basis)		
	A0.5	≤ 0,5 %	
	A0.7	≤ 0,7 %	
	A1.0	≤ 1,0 %	
	A1.5	≤ 1,5 %	
	A3.0	≤ 3,0 %	
	A6.0	≤ 6,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % maximum value to be stated	
	Net calorific value Q (MJ/kg as received) or **energy density, E** (kWh/m^3 loose and MWh/m^3 loose)		
	to be stated		
Informative	**Bulk density (BD) as received (kg/m^3 loose)**		Recommended to be stated if traded by volume basis in categories minimum (BD200, BD250, BD300, BD350, BD400, BD450)

[a] The numerical values for dimension refer to the particle sizes passing through(at least 95 % by mass) the mentioned round hole sieve size (16 mm, 45 mm, 63 mm, 90 mm and 125 mm). Dimensions of actual particles may differ from those values especially the length of the particle.

Table 17b —Specification of properties for wood chips produced from chemically treated wood industry by-products and residues and used wood- Class B.

	Master table		
	Origin: According to 6.1 and Table 1.		Woody biomass 1.1 including 1.1.1.3, 1.1.2.3, 1.1.5.3,1.1.7 1.2.2 Chemically treated wood residues, fibres and wood constituents 1.3.2 Chemically treated used wood
	Traded Form		Wood chips
Normative	**Dimensions** (mm) [a]		
		Nominal top size, mm [b]	Coarse fraction max. length of particle, max 1 %, mm
	P16	P < 16 mm	> 45 mm all < 90 mm
	P45	P < 45 mm	> 63 mm
	P63	P < 63 mm	> 90 mm
	P100	P < 100 mm	> 125 mm
	Moisture, M (w-% as received)		
	M10	≤ 10 %	
	M15	≤ 15 %	
	M20	≤ 20 %	
	M25	≤ 25 %	
	M30	≤ 30 %	
	M35	≤ 35 %	
	M40	≤ 40 %	
	M45	≤ 45 %	
	M50	≤ 50 %	
	M55	≤ 55 %	
	M55+	> 55 % maximum value to be stated	
	Ash, A (w-% of dry basis)		
	A0.5	≤ 0,5 %	
	A0.7	≤ 0,7 %	
	A1.0	≤ 1,0 %	
	A1.5	≤ 1,5 %	
	A3.0	≤ 3,0 %	
	A6.0	≤ 6,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % maximum value to be stated	
	Net calorific value Q (MJ/kg as received) or **energy density, E** (kWh/m^3 loose and MWh/m^3 loose)		
	to be stated		
	Nitrogen, N (w-% of dry basis)		
	N0.3	≤ 0,3 %	Nitrogen is normative only for chemically treated biomass
	N0.5	≤ 0,5 %	
	N1.0	≤ 1,0 %	
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % maximum value to be stated	
	Chlorine, Cl (weight of dry basis, w-%)		
	Recommended to be stated as a category Cl 0.02, Cl 0.03, Cl 0.07, Cl 0.10 and Cl 0.10+ (maximum value to be stated)		
Informative	**Bulk density (BD) as received (kg/m^3 loose)**		Recommended to be stated if traded by volume basis in categories minimum (BD200, BD250, BD300, BD350, BD400, BD450)

[a] The numerical values for dimension refer to the particle sizes passing through (at least 95 % by mass) the mentioned round hole sieve size (16 mm, 45 mm, 63 mm). Dimensions of actual particles may differ from those values especially the length of the particle.

Table 18a —Specification of properties for hog fuel produced from forest and plantation wood and used wood -Class A.

	Master table		
	Origin: According to 6.1 and Table 1.		Woody biomass 1.1 excluding short rotation coppice 1.1.1.3, 1.1.2.3, 1.1.5.3 and landscape management wood residues 1.1.7 1.2.1 Chemically untreated wood residues 1.3.1 Chemically untreated used wood
	Traded Form		Hog fuel
Normative	**Dimensions** (mm) [a]		
		Nominal top size, mm [b]	Coarse fraction, max. length of a particle, mm < 1 % of weight
	P45	P < 45 mm	> 63 mm
	P63	P < 63 mm	> 90 mm
	P100	P < 100 mm	> 125 mm
	P300	P < 300 mm	> 400 mm
	Moisture, M (w-% as received)		
	M10	≤ 10 %	
	M15	≤ 15 %	
	M20	≤ 20 %	
	M25	≤ 25 %	
	M30	≤ 30 %	
	M35	≤ 35 %	
	M40	≤ 40 %	
	M45	≤ 45 %	
	M50	≤ 50 %	
	M55	≤ 55 %	
	M55+	> 55 % maximum value to be stated	
	Ash, A (w-% of dry basis)		
	A0.5	≤ 0,5 %	
	A0.7	≤ 0,7 %	
	A1.0	≤ 1,0 %	
	A1.5	≤ 1,5 %	
	A3.0	≤ 3,0 %	
	A6.0	≤ 6,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % maximum value to be stated	
	Net calorific value Q (MJ/kg as received) or **energy density**, E (kWh/m^3 loose and MWh/m^3 loose)		
	to be stated		
Informative	**Bulk density (BD) as received (kg/m^3 loose)**		Recommended to be stated if traded by volume basis in categories(BD250, BD300, BD350, BD400, BD450)

[a] The numerical values for dimension refer to the particle sizes passing through the mentioned round hole sieve size (16 mm, 45 mm, 63 mm). Dimensions of actual particles may differ from those values especially the length of the particle.

[b] 95 % of particles are smaller than the given limit.

Table 18b —Specification of properties for hog fuel from chemically treated wood industry by-products and residues and used wood – Class B.

	Master table		
	Origin: According to 6.1 and Table 1.		Woody biomass 1.1 including 1.1.1.3, 1.1.2.3, 1.1.5.3,1.1.7 1.2.2 Chemically treated wood residues, fibres and wood constituents 1.3.2 Chemically treated used wood
	Traded Form		Hog fuel
Normative	**Dimensions** (mm) [a]		
		Nominal top size, mm [b]	Coarse fraction, max. length of a particle, mm < 1 % of weight
	P45	P < 45 mm	> 63 mm
	P63	P < 63 mm	> 90 mm
	P100	P < 100 mm	> 125 mm
	P300	P < 300 mm	> 400 mm
	Moisture, M (w-% as received)		
	M10	≤ 10 %	
	M15	≤ 15 %	
	M20	≤ 20 %	
	M25	≤ 25 %	
	M30	≤ 30 %	
	M35	≤ 35 %	
	M40	≤ 40 %	
	M45	≤ 45 %	
	M50	≤ 50 %	
	M55	≤ 55 %	
	M55+	> 55 % maximum value to be stated	
	Ash, A (w-% of dry basis)		
	A0.5	≤ 0,5 %	
	A0.7	≤ 0,7 %	
	A1.0	≤ 1,0 %	
	A1.5	≤ 1,5 %	
	A3.0	≤ 3,0 %	
	A6.0	≤ 6,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % maximum value to be stated	
	Net calorific value Q (MJ/kg as received) or **energy density**, E (kWh/m^3 loose)		
	to be stated		
	Nitrogen, N (w-% of dry basis)		
	N0.3	≤ 0,3 %	Nitrogen and chlorine are normative only for chemically treated biomass
	N0.5	≤ 0,5 %	
	N1.0	≤ 1,0 %	
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % maximum value to be stated	
	Chlorine, Cl (weight of dry basis, w-%)		
	Recommended to be states as a category Cl 0.03, Cl 0.07, Cl 0.10 and Cl 0.10+ (maximum value to be stated)		
Informative	**Bulk density (BD) as received (kg/m^3 loose)**		Recommended to be stated if traded by volume basis in categories(BD250, BD300, BD350, BD400, BD450)

[a] The numerical values for dimension refer to the particle sizes passing through (at least 95 % by mass) the mentioned round hole sieve size (16 mm, 45 mm, 63 mm, 90 mm and 125 mm). Dimensions of actual particles may differ from those values especially the length of the particle.

NOTE. Special attention should be paid to the ash melting behaviour for some biomass fuels, for example eucalyptus, poplar, short rotation coppice.

The wood chips production of company H is based on co-operative model (Figure 12). The regional farmers collect wood from deforestation or other forest activities like thinning and carry them to a storage area near the forest road, where the wood gets processed immediately or after some drying time.

In the second step the wood gets picked up with a loading crane and filled into a mobile chipper. Inside the chipper is a rotor with cutting knifes, which reduces the stocks and branches to small chips. The mobile chipper could handle stem diameter up to 50 cm and throws the wood chips onto a trailer wherein the wood chips get transported to the heating plant.

At the heating plant, the operator, who is the central figure of the whole quality management, takes a representative sample for the reception control. The reception control includes the determination of the moisture content by a rapid determination procedure. This procedure is based on a dielectric moister meter, which gets plugged at least three times per load into the wood chips and measures the moisture content via the electrical conductivity. In addition to the determination of the moisture content, the trailer gets weighed on a weigh bridge to identify the bulk of the delivery. In the end of the reception control the operator checks the particle size as well as the general condition and impurities of the wood chips by a visual inspection before they fix the price and the supplier could unload his delivery at the designated place. The payment is based upon the bulk and the moisture content. For company H differs according to a moisture content of < 20%, 20-25%, 25-30%, 30-35% and >35%. The higher moisture content the lower the price.

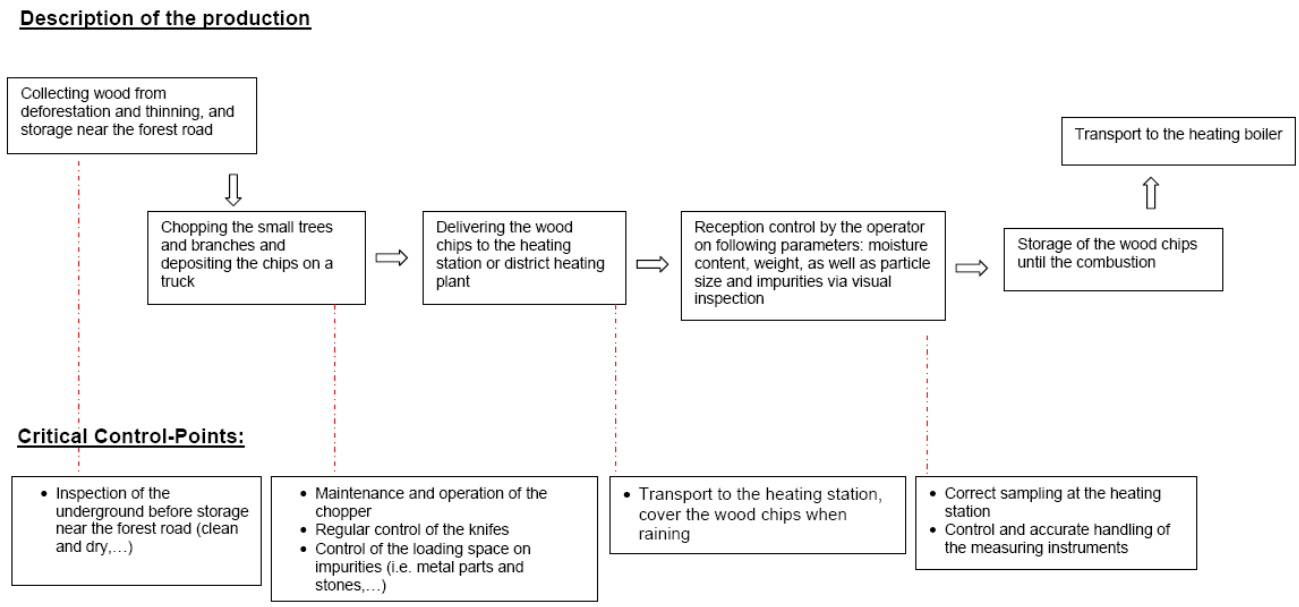


Figure 12. Description of the process for company H.

The quality is specified in Table 19.

Table 19. Specification of wood chips, company H.

	Property class according CEN/TS 14961	
	Origin	Whole trees without roots and stem wood, logging residues spruce and beech 1.1.1.5,1.1.3.3, 1.1.4.3
	Traded form	**Wood chips**
	Particle size: 75,5% < 16 mm	P45
	Moisture: 17,25 w-%	M20
	Ash, A 0,98 w-% dry basis	A1.0
	Net calorific value as received 15.24 MJ/kg	Q≥ 15.0 MJ/kg
	Bulk density, 207 kg/m^3	BD200
	Origin	Whole trees without roots and stem wood, logging residues,spruce and beech 1.1.1.5,1.1.3.3, 1.1.4.3
	Traded form	**Wood chips**
	Particle size: 85,4% < 16 mm	P45
	Moisture: 14,25w-%	M15
	Ash, 0,47 w-% dry basis	A0.5
	Net calorific value as received 16,12 MJ/kg	Q≥ 16.0 MJ/kg
	Bulk density, 202 kg/m^3	BD200

There the operator controls the quality of the wood chips by taking a sample directly from the trailer. The quality control includes the analysis of the moisture content, the weight, the particle size and the general condition of the wood chips by a visual inspection. The moisture content and the particle size are the main criterions, which affect the price. Because of the storage, clients demand a moisture content of maximum 20-35 %. The moisture content gets measured by a dielectric moisture meter, which is based on the electrical conductivity of the wood chips.

Company H does not use any standards for their combustibles. The most important things are the skills of the operator. His appraisals value the quality of the wood chips and fix the price. Another important factor is the confidence to the wood chip supplier. In consideration of the fact, that most of the wood chip producers are also partner of the company H, they strive to deliver wood chips of good quality. If the quality of the wood chips doesn't meet the requirements of the company, the operator could lower the price or reject the delivery.

Some problems, which the operators have to deal with are impurities and large particles in the woods chips, for example brooms, dung forks or other metal parts, which could damage the charging screw. From time to time it happens that the wood chip producers leave stones or metal part on the trailer and buried them with their chips. So they could get into the wood chips storage and combustion plant.

Bad shaped knifes of the chippers cause also problems with the particles size and reduces the quality of the wood chips.

Comment: From the point of view of the company H the prEN 14961 - "Solid biofuels – Fuels specifications and classes" is too detailed and complicated for their practice. There are too many property classes and they are too detailed. In practice they do not need such a detailed specification. For them it is important to know the moisture content and that it is not higher than 35 %. The weight of the delivery and the round particle size is also controlled as well as the impurity degree.

Comment: They won't determinate the ash content or even the nitrogen and chlorine content, for each wood chip delivery, that would be to expensive.

Comment: Furthermore the woods chips are a regional and natural product, which means if the nitrogen or chlorine content doesn't meet the requirements of the prEN 14691 in spit of a low impurity degree, nobody could influence this fact.

Comment: The only parameters, which the wood chip producer has a direct influence on, are the origin and sources, the moisture content, the particle size and the impurities, therefore this three property classes are the most important.

2.4 Reed canary grass bales

Figure 13. Square and round reed canary grass bales.

In the CEN/TS 14961 there is only proposal for square straw bales. In Nordic countries reed canary grass is cultivated on 20 000 hectares for energy and it is harvested both as round and square bales (Figure 13). Also it is important to state if reed canary grass is harvested in spring time (not in Autumn), because properties especially alkali metal content is lower for spring harvested reed canary grass. Table 20 shows a proposal of the company C for reed canary grass bales.

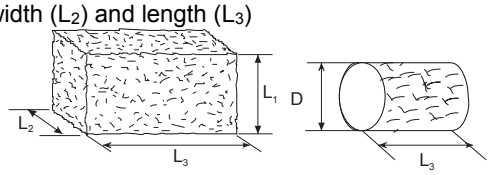
Reed canary grass (*Phalaris arundinacea* L.*)* is a wild, perennial grass that grows in Scandinavia, including Lapland. Reed canary grass thrives on wet soils and can tolerate occasional flooding. In the later stages of growth, it also manages in dry conditions. Cultivated reed canary grass suits all soil types, but the best yields have been obtained on humus rich soils. In good conditions, the dry-matter yield may be nearly ten tonnes per hectare. In practice, however, the average yield is approximately 5 tons. Reed canary grass is harvested in spring, when the moisture content of dead

grass is 10-20w-%. The fuel properties of spring-harvested reed canary grass are clearly better than those of autumn-harvested grass. Nutrients move to the rhizomes in the ripening stage. This improves the combustion properties of the straw mass and also stores nutrients for the following growing season. One reed canary grass stand can be harvested annually for more than ten years. Harvesting losses and logistics still pose challenges to the production and use of reed canary grass. The first yield is harvested in April, two years after sowing. Harvesting can be started when the moisture content of the grass is 10-15w-% and the field is firm enough to carry harvesting machinery. The harvesting season lasts a few weeks in spring. If the new growth is more than 25 cm, mowing should not be performed, as increased moisture weakens the quality of the crop. Annual fertilisation is performed after harvesting.

Harvesting is a challenging stage. In unfavourable conditions, up to half of the biomass may be lost. The normal harvesting stages are as follows: mowing, windrowing, and baling or chopping. Mowing can be performed with a mower-chopper or a disc mower. As there is a direct correlation between stubble height and harvesting losses, it is important to mow as close to the ground as possible. Plant stands that have been flattened by snow may be difficult to mow if the mower is driven in the direction of the lodged plants.

Baling can be performed with a round baler or a square baler (Figure 12). The best results are achieved on large, even sites using modern heavy-duty square balers. Baling can also be performed by using fixed-chamber and variable-chamber round balers. For storing and transportation, large square bales are the best. The density of square bales is more than 200 kg/m^3, whereas the density of round bales is 120 – 160 kg/m^3. Square bales can also be packed more tightly on trucks, which mean more efficient transportation. Round bales do not fill the truck space as well. Baled reed canary grass is chopped into lengths of 5 – 10 cm before blending it with other fuels. Chopping can be performed at fuel terminals or at power plants. In locations near energy peat production sites, harvesting can be performed by chopping the grass at site. Different types of chopping balers are available on the market. Loose chopped material can be blended with peat and delivered to power plants as a fuel blend. The most effective handling chain is one in which reed canary grass is delivered to the power plant in large square bales.

Table 20 — Specification of properties for reed canary grass bales

	Master table			
	Origin: According to 6.1 and Table 1.	2.1.2.1 Whole plant		
	Traded Form	Round bale and square bale		
Normative	**Dimensions** (mm), height (L_1), width (L_2) and length (L_3)  Round bale			
		Diameter (D)	Width (L_3)	
	P1	1 200 - 1 500	1 200	
	P2	1 600 – 1 800	1 500	
	Square big bale			
		Height (L_1)	Width (L_2)	Length (L_3)
	P1	700	1 200	1 500 - 2 800
	P2	900	1 200	1 500 – 2 800
	P3	850	850	1 000 - 3 000
	P4	1 200	1 200	1 000 – 3 000
	Bale density, BD (kg/m^3)			
	Round bale			
	BD120	120 – 160		
	BD160	> 160		
	quare bale			
	BD180	180 – 220		
	BD220	> 220		
	Moisture; M (w-% as received)			
	M10	≤ 10 %		
	M15	≤ 15 %		
	M20	≤ 20 %		
	M25	≤ 25 %		
	M30	≤ 30 %		
	M30+	> 30 %		
	Ash, A (w-% of dry basis)			
	A06	≤ 6 %		
	A10	≤ 10 %		
	A10+	> 10 % (maximum value to be stated		
	Species of biomass and harvesting time			
	Has to be stated: spring harvested reed canary grass (*Phalaris arundinacea* L.)			
	Net calorific value, Q (MJ/kg as received or **energy density, E** (kWh/m^3 loose or MWh/m^3 loose)			
	to be stated			
Informative	Particle size distribution or structure	Harvested as a whole plant. Straw length 20-200 mm.		
	Chlorine, Cl (w-% of dry basis)	Recommended to be stated as a category Cl 0.10 and Cl 0.10+ (maximum value to be stated)		
	Binding type of bales	Tying material recommended to be specified (net binding, plastic line)		

2.5 Exhausted olive cake

Figure 14. Exhausted olive cake in the traded form of grains supplied by case company A

Figure 15. Exhausted olive cake in the traded form of briquettes supplied by case company A

The European standard series prEN 14961 regarding the fuel specification and classes of solid biofuels have currently been updated closer to their final version. As the exhausted olive cake (Figure 14) is concerned an additional master table (Table 13) has been incorporated to cover the specification of its properties. A summary of the feedback from case company A concerning its product, exhausted olive cake, is presented in Table 21.

Origin and sources

This type of solid biofuel is specified by origin and source into fruit biomass and classified into chemically treated fruit residues -3.2.2.4- subgroup.

Traded form

It has already been mentioned that this solid biofuel can be met in the traded forms of briquettes and grains. In Greece, the last one referred is the common trading principle that follows the majority of fuel producers.

Properties

According to prEN 14961-1, the general master table for energy grains and fruit seeds (Table 13) is used for the specifications of properties for this type of solid biofuel. All the normative and informative properties are commented as well as the questions described in the technical annex and the instruction for this report.

Diameter (D)

As concerns the dimensions (mm), the fuel producer commented that the class D05 better describes its product. The majority of grains presents diameter less than 5mm. However, in some cases there is a percentage of 5 w-% of the grains that may have a larger diameter in the order of 5 to 7 mm.

Moisture, M

In the quality table for energy grains and fruit seeds it is given three moisture classes. The fuel producer commented that the class M20 is too high for exhausted olive cake and thought that is suitable for other biofuels such as olive kernels or even partially-dried crude olive cake. Nonetheless, the interviewee suggested that the class M10 could better describe his products. In particular, samples of different time of period through year but of the same crop give the following results: Sample A: M10 (M=5.4%-a.r) and Sample B: M10 (M=8.1%-a.r).

Ash, A

In spite of the large number of classes for the ash content defined in the master table of prEN 14961-1, the fuel producer pointed out that they are not sufficient. Specifically, the respondent made a proposal of introducing new ash classes, A4 and A10+ (maximum value to be stated) in order to better describe his product. The lower value for ash content is proposed as an intermediate class and the higher one for the exhausted olive cakes of different crops or presenting high moisture content. However, case company A's producer reported that his product belonged to categories A6 (A=3.4%-d.b) and A6+ (A=11.3%-d.b) as regards the tested samples, correspondingly.

Amount of fines, F

The interviewee claimed that this property should be omitted or else an improved definition of fines should be determined. Also, he mentioned that the various categories of dimensions describe sufficiently the product. Otherwise, the amount of fines should be classified as informative property instead of normative.

Additives

The only chemical that is added during the production of exhausted olive cake is the solvent of hexane. The producer emphasized that the used hexane does not contain heavy metals or any other halogenated compounds. He also reported that its annual consumption is estimated to approx. 40 tonnes but he did not state the addition percentage (%) on mass basis.

Nitrogen, N

According to the nitrogen content, exhausted olive cake is classified into classes N1.5 and N3.0. The respondent suggested that the product should be better described if it is categorised into the last class. This claim is owing to his intention to take into account all the possible influences on the final product, such as the various qualities of raw material and the preceding stages of treatment.

Net calorific value, Q

The interviewee make the proposal of introducing a new class for net calorific value, since his product presents higher value than the suggested through the quality table of pr EN 14961-1. Namely, he suggested the category of Q17.0 (actual value $Q_{net,ar}$=17.5MJ/kg) in order to describe better the product emphasizing its high heating value. Else wise exhausted olive case of case company A is classified into the class Q15.0.

Sulphur, S

The fuel producer expressed the opinion that informative category is more suitable for sulphur property even if additives have been used. Exhausted olive cake showing sulphur content of 0.09%-w is categorised into class S 0.15.

Chlorine, Cl

As regards the Chlorine content of exhausted olive cake, the biofuel presents a value of 16%-w and cannot be categorised into any available class of Table 13.Thus, a new class should be introduced into pr EN 14961-1 referring to this property so as to describe better the product.

Bulk density, BD

Exhausted olive cake is traded by mass basis meaning that the quantities of product are weighed and filled in packages of 25 kg each. Yet it can be traded by volume basis presenting a bulk density of 800 kg per m^3 loose. In any case, the trading principle (mass or volume) should be reported as a normative property.

Question: Are there enough property classes?

Comment: The respondent expressed the opinion that the amount of classes is sufficient for each property. Exceptions to this constitute the specifications both of ash content and calorific value. In particular, he suggested that a few new classes should be introduced into these properties in order to diversify and emphasize the quality of the product. Besides producers and/or end-users benefit greatly by a high quality fuel and a well-informed standard would keep the hard work for remaining competitive with other companies.

Question: What properties are not included?

Comment: The interviewee considered that more than enough properties are included in the pr EN standards for the fuel specifications.

Question: Are there too many property classes? What properties are unnecessary?

Comment: The response of the fuel producer to this was positive meaning that there are a few properties. In particular, he underlined that the specification of fines should be left out considering that the dimensions category satisfy this information. Moreover, the chlorine content is considered as unnecessary since the used solvent does not contain halogenated compounds.

Question: Are the properties correctly classified as normative/informative? Which classes should be adjusted?

Comment: According to the replier the nitrogen content should be reported as informative property. Moreover, should the property for amount of fines not be omitted, it has to belong to the

informative category. In addition, bulk density should be reported as normative property assuming that constitutes the trading principle.

Question: Are the threshold values suitable / reasonable with respect to the product?

Comment: He reports that they are almost suitable regarding the product.

Other comments/questions/proposals:

Fuel producer considers that the standardization of biofuels is significant and necessary. He also hopes that the national organisation of standardisation (ELOT) will take promptly the initiative on the adoption, promotion and application of above CEN specifications incorporating them within the Greek legislation. This issue will contribute to properly adjusted production lines and qualitative improved solid biofuels. However, he comments that the recommended standards may increase or demand additional costs for the quality control equipment. Finally, he wonders whether his product meets all the requirements and can be considered as solid biofuel.

Table 21. Feedback on the properties for exhausted olive cake, company A.

Traded form	**Exhausted Olive cake**	
Producer information	Case company A	
Origin and source	3.2.2.4 Chemically treated fruit residues (Exhausted Olive cake)	
Description of the biofuel	It is the residual material which is left after the crude olive cake has any remaining oil extracted from it.	
Traded form	Grains (for case company A)	
Chemical treatment	Use of solvents such as hexane in order to extract the oil from the crude olive cake and separate it from the residue.	
Normative	According prEN 14961-1, Table 13	
	Particle size: 5 mm (5 – 7 mm)	D05
	Moisture (M): 5,4%, 8.1 w-%	M10
	Ash (A) 3.4%-d.b, 11.3% d	A6
	Nitrogen (N), 1,3% d.b., 2,5% d.b	N1.5 and N3.0 (N=2.5%-d.b
	Net calorific value as received, Q	Q 17.5
Normative or Informative	Sulphur: 0.09%-d.b	S0.15
	Chlorine:0.16%-d.b	Cl (no value higher than 0,15%)
Informative	Bulk density as received: BD 800 kg/m^3	
Suitability for use	Can be used in domestic heating appliances.	
Other comments	Size of package: 25 kg Energy density: E3.9 [MWh/m^3] or 122 kWh/package	

2.6 Log wood

The origin of the log woods should be named more concrete, which means additional to the classification in table 1 the specific type of wood should be mentioned. For example: 1. Woody biomass, 1.1 Forest and plantation wood, 1.1.3 Stemwood, 1.1.3.1 Deciduous – Beech.

Furthermore the representative of Österreichischer Kachelofenverband" (Austrian tiled stove association) would recommend the declaration of the calorific value (MJ/kg). With the information of the wood type, the moisture content, the bulk density and other data, the calorific value should be ascertainable. From his point of view, the calorific value combined with the quotation of the price in €/MJ would be a market relevant tool and could help to create transparency for the costumers.

Comments from other associations

Comment: Origin and source of the wood should also state the origin country and region in terms of a sustainable cultivation and for the control of the protection of species according to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).

Comment: Type of wood should be stated according to prEN 13556 with a definite abbreviation of the botanic name.

Comment: The basic density should be stated. If the basic density of a lot is not determined and stated, an average basic density for the given type of wood has to be stated on dry basis.

Comment: Due to different diameters of the raw material and different chopping devices, there are much more geometries than shown in table 7 of prEN 14961-1. Mark them as examples. Otherwise the figures imply that other geometries are not allowed.

Comment: The dimension classes should also be divided by diameters. There are classification principles in use, which differentiate the wood size (small, medium, large) on basis of a certain wood length by diameter. Perhaps first the diameter and then the length should be stated for classification.

Comment: Classification should consistently be based on mass. Different definitions of the volume make things difficult to handle. Mass is a more understandable parameter, especially with regard to private customers.

3 Conclusions and recommendations

The classification system developed in prEN 14961 – Part 1 is basic tool for most of the companies involved in case studies. Wood pellet and briquettes producers and equipment manufacturers have also commented prEN 14961 – Part 2 and Part 3.

General conclusions from feedback

- Flexible classification system (Part 1) good basic tool for most of the companies.
- Companies involved in the case studies proposed several additional classes with threshold values for different biomass fuels based on their own product.
- Wood chips and hog fuel produced from chemically treated wood or forest wood, which may have more heavy metals should be have own tables, because this caused a lot of misunderstanding when nitrogen and chlorine is normative.
- There should be enough moisture content classes (interval 5 w-% units) because pricing is based on the moisture content and net calorific value. Also more ash classes for wood chips and hog fuel is needed.

- There should be more particle size classes for wood chips and hog fuel e.g. P31.5.
- Used wood falling to the scope of CEN/TC 335 should be classified in categories A and B (see App.1).
- Southern European companies also requested the possibility to have used wood as a raw material for wood pellets. Northern European companies also proposed that raw material should be classified as chemically untreated if the amount of chemically untreated is at least 97w-%.
- Reed canary grass is different product compared to straw bales, and most of the bales produced for the markets are round bales, now classification is only for square straw bales. Own property table for reed canary grass bales is proposed. This table might be used also miscanthus bales. Harvesting time is important and should be normative and also tying material should be stated.
- Exhausted olive cake needs different definition for fines, because the particle size is usually on average 5 mm. Proposal for fines is < 1 mm. Also nitrogen and chlorine is proposed to be informative.
- Domestic consumers need more simple classification and properties should be bind together to form a Class. Finland is proposing class A for packages pellets especially targeted for stoves, class B for packaged and bulk deliveries. Class C is for such installation which do not require so high quality fuel as classes A and B are. Austria is proposing two classes for wood pellets (wood without bark and wood-bark pellets) and no chemical treated wood is allowed.
- There are contradictive proposals of the chemical compounds for wood briquettes and pellets. Companies situating in Baltic State area and in southern Europe do not see important to state nitrogen, sulphur and heavy metal content for wood pellets or briquettes, because virgin wood includes small amount of these compounds. On the contrary Central European companies are requesting these as normative with very strict threshold values, because of their national legislation (e.g. NO_x emission limits for small scale boilers).
- For log wood classes should be stated according diameter, type of wood should be stated according to prEN 13556 with a definite abbreviation of the botanic name.

Comments from case companies were distributed to WG2 of the CENT/TC 335 in March 2008 and draft summary report before the WG2 meeting, which was held on 7 – 8 April 2008.

4 References

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Appendix 1/1 - CLASSIFICATION OF WOOD WASTE: Classes A and B (Solid biofuels)

Class	Definition of wood waste	*Origin according to CEN/TS 14961* Origin, other descriptors	Examples (prEN 14961, Table 1)	From factory:	After use:	Procedure and analysis
A	- Natural - Mechanically* treated - Heat, air or water treated	- *Chemically untreated by-products or residues from* forest and *wood processing industry (1.2.1)* - *Chemically untreated used wood (1.3.1)*	- Untreated construction wood - Veneer - Fibreboard, without glue - HDF board, uncoated - Heat-treated wood - Unpainted furniture wood	1.2.1.1 1.2.1.1 1.2.1.1 1.2.1.1 1.2.1.1 1.2.1.1	1.3.1.1 1.3.1.1 1.3.1.1 1.3.1.1 1.3.1.1	Solid biofuel → Declaration of the origin of the material required → Fuel specification of traded form and corresponding property table (prEN 14961)
B	- Coated, lacquered or otherwise chemically treated - Coating does not contain halogenated organic compounds (for example PVC) - Does not contain preservatives - No demolition wood	- *Chemically treated by-products and residues from wood processing industry (1.2.2)* - *Chemically treated used wood (1.3.2)* - Wood packings and cases from commerce and industry (1.3.2) - Wood residues from construction, partially (1.3.2)	- Plywood - Coated plywood - Chipboard - Fibreboard, with glue - MDF board, all - Furniture board - HDF board, coated - Mouldings (e.g. MDF skirting) - Painted construction wood - Pallets - Wooden concrete forms and molds	1.2.2.1 1.2.2.1 1.2.2.1 1.2.2.1 1.2.2.1 1.2.2.1 1.2.2.1 1.2.2.1 1.2.2.1 — —	1.3.2.1 1.3.2.1 1.3.2.1 1.3.2.1 1.3.2.1 1.3.2.1 1.3.2.1 1.3.2.1 1.3.2.1 1.3.2.1 1.3.2.1	Solid biofuel → Declaration of the origin of the material required → Fuel specification of traded form and corresponding property table (prEN 14961) If there is reason to suspect impurities → Reclassification into class C OR → Analysis of the chlorine and heavy metal concentration of the raw material to exclude contamination (limits for maximum concentration of virgin wood)

* Mechanical treatment includes: size reduction (for instance chipping, crushing, splitting, cutting), woodworking and mechanical wood processing

	Appendix 1/2 - CLASSIFICATION OF WOOD WASTE: Classes C and D (not solid biofuels)			
Class	**Definition of wood waste**	**Origin**	**Examples**	**Procedure and analysis**
C Excluded from prEN 14961; belonging to Solid recovered fuel standard CEN/TS 15359	- Coating contains halogenated organic compounds (for example PVC) - The origin of the material cannot be reliably verified, e.g. demolition wood - Does not contain preservatives	- Domestic wood waste - Demolition wood, excluding preservative-treated wood - Wood residues from construction, partially	- Old kitchen fittings - Used furniture - Construction wood including plastics, metals or other impurities	Alternative 1: Waste, falling under the waste incineration directive - Fuel specification according CEN/TS 15359 Alternative 2: Analysis required to prove that the levels of impurities do not exceed the given limits for chlorine (FOR EXAMPLE max. 0.1 w-%) and heavy metals of virgin wood → Can then be treated as solid biofuel (1.3.2)
D Excluded from prEN 14961 and CEN/TS 15359	- Preservative-treated (e.g. CCA, creosote)	- Demolition wood, including preservative-treated wood - Wood waste from civil engineering work	- Preservative-treated wood - Railway sleepers - Transmission line poles	The waste wood is disposed according to established legislation