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Draft Zambian Standard

BIOMASS PELLETS – Specification

Part 1: General Requirements

ZAMBIA BUREAU OF STANDARD

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This Zambian Standard has been prepared and published under the authority of the Zambia Bureau of Standards on ……………………………..

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Desire Energy
Emerging Cooking Solutions
Energy Regulation Board (ERB)
Fab Stoves
Ministry of Energy – Department of Energy
My Solar
Palm Scotts Zambia Limited
University of Zambia – Technology Development and Advisory Unit
United States Agency for International Development (USAID) – Alternatives to Charcoal Project (A2C)
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FOREWORD

The preparation of this Standard has been undertaken by the Renewable Energy Technical Committee (TC 4/20), in accordance with the procedures of ZABS. All users should ensure that they have the latest edition of this publication as standards are revised from time to time.

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This Draft Zambian Standards has been prepared with assistance drawn from: revision of this standard was necessary to ensure that the technological advancements in the sector are taken into consideration.

In the preparation of this standard, the following publication was consulted:

ISO 17225-1: 2021 *Solid Biofuels – Fuel specification and classes – Part 1: General requirements* published by the International Organization for Standardization (ISO).

ACKNOWLEDGEMENT

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ZAMBIA BUREAU OF STANDARDS

Draft Zambian Standard

BIOMASS PELLETS - Specification

Part 1: General Requirements

1.0 SCOPE

This Zambian Standard determines the fuel quality classes and specifications for solid biofuel pellets of raw and processed materials originating from:

a) Forestry and arboriculture;

b) Agriculture and horticulture;

c) Aquaculture;

d) Monocots;

e) Other organic material

Thermally treated biomass pellets (e.g. torrefied pellets) are not included in the scope of this document.

2.0 NORMATIVE REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. All standards are subject to revision and, since any reference to a standard is deemed to be a reference to the latest edition of that standard, parties to agreements based on this standard are encouraged to take steps to ensure the use of the most recent editions of the standards indicated below. Information on currently valid National and International standards can be obtained from Zambia Bureau of Standards.

ZS ISO 14780	Solid biofuels – Sample preparation
ZS ISO 16993	Solid biofuels – Conversion of analytical results from one basis to another.
ZS ISO 18135	Solid biofuels - Sampling
ZS ISO 21945	Solid biofuels – Simplified sampling method for small scale applications

3.0 DEFINITIONS

For the purposes of this standard, the following definitions shall apply:

3.1. **Additives:** material which has been intentionally introduced into the fuel feed stock to improve quality of fuel (e.g. combustion or durability properties), to reduce emissions or to make production more efficient

NOTE: Trace amounts of e.g. grease or other lubricants that are introduced into the fuel processing stream as part of normal mill operations are not considered as additives

3.2. **Ash**: residue remaining after combustion of a fuel under specified conditions, typically expressed as a percentage of the mass of dry matter in fuel

3.3. **As received:** condition of a biofuel pellet as it is received at distribution location and at end user point

3.4. **Biofuel pelle**t: densified biofuel made with or without additives usually with a cylindrical form, random length typically 5 mm to 40 mm and diameter up to 25 mm and broken ends, produced by compressing biomass

NOTE 1: Usually the biomass has been milled before densification.
NOTE 2: See also non-woody pellet, wood pellet and pellet from thermally treated biomass.

3.5. **Chemical treatment:** any treatment with chemicals other than treatment with air, water or heat

NOTE 1: Examples of chemical treatments are listed in Annex C

3.6. **Coarse pellet fines (CPF):** particles with a size ranging from ≥ 3.15 mm to < 5.6 mm resulting from breakage of pellets during production or handling.

3.7. **Commercial application:** facility that utilizes solid biofuel burning appliances or equipment that have similar fuel requirements as residential appliances.

NOTE 1: Commercial applications should not be confused with industrial applications, which can utilize a much wider array of materials and have vastly different fuel requirements.

3.8. **Fines (F):** fraction of small sized particles as defined by a specification or end-user.

NOTE 1: In the solid biofuels standards fines are always defined as particles passing through a 3.15 mm round hole sieve.

3.9. **Non-woody biomass:** biomass originating from herbaceous, fruit or aquatic biomass as well as blends or mixtures of woody and non-woody biomass

3.10. **Non-woody biofuel pellets:** biofuel pellets produced from non-woody biomass.

3.11. **Woody biomass**: biomass originating from trees, bushes and shrubs together with their fruit, leaves and needles inherent to the biomass.

Note 1: This definition includes forest, plantation and other virgin wood, wood processing industry by-products and residues, and used wood.

3.12. **Wood pellet**: biofuel pellet (3.4) made from woody biomass (3.11).

4.0 SYMBOLS AND ABBREVIATED TERMS

The symbols and abbreviated terms used in this document conform with the SI system of units as far as possible;

A Designed for ash content on dry basis A_d [% in mass]

ar as received

BD Designation for bulk density as received [kg/m^3 (loose volume)]

C Designation for fixed carbon on dry basis C_f [% in mass]

CPF Designation for amount of coarse pellet fines as received [% in mass, particles ≥ 3.15 mm and < 5.6 mm]

D Designation for diameter as received, D [mm]

DE Designation for particle density as received [g/m^3]

DT Designation for deformation temperature of the fuel ash [ºC]

DU Designation for mechanical durability as received [% in mass]

d dry (dry basis)

daf dry, ash-free

E Designation for energy density as received E_{ar} [MJ/m^3 or kWh/m^3 loose or stacked volume] (amount of energy/volume unit)

EM_d Designation for amount of heavy extraneous material on dry basis [% in mass]

F Designation for amount of fines (< 3.15 mm) as determined [% in mass]

F_s Designation for amount of small fines (< 1 mm) as determined [% in mass]

FT Designation for flow temperature of the fuel ash [ºC]

HT Designation for hemisphere temperature of the fuel ash [ºC]

L Designation for length as received, L [mm]

M Designation for moisture content as received, M_{ar} [% in mass]

P Designation for particle size distribution on analysis moisture basis

Q Designation for net calorific value at constant pressure as received, $Q_{p,net,ar}$ [MJ/kg or kWh/kg]

$Q_{V,gr,d}$ Gross calorific value at constant volume on dry basis [MJ/kg or kWh/kg]

$Q_{p,net,d}$ Net calorific value at constant pressure on dry basis [MJ/kg or kWh/kg]

SST Designation for shrinkage starting temperature of the fuel ash [ºC]

s Designation for small-scale and commercial use in particle size distribution.

U Designation for moisture content as received on dry basis U_{ar} [% in mass]

VM Designation for volatile matter on dry basis [% in mass]

Note 1: Fixed carbon (%) is calculated by the following: 100 – (moisture [% in mass] + ash [% in mass] + volatile matter [% in mass]). All percentages are on the same moisture basis.

Note 2: 1MJ/kg equals 1GJ/t or 0.2778 kWh/kg equals 1 MWh/t and 1 MWh/t is 3.6 MJ/kg. 1g/cm^3 equals 1 kg/dm^3. 1 mg/kg equals 0.0001%.

Note 3: Designation symbols are used in combination with a number to specify property levels in Table 3 to 15. For designation of chemical properties, chemical symbols such as S (sulfur), Cl (chlorine), and N (nitrogen) are used and the property class is added at the end of the symbol.

5.0 PRINCIPLE

5.1 Solid biofuels are specified by;

Origin and source, clause 6

5.2 For specification of origin and source, see Table 1 and for

5.3 For specification of properties see Table 4.

5.4 Table 4 list the normative properties, which shall be specified and informative properties, which are voluntary. Normative properties vary depending on both origin and traded form.

5.5 Example of Specification

Origin: Logging residues (1.1.4)

Traded form: Wood chips

Properties: Dimensions P45, Fines F05, Moisture M40, Ash A1.5

In the case of wood chips and hog fuel (Table 5) the properties of dimensions, fines, moisture and ash are normative in the specification. Other properties are informative.

Product standards for graded solid biofuels are given in other parts of this ISO series.

6.0 CLASSIFICATION OF ORIGIN AND SOURCES OF SOLID BIOFUELS

6.1 General

6.1.1 The classification is based on the biofuel origin and source. In the hierarchical classification system (Table 1) the main origin-based solid biofuel groups are:

a) Woody biomass;

b) Herbaceous biomass;

c) Fruit biomass;

d) Aquatic biomass;

e) Blends and mixtures.

6.1.2 Woody biomass is biomass from trees, bushes and shrubs.

6.1.3 Herbaceous biomass is from plants that have a non-woody stem and which die back at the end of the growing season. It includes grains and their by-products.

6.1.4 Fruit biomass is biomass from those parts of a plant which are from or hold seeds.

6.1.5 Aquatic biomass is from so called hydrophytic plants or hydrophytes, which are plants that have adapted to living in or on aquatic environments.

6.1.6 If appropriate, also the actual species (e.g. spruce, wheat) of biomass should be stated.

6.1.7 The term "Blends and mixtures" in Table 1 refers to material of various origin within the given box in the classification table and appears on all four classification levels. Blends are intentionally mixed biofuels, whereas mixtures are unintentionally mixed biofuels. The origin of the blend and mixture shall be described using Table 1.

6.1.8 If a solid biofuel blend or mixture contains chemically treated material, it shall be stated.

6.1.9 The second level of classification in Table 1 describes fuels from different sources within the main groups, primarily stating whether the biomass is a virgin material, a by-product or a residue from the industry.

6.1.10 Groups in Table 1 are further divided into third and fourth level sub-groups. The purpose of Table 1 is to allow the possibility to differentiate and specify biofuel material based on origin with as much detail as needed. With the help of typical values from informative Annex B information on physical and chemical properties can be deduced.

6.1.11 Examples for classification according to Table 1:

a) Whole trees without roots from birch (1.1.1.1);

b) Blend (1.1.1.5) of broad-leaf and coniferous whole trees without roots (1.1.1.1, 1.1.1.2);

c) Oil palm stem (1.1.3.3);

d) Logging residues (1.1.4);

e) Oil palm branches (1.1.4.1);

f) Logging residues from spruce stands (1.1.4.2);

g) Sawdust from broad-leaf (1.2.1.1);

h) Plywood from coniferous (1.2.2.1);

i) Plywood residues (1.2.2.1);

j) Grinding dust from furniture industry (1.2.2.1);

k) Lignin (1.2.2.4);

l) Unpainted and untreated construction wood (1.3.1.1);

m) Pallets (1.3.1.1 or 1.3.2.1);

n) Demolition wood (1.3.2.1)

o) Straw from wheat, barley, oat, rye (2.1.1.2);

p) Rice husk (2.1.1.4);

q) Reed canary grass (2.1.2.1);

r) Bamboo (2.1.2.5);

s) Grains or seeds crops from food processing industry (2.2.1.1);

t) Palm kernel or palm shell (3.1.2.3);

u) Oil palm fruit bunch (3.2.1.2);

v) Olive residues from olive pressing (3.2.2.4);

w) Kelp (4.3.2.4, Latin name to be stated);

x) Blend (5.1); 80 % in mass sawdust from coniferous (1.2.1.2) and 20 % in mass reed canary grass (2.1.2.1);

y) Mixture (1.1.1.5); whole trees without roots from birch (1.1.1.1), whole trees without roots from spruce (1.1.1.2);

z) Blend (1.2.3); 99 % in m

Table 1 — Classification of origin and sources of solid biofuels

1. Woody biomass	1.1 Forest, plantation and other virgin wood	1.1.1 Whole trees without roots	1.1.1.1 Broad-leaf
			1.1.1.2 Coniferous
			1.1.1.3 Short rotation coppice
			1.1.1.4 Bushes
			1.1.1.5 Blends and mixtures
		1.1.2 Whole trees with roots	1.1.2.1 Broad-leaf
			1.1.2.2 Coniferous
			1.1.2.3 Short rotation coppice
			1.1.2.4 Bushes
			1.1.2.5 Blends and mixtures
		1.1.3 Stemwood	1.1.3.1 Broad-leaf with bark
			1.1.3.2 Coniferous with bark
			1.1.3.3 Broad-leaf without bark
			1.1.3.4 Coniferous without bark
			1.1.3.5 Blends and mixtures
		1.1.4 Logging residues	1.1.4.1 Fresh/Green, Broad-leaf (including leaves)
			1.1.4.2 Fresh/Green, Coniferous (including needles)
			1.1.4.3 Stored, Broad-leaf
			1.1.4.4 Stored, Coniferous
			1.1.4.5 Blends and mixtures
		1.1.5 Stumps/roots	1.1.5.1 Broad-leaf
			1.1.5.2 Coniferous
			1.1.5.3 Short rotation coppice
			1.1.5.4 Bushes
			1.1.5.5 Blends and mixtures
		1.1.6 Bark (from forestry operations)	
		1.1.7 Segregated wood from gardens, parks, roadside maintenance, vineyards, fruit orchards and driftwood from freshwater	
		1.1.8 Blends and mixtures	

	1.2 By-products and residues from wood processing industry	1.2.1 Chemically untreated wood by-products and residues	1.2.1.1 Broad-leaf with bark
			1.2.1.2 Coniferous with bark
			1.2.1.3 Broad-leaf without bark
			1.2.1.4 Coniferous without bark
			1.2.1.5 Bark (from industry operations)
		1.2.2 Chemically treated wood by-products, residues, fibres and wood constituents	1.2.2.1 Without bark
			1.2.2.2 With bark
			1.2.2.3 Bark (from industry operations)
			1.2.2.4 Fibres and wood constituents
		1.2.3 Blends and mixtures	
	1.3 Used wood	1.3.1 Chemically untreated used wood	1.3.1.1 Without bark
			1.3.1.2 With bark
			1.3.1.3 Bark
		1.3.2 Chemically treated used wood	1.3.2.1 Without bark
			1.3.2.2 With bark
			1.3.2.3 Bark
		1.3.3 Blends and mixtures	
	1.4 Blends and mixtures		
2. Herbaceous biomass	2.1 Herbaceous biomass from agriculture and horticulture	2.1.1 Cereal crops	2.1.1.1 Whole plant
			2.1.1.2 Straw parts
			2.1.1.3 Grains or seeds
			2.1.1.4 Husks or shells
			2.1.1.5 Blends and mixtures
		2.1.2 Grasses	2.1.2.1 Whole plant
			2.1.2.2 Straw parts
			2.1.2.3 Seeds
			2.1.2.4 Shells
			2.1.2.5 Bamboo
			2.1.2.6 Blends and mixtures
		2.1.3 Oil seed crops	2.1.3.1 Whole plant
			2.1.3.2 Stalks and leaves
			2.1.3.3 Seeds
			2.1.3.4 Husks or shells
			2.1.3.5 Blends and mixtures

		2.1.4 Root crops	2.1.4.1 Whole plant 2.1.4.2 Stalks and leaves 2.1.4.3 Root 2.1.4.4 Blends and mixtures
		2.1.5 Legume crops	2.1.5.1 Whole plant 2.1.5.2 Stalks and leaves 2.1.5.3 Fruit 2.1.5.4 Pods 2.1.5.5 Blends and mixtures
		2.1.6 Flowers	2.1.6.1 Whole plant 2.1.6.2 Stalks and leaves 2.1.6.3 Seeds 2.1.6.4 Blends and mixtures
		2.1.7 Segregated herbaceous biomass from gardens, parks, roadside maintenance, vineyards and fruit orchards	
		2.1.8 Blends and mixtures	
	2.2 By-products and residues from food and herbaceous processing industry	2.2.1 Chemically untreated herbaceous residues	2.2.1.1 Cereal crops and grasses 2.2.1.2 Oil seed crops 2.2.1.3 Root crops 2.2.1.4 Legume crops 2.2.1.5 Flowers 2.2.1.6 Blends and mixtures
		2.2.2 Chemically treated herbaceous residues	2.2.2.1 Cereal crops and grasses 2.2.2.2 Oil seed crops 2.2.2.3 Root crops 2.2.2.4 Legume crops 2.2.2.5 Flowers 2.2.2.6 Blends and mixtures
		2.2.3 Blends and mixtures	
	2.3 Blends and mixtures		

3. Fruit biomass	3.1 Orchard and horticulture fruit	3.1.1 Berries	3.1.1.1 Whole berries
			3.1.1.2 Flesh
			3.1.1.3 Seeds
			3.1.1.4 Blends and mixtures
		3.1.2 Stone/kernel fruits	3.1.2.1 Whole fruit
			3.1.2.2 Flesh
			3.1.2.3 Stone/kernel/fruit fibre
			3.1.2.4 Blends and mixtures
		3.1.3 Nuts and acorns	3.1.3.1 Whole nuts
			3.1.3.2 Shells/husks
			3.1.3.3 Kernels
			3.1.3.4 Blends and mixtures
		3.1.4 Blends and mixtures	
	3.2 By-products and residues from food and fruit processing industry	3.2.1 Chemically untreated fruit residues	3.2.1.1 Berries
			3.2.1.2 Stone/kernel fruits/fruit fibre
			3.2.1.3 Nuts and acorns
			3.2.1.4 Crude olive cake
			3.2.1.5 Blends and mixtures
		3.2.2 Chemically treated fruit residues	3.2.2.1 Berries
			3.2.2.2 Stone/kernel fruits
			3.2.2.3 Nuts and acorns
			3.2.2.4 Exhausted olive cake
			3.2.2.5 Blends and mixtures
		3.2.3 Blends and mixtures	
	3.3 Blends and mixtures		

4. Aquatic biomass	4.1 Algae	4.1.1 Micro algae (Latin name to be stated)	
		4.1.2 Macro algae (Latin name to be stated)	
			4.1.2.1 Green sea weed (Latin name to be stated)
			4.1.2.2 Brown sea weed (Latin name to be sated)
			4.1.2.3 Red sea weed (Latin name to be stated)
		4.1.3 Blends and mixtures	
	4.2 Water hyacinths		
	4.3 Lake and sea grass	4.3.1 Lake grass (Latin name to be stated)	
		4.3.2 Sea grass (Latin name to be stated)	
		4.3.3 Blends and mixtures	
	4.4 Reeds	4.4.1 Common reed	
		4.4.2 Other reed	
		4.4.3 Blends and mixtures	
	4.5 Blends and mixtures		
5 Blends and mixtures	5.1 Blends		
	5.2 Mixtures		

Note1: Driftwood from saltwater is not recommended as a fuel
Note 2: Group 5 “Blends and mixtures” include blends and mixtures from the main origin-based solid biofuel groups 1 to 4.

6.2 Woody biomass

6.2.1 Forest, plantation and other virgin wood

Forest, plantation and other virgin wood in this group may only have been subjected to size reduction, debarking, drying or wetting. Forest, plantation and other virgin wood includes wood from forests, parks, gardens, plantations, roadside maintenance and from short rotation forests and coppice.

6.2.2 By-products and residues from wood processing industry

Wood by-products and wood residues from industrial production are classified in this group. These biofuels can be chemically untreated (for example residues from debarking, sawing or size reduction, shaping, pressing) or chemically treated wood residues from wood processing and the production of panels and furniture (glued, painted, coated, lacquered or otherwise treated wood), as long as they do not contain heavy metals or halogenated organic compounds as a result of treatment with wood preservatives or coating.

6.2.3 Used wood

This group includes post-consumer/post society wood waste; natural or merely mechanically processed wood, contaminated only to an insignificant extent during use by substances that are not normally found in wood in its natural state (for example pallets, transport cases, boxes, wood packages, cable reels, construction wood). With respect to treatment the same criteria apply as with respect to “wood processing industry by-products and residues”, i.e. the used wood shall not contain heavy metals more than in virgin wood, or halogenated organic compounds as a result of treatment with wood preservatives or coating.

6.2.4 Blends and mixtures

This refers to blends and mixtures of woody biomass in the groups 1.1 to 1.3 in Table 1. The mixing can be either intentional (blends) or unintentional (mixture).

6.3 Herbaceous biomass

6.3.1 Herbaceous biomass from agriculture and horticulture

Material, which comes directly from the field, perhaps after a storage period, and may only have been subject to size reduction and drying. It covers herbaceous material from agricultural and horticultural fields and from gardens and parks such as maize stalks, rice husks e.t.c.

6.3.2 By-products and residues from food and herbaceous processing industry

This refers to any herbaceous biomass material that is left over after industrial handling and treatment.
Examples are residues from the production of sugar from sugarcane, barley malt residues from beer production and raw vegetable residues from food processing industry.

6.3.3 Blends and mixtures

This refers to blends and mixtures of herbaceous biomass in the groups 2.1 to 2.2 in Table 1. The mixing can be either intentional (blends) or unintentional (mixtures).

6.4 Fruit biomass

6.4.1 Orchard and horticulture fruit

Fruit from trees, bushes and fruit from herbs (e.g. tomatoes and grapes) are classified in this group.

6.4.2 By-products and residues from food and fruit processing industry

This refers to a fruit biomass material that is left over after industrial handling and treatment. Examples are pressing residues from palm oil or pineapple processing and processed (e.g. heated, steamed, cooked, etc.)

vegetable residues from food processing industry.

6.4.3 Blends and mixtures

This refers to blends and mixtures of fruit biomass in the groups 3.1 to 3.2 in Table 1. The mixing can be either intentional (blends) or unintentional (mixtures).

6.5 Aquatic biomass

Aquatic biomasses are divided into the following main species: algae, water hyacinths, lake and seaweed.

6.6 Biomass blends and mixtures

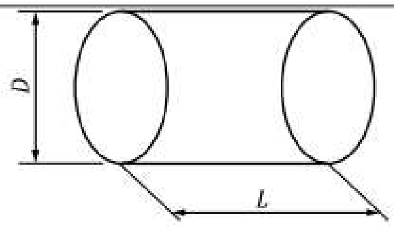
These include blends and mixtures of different biomasses mentioned above under 6.2 to 6.5. The mixing can be either intentional (blends) or unintentional (mixtures).

7.0 SPECIFICATION OF PROPERTIES FOR BIOFUEL PELLETS

Biofuel pellets of typical diameter ≤ 25 mm and mechanically compressed.

For a specification of a solid biofuel, the denominations given in Table 2 are normative and informative properties. In Table 4 biofuel pellets are defined by property classes. When specifying a class within a property, the average numerical value from the whole lot or defined portion from the lot (e.g. shipload, truckload or bag) shall determine which class shall be used.

Table 2 — Specification of properties for pellets

Master table			
Normative	**Origin:** According to 6.1 and Table 1		Woody biomass (1); Herbaceous biomass (2); Fruit biomass (3); Aquatic biomass (4); Blends and mixtures (5).
	Traded Form (see Table 2)		Pellets
	Dimensions (mm) ISO 17829		
	Diameter (*D*) and **Length** (*L*) [a]		
	D06	6 mm ± 1,0 mm and 3,15 mm ≤ L ≤ 40 mm	 *L* length and *D* diameter **Figure 3 — Dimensions (mm)**
	D08	8 mm ± 1,0 mm and 3,15 mm ≤ L ≤ 40 mm	
	D10	10 mm ± 1,0 mm and 3,15 mm ≤ L ≤ 40 mm	
	D12	12 mm ± 1,0 mm and 3,15 mm ≤ L ≤ 50 mm	
	D25	25 mm ± 1,0 mm, and 10 mm ≤ L ≤ 50 mm	
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2		
	M05	≤ 5 %	
	M08	≤ 8 %	
	M10	≤ 10 %	
	M12	≤ 12 %	
	M15	≤ 15 %	

Ash, A (% in mass of dry basis) ISO 18122	
A0.5	≤ 0,5 %
A0.7	≤ 0,7 %
A1.0	≤ 1,0 %
A1.2	≤ 1,2 %
A1.5	≤ 1,5 %
A2.0	≤ 2,0 %
A3.0	≤ 3,0 %
A4.0	≤ 4,0 %
A5.0	≤ 5,0 %
A6.0	≤ 6,0 %
A7.0	≤ 7,0 %
A8.0	≤ 8,0 %
A10.0	≤ 10,0 %
A10.0+	> 10,0 % (maximum value to be stated)
Mechanical durability, DU (% in mass of pellets after testing) ISO 17831-1	
DU 98.0	≥ 98,0%
DU97.5	≥ 97,5 %
DU96.5	≥ 96,5 %
DU96.0	≥ 96,0 %
DU95.0	≥ 95,0 %
DU95.0-	< 95,0 % (minimum value to be stated)
Amount of fines, F (% in mass, < 3,15 mm) after production when loaded or packed, ISO 18846	
F1.0	≤ 1,0 %
F2.0	≤ 2,0 %
F3.0	≤ 3,0 %
F4.0	≤ 4,0 %
F5.0	≤ 5,0 %
F6.0	≤ 6,0 %
F6.0+	> 6,0 % (maximum value to be stated)
Additives (% in mass of pressing mass) [b]	Type and content of pressing aids, slagging inhibitors or any other additives shall be stated
Bulk density, BD (kg/ m^3 as received) ISO 17828	
BD500	≥ 500 kg/m^3
BD550	≥ 550 kg/m^3
BD580	≥ 580 kg/m^3
BD600	≥ 600 kg/m^3
BD625	≥ 625 kg/m^3
BD650	≥ 650 kg/m^3
BD700	≥ 700 kg/m^3
BD750	≥ 750 kg/m^3
BD800+	> 800 kg/m^3 (minimum value to be stated)
Net calorific value, Q (MJ/kg or kWh/kg as received) ISO 18125	Minimum value to be stated [c]

Normative/ Informative	**Nitrogen, N** (% in mass of dry basis) ISO 16948		
	N0.2	≤ 0,2 %	Normative:
	N0.3	≤ 0,3 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2)
	N0.5	≤ 0,5 %	Informative:
	N0.6	≤ 0,6 %	All fuels that are not chemically treated (see the exceptions above)
	N0.7	≤ 0,7 %	
	N1.0	≤ 1,0 %	
	N1.5	≤ 1,5 %	
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % (maximum value to be stated)	
	Sulfur, S (% in mass of dry basis) ISO 16994		
	S0.02	≤ 0,02 %	Normative:
	S0.03	≤ 0,03 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2) or if sulfur containing additives have been used.
	S0.04	≤ 0,04 %	Informative:
	S0.05	≤ 0,05 %	All fuels that are not chemically treated (see the exceptions above)
	S0.08	≤ 0,08 %	
	S0.10	≤ 0,10 %	
	S0.20	≤ 0,20 %	
	S0.30	≤ 0,30 %	
	S0.30+	> 0,30 % (maximum value to be stated)	
	Chlorine, Cl (% in mass of dry basis) ISO 16994		
	Cl0.01	≤ 0,01 %	Normative:
	Cl0.02	≤ 0,02 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2)
	Cl0.03	≤ 0,03 %	Informative:
	Cl0.05	≤ 0,05 %	All fuels that are not chemically treated (see the exceptions above)
	Cl0.07	≤ 0,07 %	
	Cl0.10	≤ 0,10 %	
	Cl0.20	≤ 0,20 %	
	Cl0.30	≤ 0,30 %	
	Cl0.30+	> 0,30 % (maximum value to be stated)	
	Fixed carbon, C [d] (% in mass of dry basis)		
	Minimum value to be stated		Normative only for thermally treated biomass pellets
	Volatile matter, VM (% in mass of dry basis) ISO 18123		
	Maximum value to be stated		Normative only for thermally treated biomass pellets
	Particle size distribution of disintegrated pellets (% in mass of dry basis) ISO 17830		Values to be stated for pellets for industrial use

Informa-tive	**Ash melting behaviour** [e] (°C) ISO 21404[3]	DT, HT and FT should be stated
	Coarse pellet fines, CPF (3,15 mm ≤ CPF < 5,6 mm, % in mass) ISO 18846	Should be stated
	Particle density, DE, ISO 18847	Should be stated

[a] Maximum length for classes *D*06, *D*08 and *D*10 shall be ≤ 50 mm. Pellets are longer than 3,15 mm, if they stay on a round hole-sieve of 3,15 mm.

[b] The maximum amount of additive is 20 % in mass of pressing mass. Type stated (e.g. starch, corn flour, potato flour, vegetable oil, lignin). If amount is greater, then raw material for pellet is blend.

[c] Minimum value for torrefied or other thermally treated biomass pellets is usual ≥ 18 MJ/kg.

[d] Fixed carbon (%) is calculated by the following: 100 – (moisture [% in mass] + ash [% in mass] + volatile matter [% in mass]). All percentages are on the same moisture basis.

[e] Special attention should be paid to the ash melting behaviour for some biomass fuels, for example eucalyptus, poplar, short rotation coppice, straw, miscanthus and olive stone. It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

NOTE 1: The ash class A3.0 (≤ 3 % in mass) means that the ash content shall not be higher than 3.0 % in mass to belong to this class.
NOTE 2: For all properties the lowest possible class shall be stated, except for bulk density, particle density and mechanical durability where the highest possible class shall be stated. Only one class shall be specified.
NOTE 3: A fuel with a moisture content of 17 % in mass should be categorized as M20 and not M10 or M30.

The documents listed in Clause 2 shall be used for the sampling (ZS ISO 18135 or ZS ISO 21945), sample preparation (ZS ISO 14780) and analysis of determination of the properties of solid biofuels.

To ensure resources are used appropriately and the declaration is accurate, use the most appropriate measure below:

a) Using previous measured values or obtained by experience of same raw material (see Annex B);

b) Calculation of properties, e.g. by using typical values and considering documented specific values;

c) Carrying out of analysis:

   a. With simplified methods if available;

   b. With reference methods.

The responsibility of the producer or supplier to provide correct and accurate information is exactly the same whether laboratory analysis is performed or not. Typical values do not release the producer or supplier from providing accurate and reliable information.

Conversion of a value on a dry basis (d) to a dry, ash free basis (daf) or to as received basis (ar) is given in ISO 16993.

Typical values for some physical and chemical properties of solid biofuels are listed in Annex B. These can be used as an indication of the properties when needed, however, they may not be used for the limitation of the fuel parameters.

For Table 2: only chemically treated biomass that are included in the scope, should be considered, i.e. wood waste which can contain halogenated organic compounds or heavy metals more than virgin wood as a result of treatment with wood preservatives or coating, are not included. Examples of chemical treatment are mentioned in Annex C.

NOTE 1: It is important to carry out laboratory analysis, if raw material basis is changed.
NOTE 2: For Tables 3 to 15 is stated that the net calorific value should be specified on as received basis. The net calorific value will vary depending on the actual moisture content in the fuel. The value given in a specification is thus valid only for the actual connected moisture content. The net calorific value as received (qp,net,ar, designation Q) can be calculated using both the net calorific value on a

dry basis (qp,net,d) and the moisture content (see Annex D).

ANNEX A
(Informative)

Typical values of solid biomass fuels

Table A.1 – Typical values for virgin wood materials, without or with insignificant amounts of bark, leaves and needles

Parameter	Unit	Coniferous wood (1.1.3.4 and 1.2.1.4)		Broad-leaf wood (1.1.3.3 and 1.2.1.3)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	0,3	0,1 to 1,0	0,3	0,2 to 1,0
Gross calorific value $Q_{V,\text{gr,d}}$	MJ/kg d	20,5	20,0 to 20,8	20,1	19,4 to 20,4
Net calorific value $Q_{p,\text{net,d}}$	MJ/kg d	19,1	18,5 to 19,8	18,9	18,4 to 19,2
Carbon, C	% in mass d	51	47 to 54	49	48 to 52
Hydrogen, H	% in mass d	6,3	5,6 to 7,0	6,2	5,9 to 6,5
Oxygen, O	% in mass d	42	40 to 44	44	41 to 45
Nitrogen, N	% in mass d	0,1	< 0,1 to 0,5	0,1	< 0,1 to 0,5
Sulfur, S	% in mass d	< 0,02	< 0,01 to 0,02	0,02	< 0,01 to 0,05
Chlorine, Cl	% in mass d	0,01	< 0,01 to 0,03	0,01	< 0,01 to 0,03
Fluorine, F	% in mass d	< 0,000 5	< 0,000 5	< 0,000 5	< 0,000 5
Aluminium, Al	mg/kg d	100	30 to 400	20	< 10 to 50
Calcium, Ca	mg/kg d	900	500 to 1 000	1 200	800 to 20 000
Iron, Fe	mg/kg d	25	10 to 100	25	10 to 100
Potassium, K	mg/kg d	400	200 to 500	800	500 to 1 500
Magnesium, Mg	mg/kg d	150	100 to 200	200	100 to 400
Manganese, Mn	mg/kg d	100	40 to 200	83	not specified
Sodium, Na	mg/kg d	20	10 to 50	50	10 to 200
Phosphorus, P	mg/kg d	60	50 to 100	100	50 to 200
Silicon, Si	mg/kg d	150	100 to 200	150	100 to 200
Titanium, Ti	mg/kg d	< 20	< 20	< 20	< 20
Arsenic, As	mg/kg d	< 0,1	< 0,1 to 1,0	< 0,1	< 0,1 to 1,0
Cadmium, Cd	mg/kg d	0,10	< 0,05 to 0,50	0,10	< 0,05 to 0,50
Chromium, Cr	mg/kg d	1,0	0,2 to 10,0	1,0	0,2 to 10,0
Copper, Cu	mg/kg d	2,0	0,5 to 10,0	2,0	0,5 to 10,0
Mercury, Hg	mg/kg d	0,02	< 0,02 to 0,05	0,02	< 0,02 to 0,05
Nickel, Ni	mg/kg d	0,5	< 0,1 to 10,0	0,5	< 0,1 to 10,0
Lead, Pb	mg/kg d	2,0	< 0,5 to 10,0	2,0	< 0,5 to 10,0

Parameter	Unit	Coniferous wood (1.1.3.4 and 1.2.1.4)		Broad-leaf wood (1.1.3.3 and 1.2.1.3)	
		Typical value	Typical variation	Typical value	Typical variation
Vanadium, V	mg/kg d	< 2	< 2	< 2	< 2
Zinc, Zn	mg/kg d	10	5 to 50	10	5 to 100
[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch and German research. Formulas how to calculate different bases are given in ISO 16993					

Table A.2 – Typical values for virgin bark materials

Parameter	Unit	Bark from coniferous wood (1.1.6 and 1.2.1.5)		Bark from broad-leaf wood (1.1.6 and 1.2.1.5)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	3,0	< 1 to 5	1,8	0,8 to 5,0
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	20,4	18,0 to 21,4	20	18,0 to 22,7
Net calorific value $Q_{p,net,d}$	MJ/kg d	19,2	17,5 to 20,5	19	17,1 to 21,3
Carbon, C	% in mass d	52	48 to 55	52	47 to 55
Hydrogen, H	% in mass d	5,9	5,5 to 6,4	5,8	5,3 to 6,4
Oxygen, O	% in mass d	38	34 to 42	38	32 to 42
Nitrogen, N	% in mass d	0,5	0,3 to 0,9	0,3	0,1 to 0,8
Sulfur, S	% in mass d	0,03	< 0,02 to 0,05	0,03	< 0,02 to 0,20
Chlorine, Cl	% in mass d	0,02	< 0,01 to 0,05	0,02	< 0,01 to 0,05
Fluorine, F	% in mass d	0,001	< 0,000 5 to 0,002	not specified	not specified
Aluminium, Al	mg/kg d	800	400 to 1 200	50	30 to 100
Calcium, Ca	mg/kg d	5 000	1 000 to 15 000	15 000	10 000 to 20 000
Iron, Fe	mg/kg d	500	100 to 800	100	50 to 200
Potassium, K	mg/kg d	2 000	1 000 to 3 000	2 000	1 000 to 3 200
Magnesium, Mg	mg/kg d	1 000	400 to 1 500	500	400 to 1 000
Manganese, Mn	mg/kg d	500	9 to 840	190	not specified
Sodium, Na	mg/kg d	300	70 to 2 000	100	20 to 1 000
Phosphorus, P	mg/kg d	400	20 to 600	400	300 to 700
Silicon, Si	mg/kg d	2 000	500 to 5 000	2 500	2 000 to 20 000
Arsenic, As	mg/kg d	1,0	0,1 to 4,0	0,4	0,1 to 4
Cadmium, Cd	mg/kg d	0,5	0,2 to 1,0	0,5	0,2 to 1,2
Chromium, Cr	mg/kg d	5	1 to 10	5	1 to 30
Copper, Cu	mg/kg d	5	3 to 30	5	2 to 20
Mercury, Hg	mg/kg d	0,05	0,01 to 0,1,	< 0,05	not specified
Nickel, Ni	mg/kg d	10	2 to 20	10	2 to 10
Lead, Pb	mg/kg d	4	1 to 30	15	2 to 30
Vanadium, V	mg/kg d	1,0	0,7 to 2,0	2	1 to 4

Parameter	Unit	Bark from coniferous wood (1.1.6 and 1.2.1.5)		Bark from broad-leaf wood (1.1.6 and 1.2.1.5)	
		Typical value	Typical variation	Typical value	Typical variation
Zinc, Zn	mg/kg d	100	70 to 200	50	7 to 200
[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch and German research. Formulas how to calculate different bases are given in ISO 16993.					

Table A.3 – Typical values for virgin wood materials, logging residues

Parameter	Unit	Coniferous wood (1.1.4.2 and 1.1.4.4)		Broad-leaf wood (1.1.4.1 and 1.1.4.3)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	3,0	< 1 to 10	5,0	2 to 10
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	20,5	19,5 to 21,5	19,7	19,5 to 20,0
Net calorific value $Q_{p,net,d}$	MJ/kg d	19,2	18,5 to 20,5	18,7	18,3 to 18,5
Carbon, C	% in mass d	51	48 to 52	51	50 to 51
Hydrogen, H	% in mass d	6,0	5,7 to 6,2	6,0	5,8 to 6,1
Oxygen, O	% in mass d	40	38 to 44	40	40 to 43
Nitrogen, N	% in mass d	0,5	0,3 to 0,8	0,5	0,3 to 0,8
Sulfur, S	% in mass d	< 0,02	< 0,02 to 0,06	0,04	0,01 to 0,08
Chlorine, Cl	% in mass d	0,01	< 0,01 to 0,04	0,01	< 0,01 to 0,02
Fluorine, F	% in mass d	0,001	not specified	0,002	0,0 to 0,001
Aluminium, Al	mg/kg d	not speci-fied	not specified	250	1 to 3 000
Calcium, Ca	mg/kg d	5 000	2 000 to 8 000	4 000	3 000 to 5 000
Iron, Fe	mg/kg d	1 500	500 to 2 000	150	10 to 1 500
Potassium, K	mg/kg d	2 000	1 000 to 4 000	1 500	1 000 to 4 000
Magnesium, Mg	mg/kg d	800	400 to 2 000	250	100 to 400
Manganese, Mn	mg/kg d	130	80 to 170	120	10 to 800
Sodium, Na	mg/kg d	200	75 to 300	100	20 to 200
Phosphorus, P	mg/kg d	500	not specified	300	30 to 1 000
Silicon, Si	mg/kg d	3 000	200 to 10 000	150	75 to 250
Titanium, Ti	mg/kg d	not speci-fied	not specified	7	1 to 40
Arsenic, As	mg/kg d	0,6	0,2 to 1	1	0 to 2
Cadmium, Cd	mg/kg d	0,2	0,1 to 0,8	0,5	0 to 3
Chromium, Cr	mg/kg d	1	0,7 to 1,2	8	1 to 40
Copper, Cu	mg/kg d	10	10 to 200	10	1 to 100
Mercury, Hg	mg/kg d	0,03	not specified	0,02	0 to 2
Nickel, Ni	mg/kg d	1,6	0,4 to 3	10	1 to 80
Lead, Pb	mg/kg d	1,3	0,4 to 4	1,5	0,5 to 5
Vanadium, V	mg/kg d	0,6	0,1 to 1	0,5	0,1 to 3
Zinc, Zn	mg/kg d	20	8 to 30	50	2 to 100

Parameter	Unit	Coniferous wood (1.1.4.2 and 1.1.4.4)		Broad-leaf wood (1.1.4.1 and 1.1.4.3)	
		Typical value	Typical variation	Typical value	Typical variation
[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch, Spanish and German research. Formulas how to calculate different bases are given in ISO 16993.					

Table A.4 – Typical values for virgin wood materials, short rotation coppice

Parameter	Unit	Willow (Salix) (1.1.1.3)		Poplar (1.1.1.3)		Eucalyptus (1.1.1.3)	
		Typical value	Typical variation	Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	2,0	1,1 to 4,0	2,0	1,5 to 3,4	2,0	0,5 to 4,0
Gross calorific value $q_{V,gr,d}$	MJ/kg d	19,9	19,2 to 20,4	19,8	19,5 to 20,1	19,5	19,3 to 21,2
Net calorific value $q_{p,net,d}$	MJ/kg d	18,4	17,7 to 19,0	18,4	18,1 to 18,8	18,1	17,6 to 18,4
Carbon, C	% in mass d	48	46 to 49	48	46 to 50	49	46 to 52,7
Hydrogen, H	% in mass d	6,1	5,7 to 6,4	6,2	5,7 to 6,5	5,8	4,8 to 6,2
Oxygen, O	% in mass d	43	40 to 44	43	39 to 45	42	42 to 43
Nitrogen, N	% in mass d	0,5	0,2 to 0,8	0,4	0,2 to 0,6	0,5	0,1 to 1,4
Sulfur, S	% in mass d	0,05	0,02 to 0,10	0,03	0,02 to 0,10	< 0,02	< 0,01 to 0,11
Chlorine, Cl	% in mass d	0,03	0,01 to 0,05	< 0,01	< 0,01 to 0,05	0,1	< 0,09 to 0,18
Fluorine, F	% in mass d	0,003	0 to 0,01	not specified		< 0,01	< 0,01
Aluminium, Al	mg/kg d	50	3 to 100	10	not specified	10	1 to 14
Calcium, Ca	mg/kg d	5 000	2 000 to 9 000	5 000	4 000 to 6 000	1 200	900 to 3 000
Iron, Fe	mg/kg d	100	30 to 600	30	not specified	7	3 to 14
Potassium, K	mg/kg d	2 500	1 700 to 4 000	2 500	2 000 to 4 000	5 000	1 500 to 6 000
Magnesium, Mg	mg/kg d	500	200 to 800	500	200 to 800	400	380 to 1 500
Manganese, Mn	mg/kg d	97	79 to 160	20	not specified	not specified	
Sodium, Na	mg/kg d	not specified	10 to 450	25	10 to 60	50	20 to 85
Phosphorus, P	mg/kg d	800	500 to 1 300	1 000	800 to 1 100	500	90 to 1 000
Silicon, Si	mg/kg d	500	2 to 2 000	not specified		30	28 to 46
Titanium, Ti	mg/kg d	10	< 10 to 50	not specified		0,3	0,2 to 1,7

Parameter	Unit	Willow (Salix) (1.1.1.3)		Poplar (1.1.1.3)		Eucalyptus (1.1.1.3)	
		Typical value	Typical variation	Typical value	Typical variation	Typical value	Typical variation
Arsenic, As	mg/kgd	< 0,1	< 0,1	< 0,1	< 0,1 to 0,2	< 0,4	< 0,4
Cadmium, Cd	mg/kgd	2	0,2 to 5	0,5	0,2 to 1	0,1	< 0,2
Chromium, Cr	mg/kgd	1	0,3 to 5	1	0,3 to 2	0,4	< 1
Copper, Cu	mg/kgd	3	2 to 4	3	2 to 4	3	3 to 4
Mercury, Hg	mg/kgd	< 0,03	< 0,03	< 0,03	< 0,03	not specified	
Nickel, Ni	mg/kgd	0,5	0,2 to 2	0,5	0,2 to 1,0	1	0,3 to 3
Lead, Pb	mg/kgd	0,1	0,1 to 0,2	0,1	0,1 to 0,3	1	0,3 to 2
Vanadium, V	mg/kgd	0,3	0,2 to 0,6	not specified		0,3	< 0,5
Zinc, Zn	mg/kgd	70	40 to 100	50	30 to 100	6	< 10
[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch, Spanish, French and German research. Formulas how to calculate different bases are given in ISO 16993.							

Table A.5 – Typical values for virgin straw materials, with insignificant amounts of grains

Parameter	Unit	Straw from wheat, rye, barley (2.1.1.2)		Straw from oilseed rape (2.1.3.2)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	5	2 to 10	5	2 to 10
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	18,8	16,6 to 20,1	18,8	16,6 to 20,1
Net calorific value $Q_{p,net,d}$	MJ/kg d	17,6	15,8 to 19,1	17,6	15,8 to 19,1
Carbon, C	% in mass d	47	41 to 50	48	42 to 52
Hydrogen, H	% in mass d	6,0	5,4 to 6,5	6,0	5,4 to 6,5
Oxygen, O	% in mass d	41	36 to 45	41	36 to 45
Nitrogen, N	% in mass d	0,5	0,2 to 1,5	0,8	0,3 to 1,6
Sulfur, S	% in mass d	0,1	< 0,05 to 0,2	0,3	< 0,05 to 0,7
Chlorine, Cl	% in mass d	0,4	< 0,1 to 1,2	0,5	< 0,1 to 1,1
Fluorine, F	% in mass d	0,000 5	not specified	not specified	not specified
Aluminium, Al	mg/kg d	50	Up to 700	50	Up to 700
Calcium, Ca	mg/kg d	4 000	2 000 to 7 000	15 000	8 000 to 20 000
Iron, Fe	mg/kg d	100	Up to 500	100	Up to 500
Potassium, K	mg/kg d	10 000	2 000 to 26 000	10 000	2 000 to 26 000
Magnesium, Mg	mg/kg d	700	400 to 1 300	700	300 to 2 200
Manganese, Mn	mg/kg d	40	20 to 100	not specified	not specified
Sodium, Na	mg/kg d	500	Up to 3 000	500	Up to 3 000
Phosphorus, P	mg/kg d	1 000	300 to 2 900	1 000	300 to 2 700
Silicon, Si	mg/kg d	10 000	1 000 to 20 000	1 000	100 to 3 000
Titanium, Ti	mg/kg d	70	5 to 200	not specified	not specified
Arsenic, As	mg/kg d	< 0,1	< 0,1 to 2,0	< 0,1	< 0,1 to 0,5
Cadmium, Cd	mg/kg d	0,10	< 0,05 to 0,30	0,10	< 0,05 to 0,30
Chromium, Cr	mg/kg d	10	1 to 60	10	1 to 60
Copper, Cu	mg/kg d	2	1 to 10	2	1 to 10
Mercury, Hg	mg/kg d	0,02	< 0,02 to 0,05	0,02	< 0,02 to 0,05
Nickel, Ni	mg/kg d	1,0	0,2 to 4,0	1,0	0,2 to 4,0
Lead, Pb	mg/kg d	0,5	0,1 to 3,0	2,0	1,0 to 13,0
Vanadium, V	mg/kg d	3	1 to 6	not specified	not specified
Zinc, Zn	mg/kg d	10	3 to 60	10	5 to 20

[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch and German research. Formulas how to calculate different bases are given in ISO 16993.

Table A.6 – Typical values for virgin cereal grain materials

Parameter	Unit	Grain from wheat, rye, barley (2.1.1.3)		Grains from rape (2.1.1.3)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	2	1,2 to 4	4,3	3,75 to 5,5
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	18, 0	16,5 to 19, 6	28,1	27,5 to 29,0
Net calorific value $Q_{p,net,d}$	MJ/kg d	16,5	15,0 to 18,1	26,6	not specified
Carbon, C	% in mass d	45	42 to 50	60	not specified
Hydrogen, H	% in mass d	6,5	5,5 to 6,5	7,1	not specified
Oxygen, O	% in mass d	44	43 to 50	23	not specified
Nitrogen, N	% in mass d	2	not specified	3,8	not specified
Sulfur, S	% in mass d	0,16	0,05 to 0,1	0,1	not specified
Chlorine, Cl	% in mass d	0,11	0,05 to 0,5	0,07	0,01 to 0,15
Aluminium, Al	mg/kg d	not specified	< 20	not specified	not specified
Calcium, Ca	mg/kg d	600	100 to 1 200	5 000	3 200 to 6 400
Iron, Fe	mg/kg d	75	15 to 200	93	not specified
Potassium, K	mg/kg d	5 000	3 700 to 6 500	8 400	not specified
Magnesium, Mg	mg/kg d	1 400	1 000 to 2 100	2 600	not specified
Manganese, Mn	mg/kg d	30	9 to 60	39	not specified
Sodium, Na	mg/kg d	100	50 to 120	100	50 to 120
Phosphorus, P	mg/kg d	3 400	2 100 to 4 300	7 300	not specified
Silicon, Si	mg/kg d	50	10 to 200	not specified	not specified
Titanium, Ti	mg/kg d	not specified	< 50 to 100	not specified	not specified
Arsenic, As	mg/kg d	≤ 0,5	0,0 to 0,7	not specified	not specified
Cadmium, Cd	mg/kg d	0,01	0,0 to 0,7	not specified	not specified
Chromium, Cr	mg/kg d	0,5	< 0,5 to 1,0	not specified	not specified
Copper, Cu	mg/kg d	5	1,5 to 12	2,6	not specified
Mercury, Hg	mg/kg d	< 0,02	< 0,02	not specified	not specified
Nickel, Ni	mg/kg d	1,0	0,2 to 2,0	not specified	not specified
Lead, Pb	mg/kg d	0,9	≤ 0,1 to 1	not specified	not specified
Vanadium, V	mg/kg d	not specified	not specified	not specified	not specified
Zinc, Zn	mg/kg d	22	17 to 34	not specified	not specified

[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch, French (including rye) and German research. Formulas how to calculate different bases are given in ISO 16993.

Table A.7 – Typical values for virgin reed canary grass

Parameter	Unit	Summer harvest (July – Oct) (2.1.2.1)		Delayed harvest (March – May) (2.1.2.1)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	6,5	2,5 to 10	6,9	1,0 to 8,0
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	17,7	not specified	17,8	17,7 to 18,0
Net calorific value $Q_{p,net,d}$	MJ/kg d	16,6	not specified	16,5	16,5 to 17,0
Carbon, C	% in mass d	46	not specified	46	45 to 50
Hydrogen, H	% in mass d	5,7	not specified	5,8	5,7 to 6,2
Oxygen, O	% in mass d	40	not specified	42	40 to 43
Nitrogen, N	% in mass d	1,3	not specified	0,9	0,4 to 2,0
Sulfur, S	% in mass d	0,1	0,1 to 0,2	0,13	0,04 to 0,17
Chlorine, Cl	% in mass d	0,5	0,2 to 0,6	0,025	0,01 to 0,09
Aluminium, Al	mg/kg d	not specified	not specified	not specified	20
Calcium, Ca	mg/kg d	3 500	1 300 to 5 700	2 000	800 to 3 200
Iron, Fe	mg/kg d	not specified	not specified	140	60 to 220
Potassium, K	mg/kg d	12 000	3 100 to 22 000	2 700	< 800 to 6 000
Magnesium, Mg	mg/kg d	1 300	300 to 2 300	500	100 to 900
Manganese, Mn	mg/kg d	not specified	not specified	160	< 200
Sodium, Na	mg/kg d	200	< 100 to 400	200	< 20 to 400
Phosphorus, P	mg/kg d	1 700	500 to 3 000	1 100	300 to 2 000
Silicon, Si	mg/kg d	12 000	< 1 000 to 25 000	18 000	2 300 to 30 000
Arsenic, As	mg/kg d	0,1	< 0,1 to 0,2	0,2	< 0,1 to 0,5
Cadmium, Cd	mg/kg d	0,04	< 0,04 to 0,10	0,06	< 0,04 to 0,20
Chromium, Cr	mg/kg d	not specified	not specified	not specified	not specified
Copper, Cu	mg/kg d	not specified	not specified	not specified	not specified
Mercury, Hg	mg/kg d	0,03	< 0,02 to 0,05	0,03	< 0,02 to 0,05
Nickel, Ni	mg/kg d	not specified	not specified	not specified	not specified
Lead, Pb	mg/kg d	1,0	< 0,5 to 4,0	2,0	< 0,5 to 5,0

[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish and German research. Formulas how to calculate different bases are given in ISO 16993.

Table A.8 – Typical values for virgin grass in general (hay) and miscanthus

Parameter	Unit	Grass, in general (2.1.2.1)		Miscanthus (China reed) (2.1.2.1)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	7	4 to 10	4	1 to 6
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	18,0	18 to 20	19,0	17 to 20
Net calorific value $Q_{p,net,d}$	MJ/kg d	17,1	16 to 19	17,7	16 to 19
Carbon, C	% in mass d	46	45 to 50	47	46 to 52
Hydrogen, H	% in mass d	5,9	5 to 7	6,1	5 to 6,5
Oxygen, O	% in mass d	40	38 to 48	42	40 to 45
Nitrogen, N	% in mass d	1,3	1 to 2	0,7	0,1 to 1,5
Sulfur, S	% in mass d	0,2	0 to 0,5	0,2	0,02 to 0,6
Chlorine, Cl	% in mass d	0,7	0,02 to 1,3	0,2	0,02 to 0,6
Fluorine, F	% in mass d	0,001	0,001 to 0,003	0,002	0,001 to 0,003
Aluminium, Al	mg/kg d	200	20 to 300	100	50 to 200
Calcium, Ca	mg/kg d	3 500	2 500 to 5 500	2 000	900 to 3 000
Iron, Fe	mg/kg d	600	100 to 1 200	100	40 to 400
Potassium, K	mg/kg d	15 000	4 900 to 24 000	7 000	1 000 to 11 000
Magnesium, Mg	mg/kg d	1 700	800 to 2 300	600	300 to 900
Manganese, Mn	mg/kg d	1 000	200 to 2 600	20	10 to 100
Sodium, Na	mg/kg d	3 000	1 400 to 6 300	70	20 to 100
Phosphorus, P	mg/kg d	15 000	3 000 to 25 000	500	200 to 800
Silicon, Si	mg/kg d	not specified	not specified	8 000	2 000 to 10 000
Titanium, Ti	mg/kg d	not specified	not specified	5	3 to 10
Arsenic, As	mg/kg d	0,1	< 0,1 to 1,4	0,2	< 0,1 to 0,2
Cadmium, Cd	mg/kg d	0,20	0,03 to 0,60	0,10	0,05 to 0,2
Chromium, Cr	mg/kg d	1,0	0,2 to 3,0	1	0,4 to 6
Copper, Cu	mg/kg d	5	2 to 10	2	1 to 6
Mercury, Hg	mg/kg d	< 0,02	< 0,02 to 0,03	0,03	< 0,02 to 0,1
Nickel, Ni	mg/kg d	2,0	0,5 to 5,0	2	0,5 to 5
Lead, Pb	mg/kg d	1,0	< 0,5 to 2,0	2	< 0,5 to 5
Vanadium, V	mg/kg d	3	not specified	< 1	not specified
Zinc, Zn	mg/kg d	25	10 to 60	10	3 to 30

[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch and German research. Formulas how to calculate different bases are given in ISO 16993.

Table A.9 – Typical values for olive and grape cake

Parameter	Unit	Olive cake			Grape cake	
		Crude olive cake 3.2.1.4	Exhausted olive cake 3.2.2.4	Olive kernels/ stones 3.2.1.2	Crude grape cake 3.2.1.1	Exhausted grape cake 3.2.1.1, 3.2.2.1
Ash	% in mass d	10	3,4 to 11,3	0,3 to 2,0	4,5 to 11,2	6 to 13
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	19,4 to 21,4	18,1 to 21,6	18,6 to 20,8	19,3 to 22,0	
Net calorific value $Q_{p,net,d}$	MJ/kg d	18,1 to 20,7	13,9 to 19,2	15,2 to 18,2	16,7	19,0
Carbon, C	% in mass d	50	48 to 52	45,7 to 52,3	54	46,0 to 54,4
Hydrogen, H	% in mass d	6,9	4,6 to 6,3	6,1 to 6,8	6,8	5,8 to 7,5
Oxygen, O	% in mass d	30	33	38,5 to 42,1	not specified	not specified
Nitrogen, N	% in mass d	1,5	1,4 to 2,7	0,1 to 0,4	1,5	1,9 to 2,4
Sulfur, S	% in mass d	0,2	0,0 to 0,5	0,01 to 0,05	0,20	0,03 to 0,18
Chlorine, Cl	% in mass d	0,2	0,1 to 0,4	0,01 to 0,12	not specified	< 0,05
Aluminium	mg/kg d	1 250	2 700	559	not specified	not specified
Calcium, Ca	mg/kg d	6 900	17 200	968	not specified	not specified
Iron, Fe	mg/kg d	1 000	1 900	391	not specified	not specified
Potassium, K	mg/kg d	6 000 to 16 000	17 500	6 950	not specified	12 500 to 35 700
Magnesium, Mg	mg/kg d	3 400	4 000	316	not specified	not specified
Manganese, Mn	mg/kg d	< 26	17 to 44	12	not specified	14 to 36
Sodium, Na	mg/kg d	44 to 1 000	250 to 450	120	not specified	34 to 180
Phosphorus, P	mg/kg d	2 450	30 to 1 750	590	not specified	not specified
Silicon, Si	mg/kg d	14 to 6 600	20 to 11 850	9 to 3 500	not specified	not specified
Titanium,- Ti	mg/kg d	53	145	39	not specified	not specified
Arsenic, As	mg/kg d	0,4	4	<0,1 to 0,8	not specified	not specified
Cadmium, Cd	mg/kg d	< 0,1	< 0,5	< 0,1 to 0,2	not specified	0,05 to 0,18
Chromium, Cr	mg/kg d	3	3 to 13	< 1 to 3	not specified	0,73 to 1,54
Copper, Cu	mg/kg d	14	10 to 20	2.2 to 13	not specified	48 to 190
Mercury, Hg	mg/kg d	not specified	0,1	< 0,01	not specified	not specified
Nickel, Ni	mg/kg d	2	2 to 17	< 0,05 to 7,4	not specified	0,66 to 1,64

Parameter	Unit	Olive cake			Grape cake	
		Crude olive cake 3.2.1.4	Exhausted olive cake 3.2.2.4	Olive kernels/ stones 3.2.1.2	Crude grape cake 3.2.1.1	Exhausted grape cake 3.2.1.1, 3.2.2.1
Lead, Pb	mg/kg d	2	15	2,1	not specified	0,35 to 2,70
Vanadium, V	mg/kg d	not specified	5	not specified	not specified	not specified
Zinc, Zn	mg/kg d	19	19	1 to 9	not specified	not specified
Cobalt, Co	mg/kg d	not specified	1	not specified	not specified	not specified
Silver, Ag	mg/kg d	not specified	4	not specified	not specified	not specified
Tin, Sn	mg/kg d	not specified	4	not specified	not specified	not specified

[a] Data are obtained from a combination of mainly Austrian, Dutch, Italian, Greek and Spanish research. Formulas how to calculate different bases are given in ISO 16993.

NOTE 1 Crude olive cake is a by-product of the first industrial olive oil extraction process. The chemical composition can vary according to the pressing method utilized.

NOTE 2 Exhausted olive cake is a by-product of the second industrial olive oil extraction process that remains after oil extraction (chemical treatment from the above mentioned crude olive cake).

NOTE 3 Olive kernels is a by-product of the first industrial olive oil extraction process, by which a certain quantity of the olive cake produced is separated, giving as a result this high quality biofuel.

NOTE 4 Crude grape cake is a by-product that remains after the grapes have been pressed.

NOTE 5 Exhausted grape cake is a residual material, which remains after water or chemical treatment from crude grape cake.

Table A.10 – Typical values for fruit stones and shells

Parameter	Unit	Fruit stones and shells		
		Apricot, peach, cherry fruit stone 3.2.1.2	Almond, hazelnut, pinenut shells 3.1.3.2	Oil palm shell, nut, fibre
Ash	% in mass d	0,2 to 1,0	0,95 to 3,00	1,4 to 7,4
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	not specified	19 to 20	not specified
Net calorific value $Q_{p,net,d}$	MJ/kg d	19,5 to 22,9	17,5 to 19,0	18,0 to 24,8
Carbon, C	% in mass d	51 to 55	44 to 50	46,3 to 58,5
Hydrogen, H	% in mass d	5 to 7	5 to 6	5,9 to 12,6
Oxygen, O	% in mass d	43	40 to 45	43,0 to 50,2
Nitrogen, N	% in mass d	0,2 to 0,3	0,1 to 1,2	0,04 to 0,5
Sulfur, S	% in mass d	0,05 to 0,50	0,04 to 0,22	0,03 to 0,09
Chlorine, Cl	% in mass d	0,04	0,004 to 0,09	0,10 to 0,25
Aluminium, Al	mg/kg d	not specified	65	600 to 16 500
Calcium, Ca	mg/kg d	not specified	300 to1200	1 200 to 4 500
Iron, Fe	mg/kg d	not specified	58 to 66	2 000 to 13 400
Potassium, K	mg/kg d	not specified	1 500 to 1 750	2 800 to 21 000
Magnesium, Mg	mg/kg d	not specified	175 to 300	1 300 to 2 300
Manganese, Mn	mg/kg d	not specified	3 to 12	30 to 45
Sodium, Na	mg/kg d	not specified	62 to 73	30 to 40

[a] Data are obtained from a combination of mainly Austrian, Dutch, Italian, Greek, Spanish and Malaysian research. Formulas how to calculate different bases are given in ISO 16993.

Parameter	Unit	Fruit stones and shells		
		Apricot, peach, cherry fruit stone 3.2.1.2	Almond, hazelnut, pinenut shells 3.1.3.2	Oil palm shell, nut, fibre
Phosphorus, P	mg/kg d	not specified	79 to 82	500 to 2 000
Silicon, Si	mg/kg d	not specified	580 to 4 200	2 200 to 34 000
Titanium,Ti	mg/kg d	not specified	1 to 6	20 to 400
Zinc, Zn	mg/kg d	not specified	2,3 to 5,3	500 to 1 600
[a] Data are obtained from a combination of mainly Austrian, Dutch, Italian, Greek, Spanish and Malaysian research. Formulas how to calculate different bases are given in ISO 16993.				

Table A.11 – Typical values for selected types of husks, stalks, cotton gin trash and malva

Parameter	Unit	Rice husk 2.1.1.4	Cotton stalks 2.1.1.2	Cotton gin trash 2.1.1.2	Sunflower husk 2.1.6.2	Pensylvanian malva 2.1.6.2
Ash	% in mass d	13 to 23	6,0 to 6,7	1,6 to 9,4	1,9 to 7,6	2,8
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	14,7 to 6,6	15,8 to 18,3	16,4 to 17,5	18 to 23	19,0
Net calorific value $Q_{p,net,d}$	MJ/kg d	14,5 to 16,2			17 to 22	17,7
Carbon, C	% in mass d	38 to 43	39,5 to 47,0	39,6 to 43,7	51,5 to 52,9	not specified
Hydrogen, H	% in mass d	4,3 to 5,1	5,1 to 5,8	5,3 to 6,1	5,0 to 6,6	5,9
Oxygen, O	% in mass d	35 to 47	not specified	not specified	36 to 43	not specified
Nitrogen, N	% in mass d	0,1 to 0,8	0,65 to 1,25	0,2 to 2,9	0,6 to 1,4	not specified
Sulfur, S	% in mass d	0,02 to 0,10	0,02 to 0,21	not specified	0	0,05
Chlorine, Cl	% in mass d	0,03 to 0,3	0,08	not specified	0 to 0,1	0,02
Potassium, K	mg/kg d	2 800 to 4 300	not specified	not specified	not specified	not specified
Sodium, Na	mg/kg d	33 to 38	not specified	not specified	not specified	not specified
[a] Data are obtained from a combination of mainly Italian, Greek and Finnish research. Formulas how to calculate different bases are given in ISO 16993.						

ANNEX B
(Informative)

Examples of possible causes for deviant levels for different properties and consequences of handling and treatment for the properties of biomass

Table B.1 – Examples of possible causes for deviant levels for different properties

Property	Deviation	Possible causes
Ash, d	High value	Contamination with soil/sand Higher content of bark than specified (only wood) Inorganic additives Chemical treatments such as paint, preservation (only wood)
Net calorific value $Q_{p,\text{net,d}}$	Low value	High ash content Content of combustible material with lower calorific value as e.g. glues (only wood)
Net calorific value $Q_{p,\text{net,d}}$	High value	Content of combustible material with higher calorific value as e.g. resin, vegetable or mineral oils, plastic
N, d	High value	Higher content of bark than specified (only wood) Glue (only wood) Plastic (laminate)
S, d	High value	Higher content of bark than specified (only wood) Organic additives as corn flour, potato flour Additives containing sulfur compounds Treatment with chemicals containing sulfur, as sulfuric acid
Cl, d	High value	Higher content of bark than specified (only wood) Origin of biomass from coast near locations and exposed from seawater Contamination during storage/transportation by road salting Preservation chemicals (only wood)
Si, d	High value	Contamination with soil/sand Higher content of bark/needles/leaves than specified (only wood)
Ti, d	High value	Paint (only wood)
As, d	High value	Preservation chemicals
Cr, d	High value	Preservation chemicals Contamination with soil/sand
Cu, d	High value	Preservation chemicals Contamination with soil/sand
Hg, d	High value	Contamination with soil/sand
Cd, d	High value	Paint (only wood) Plastic Fertilizer (e.g. ash, sewage sludge (issued from waste water treatment or chemical process)

Property	Deviation	Possible causes
Ni, d	High value	Contamination from working up machinery Mineral oils
Pb, d	High value	Environmental contamination (e.g. traffic) Paint (only wood) Plastic Fertilizer (e.g. ash, sewage sludge (issued from waste water treatment or chemical process)

Note: Chemically treated wood waste that can contain halogenated organic compounds or heavy metals, is not included in the scope of this document. As the presence of such materials or the remains of other materials can occur accidentally, examples for these incidents are given also.

Table B.2 – Examples of consequences of handling and treatments for the properties of biomass

Circumstance	Possible consequences
Handling, storage or transportation	— increased content of ash and Si due to contamination with soil/sand (can also lead to decrease of ash melting; DT, especially if alkali (Na, K) present) — increased content of Cl due to contamination with road salting
Mechanical contamination	— increased content of metals as Fe, Cr and Ni from the working tools/machinery
Environmental contamination	— increased content of Cl due to deposition from the sea spray/fog — increased content of heavy metals as Pb and Zn due to exposition to society activities as traffic — increased content of Cd, Pb due to fertilizer (e.g. sewage sludge)
Additives (pellets and briquettes)	**Possible consequences**
Inorganic additives: Limestone Kaolin	— increased content of ash and Ca — increased content of ash, Si and Al
Organic additives: Other solid biomass Vegetable oils	— changes, depending on type and quality of the particular material. Higher amounts of e.g. corn or potato flour can cause increased content of e.g. ash and S — increased calorific value
Chemical treatments	**Possible consequences**
Glue	— increased content of N — decreased calorific value
Lye	— increased content of Na
Paints [a]	— increased content of ash — increased content of metals as Pb, Ti and Zn depending of the actual pigments
Plastics (laminate) [a]	— increased calorific value — increased content of N (e.g. ABS or celluloid plastics) — increased content of Cl or F (e.g. PVC or polytetrafluoroethylene (PTFE) plastics) — increased contents of metals as Cd, Pb, Zn depending of the content of additives in the plastic

Circumstance	Possible consequences
Preservations [a]	— increased content of ash — increased content of As, B, Cl, Cr, Cu, F, P or Zn depending of the used type of preservation chemical
Sulfuric acids	— increased content of S
[a] Chemical treatments containing halogenated organic compounds (as Cl, F) or heavy metals (as As, Pb) is not included in the scope of the document.	

ANNEX C
(Informative)

Calculation of the net calorific value at different bases and energy density as received

C.1 The net calorific value of dry basis

The net calorific value at a constant pressure for a dry sample (dry basis, in dry mattter) is delivered from the corresponding gross calorific value at a constant volume according to Formula (C.1).

$$q_{p,net,d} = q_{V,gr,d} - 212.2 \ x \ 0.8[w(O)_d + w(N)_D] \quad \text{(C.1)}$$

Where

$Q_{p,net,d}$	is the net calorific value for dry matter at a constant pressure in joules per gram(J/g) or kilojoules per kilogram (kJ/kg);
$Q_{V,gr,d}$	is the gross calorific value for dry matter at a constant volume in joules per gram(J/g) or kilojoules per kilogram (kJ/kg);
$w(H)_d$	is the hydrogen content, in percentage by mass, of the moisture-free (dry) biofuel (including the hydrogen from the water of hydration of the mineral matter as well as the hydrogen in the biofuel substance);
$w(O)_d$	is the oxygen content, in percentage by mass, of the moisture-free biofuel;
$w(N)_d$	is the nitrogen content, in percentage by mass, of the moisture-free biofuel.

For the calculation of the net calorific value as received using Formula (C.2), the result from Formula (C.1) in joules per gram (J/g) or kilojoules per kilogram (kJ/kg), shall be divided by 1000 to get the result in megajoules per kilogram (MJ/kg).

Note: $[w(O)_d + w(N)_D]$ can be derived by subtracting from 100 (% in mass) the percentages of ash, carbon, hydrogen and sulfur.

C.2 The net calorific value as received

a) Calculation from dry basis
The net calorific value (at constant pressure) as received (the moist biofuel) can be calculated on the net calorific value of the dry bases according to Formula (C.2).

$$Q_{p,net,ar} = Q_{p,net,d} \ x \left(\frac{100-M_{ar}}{100}\right) - 0.02443 \ x \ M_{ar} \quad \text{(C.2)}$$

Where

$Q_{p,net,ar}$	is the net calorific value (at constant pressure) as received in megajoules per kilogram (MJ/ kg);

$Q_{p,net,d}$ is the net calorific value (at constant pressure) in dry matter in megajoules per kilogram (MJ/kg);

M_{ar} is the moisture content as received [% in mass].
0.02443 is the correction factor of the enthalpy of vaporization (constant pressure) for water (moisture) at 25°C (in megajoules per kilogram (MJ/kg) per 1% in mass of moisture).

b) Calculation from dry and ash-free basis
The net calorific value (at constant pressure) on as received (the moist biofuel) can be calculated from a net calorific value of the dry and ash-free bases according to Formula (C.3).

$$Q_{p,net,ar} \left[Q_{p,net,daf}\, x \left[\frac{100- A_d}{100}\right] x \left[\frac{100- M_{ar}}{100}\right]\right] - 0.02443\, x\, M_{ar} \quad \text{(C.3)}$$

Where

$Q_{p,net,ar}$ is the net calorific value (at constant pressure) as received, in megajoules per kilogram (MJ/kg);
$Q_{p,net,daf}$ is the net calorific value (at constant pressure) in dry and ash-free basis, in megajoules per kilogram (MJ/kg);
M_{ar} is the moisture content as received [% in mass].

A_d is the ash content in dry basis (% in mass)

0.002443 is the correction factor of the enthalpy of vaporization (constant pressure) for water (moisture) at 25°C (in megajoules per kilogram (MJ/kg) per 1% in mass of moisture).

In both the above cases a) and b), the calorific value can be either determined for that particular lot or a typical value can be used.

1) If the ash content of the fuel is low and rather constant, the calculation can be based on the dry basis equation with a typical value of $Q_{p,net,d}$;

2) If the ash content varies quite a lot (or is high) for the specific biofuel then using the equation for dry and ash-free basis with a typical value of $Q_{p,net,daf}$ is preferable.

The result shall be reported to the nearest 0.01 MJ/kg.

C.3 Energy density as received

The wood fuels for small-scale heating plants and households are traded usually on a volume basis and the energy content (net calorific value) is specified often as megawatt hours (MWh) per bulk volume. Bulk density and moisture content are measured or estimated.

The energy density as received can be calculated according to Formula (C.4)

$$E_{ar} = \frac{1}{3600}\, x\, Q_{p,net,ar}\, x\, BD_{ar} \quad \text{(C.4)}$$

Where

E_{ar} is the energy density of the biofuel as received, in megawatts hour per cubic metre (MWh/ m3) of bulk volume;

$Q_{p,net,ar}$	is the net calorific value (at constant pressure) as received, in megajoules per kilogram (MJ/kg);
BD_{ar}	is the bulk density, i.e. volume weight of the biofuel as received, in kilograms per cubic metre (kg/m3) of bulk volume;
$\frac{1}{3600}$	is the conversion factor for the energy units (megajoules (MJ) to megawatts hour (MWh)).

The result shall be reported to the nearest 0.01 MWh/m^3. The values of net calorific value and bulk density used in equations can be either measured or based on typical values of biofuels. The typical net calorific values of solid biofuels are reported in Annex A of this document.