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Abbreviations

BEE	Biomass Energy Europe
DFBG	Dual Fluidized Bed Gasification
RED	Renewable Energy Directive
NUTS	Nomenclature of territorial units for statistics
TRL	Technology Readiness Level
BtL	Biomass to Liquid
EU	European Union
EU28	European Union (28 member states)
WP	Work Package

Contents

Executive Summary

Within this document, the feedstock selection and characterization of the BioSFerA project takes place. The feedstock selection was based on the fulfilment of three main prerequisites: availability/sustainability i.e. capacities for large scale applications, favourable technical characteristics for good performance at the integrated BioSFerA system and market competitiveness.

At first, an extended screening of biogenic residues around Europe was carried out and a general feedstock placement in terms of capacities around Europe has been performed. Utilizing literature data as well as taking advantage of the experience of the consortium in technical matters (e.g. gasification), but also supply chains and logistics models for agro-biomass, the most important technical & market criteria have been identified.

At least four (4) types of feedstock that comply with the overall requirements are selected and characterized in terms of ultimate & proximate analysis and ash composition. The selected feedstock types as well as additional reliable and already tested fuels that are attached also in the present document will be the basis for the forthcoming bench scale gasification tests (Task 3.1), the development of sustainable real-case scenarios (Task 2.4) and the full-process basic definition (Task 2.5).

The analyses certificates for the feedstock characterization are attached in the Annexes.

1. Introduction

The objective of this deliverable is the extended screening of biogenic residues all around Europe and the election of at least four types of feedstock as the most promising input for BioSFerA project in terms of capacity, technical characteristics & market price. Fuel characterization for the selected types of feedstock will be performed including proximate & ultimate analysis and ash composition. The selected feedstock will be the basis for subsequent project activities such as the development of sustainable real-case scenarios (D2.4), the bench scale gasification tests (D3.1) as well as the process basic definition (D2.5).

1.1. Biomass definition and types of biomass potentials

Biomass is defined as the biodegradable fraction of products, waste and residues of biological origin from agriculture (including vegetal and animal substances), forestry and related industries, including fisheries and the aquaculture, as well as the biodegradable fraction of industrial and municipal wastes. The main constituents of plant biomass are cellulose, hemicellulose, lignin and proteins. Woody plants are typically characterized as slowly growing species composed of tightly bound fibers, which gives hard external surface while herbaceous plants are usually perennial species, composed of more loosely bound fibers. This indicates that herbaceous plants have a lower percentage of lignin in their structure, which is responsible for binding bounds cellulosic fibers. The higher ratio of cellulose and hemicellulose to lignin in given biomass, the higher the gaseous product yields from potential gasification, and therefore, the relative quantity of cellulose and lignin in plant material is one of the factors which determines the suitability of plant species for being used as energy source. Biomass can be classified according to its origin, nature or its energy application. Focused on its origin, biomass can be categorised into a) residual biomass, b) produced biomass and c) biomass from agricultural surpluses [1], [2].

In general terms, the residual biomass is referred to any material that has been generated as a consequence of a human or animal activity but has not generated any economic value in the context and its energy use can turn a residue into a by-product. In this category, the agricultural biomass holds the lions share and it is expectable since agriculture consists one of the most profitable economic activities in the world. However, the residual forestry biomass concentrates vast amounts of residues around the world which in align with the agricultural biomass represent the two main biomass resources around the world. Among them, the agroforestry industry also produces residual biomass during its productive processes, particularly those for olive oil extraction, wine making and wood processing [3],[4]. Moreover, wastes from intensive livestock operations, from poultry farms, pig farms, cattle farms and slaughterhouses are also considered as biomass residues. This potential derives during the raising of sheep, lambs and goats. Since their wastes are scattered, they cannot be used for energy purposes such as large scale biofuel production. For that reason, this deliverable is not dealing with the last category of residual biomass [5].

So far, several biomass potential studies have been carried out, in the frame of EU funding projects, in order to improve the accuracy and comparability of future biomass resource assessments. Since the approaches that were adopted were different, the results from these studies are difficult to be compared and interpreted. The Biomass Energy Europe (BEE) project [6] was developed in response to this. It provides a wide overview of state-of-the-art biomass resource assessments and it also proposes several generic approaches, definitions, conversions and a classification of biomass feedstock types in order to improve the accuracy and comparability of future biomass resource assessments[7]. Following the same pattern, other projects like the EuroPruning [8] focused on the categorisation of the pruning residues, while the S2BIOM [9] approach added to the merely statistical methods for spatial disaggregation and utilised data sources both from national and from subnational level.

Nevertheless, based on the BEE assessment five types of biomass potentials are commonly distinguished and presented in Table 1.

Table 1. Types of biomass potentials according to BEE project [1],[10].

Type of potential	Definition
Theoretical potential	*The overall maximum amount of terrestrial biomass which can be considered theoretically available for bioenergy production within fundamental bio-physical limits. In the case of biomass from crops and forests, the theoretical potential represents the maximum productivity under theoretically optimal management taking into account limitations that result from soil, temperature, solar radiation and rainfall. In the case of residues and waste, the theoretical potentials equal the total amount that is produced.*
Technical potential	*The fraction of the theoretical potential which is available under the regarded techno-structural framework conditions with the current technological possibilities (such as harvesting techniques, infrastructure and accessibility, processing techniques). It also takes into account spatial confinements due to other land uses (food, feed and fibre production) as well as ecological (e.g. nature reserves) and possibly other non-technical constraints.*
Economic potential	*The share of the technical potential which meets criteria of economic profitability within the given framework conditions.*
Implementation potential	*The fraction of the economic potential that can be implemented within a certain time frame and under concrete socio-political framework conditions, including economic, institutional and social constraints and policy incentives. Studies that focus on the feasibility or the economic, environmental or social impacts of bioenergy policies are also included in this type.*
Sustainable implementation potential	*The result of integrating environmental, economic and social sustainability criteria in biomass resources assessment. This means that sustainability criteria act like a filter on the theoretical, technical, economic and implementation potentials leading in the end to a sustainable implementation potential. Depending on the type of potential, sustainability criteria can be applied to different extents.*

From all the mentioned types of biomass potentials, the most common is the technical biomass potential since it can cover a wider range of bio economy uses and this is the basic potential on which largely the BioSFerA feedstock screening is based.

1.2. BioSFerA and biogenic feedstock

Within BioSFerA concept, the thermochemical and subsequent biological treatment of biogenic residues aims to yield drop-in liquid biofuels for aviation and maritime use. Thanks to the Dual Fluidized Bed Gasification technology (DFBG) developed by VTT, the process can be driven feedstock-flexible using a broad and variable portfolio of biogenic residues which may be lower quality carbon sources compared to the sugar-, starch- and oil plants used for conventional liquid biofuels, but nevertheless do not come in conflict with food production and tend to avoid land use restrictions. Using biogenic residues also has the advantage of being in line with the EU's biofuels policy documented in the RED II [11] directive, mentioning the promotion of residue based biofuels (or so-called advanced biofuels).

Therefore, BioSFerA feedstock screening and selection will refer to any biomass available for non-food use which can be produced and harvested given state-of-the-art technologies and practices. Since the BioSFerA project aims for demonstrating DFBG of biogenic residues and establish a feedstock-flexible technology, the consortium is called to have always on mind the constraints regarding the market penetration and scaling potential of the selected feedstock-to-end use chains. Feedstock supply chains [12] often represent the lion's share in bioenergy deployment costs and especially when also considering seasonal aspects for feedstock sourcing and pricing, major obstacles regarding the economic feasibility and upscaling potential may arise. The DFBG feedstock flexibility along with the higher durability of the BioSFerA biological part in feedstock contaminants compared to conventional fuel synthesis units (e.g. Fischer-Tropsch), enables the carry out of an extended feedstock screening that targets to sustainable and cost-effective supply chains. A balance between the best performing feedstock and the highest market potential must be found and direct initially the feedstock selection (Task 2.3) and subsequently the feasible implementation scenarios (Task 2.4) development.

In the upcoming sections of this deliverable, a classification of possibly relevant biogenic residues and biogenic carbon carriers is performed, their capacity around Europe is investigated with the aid of S2BIOM toolset in a scalable way (area – country – specific region), and after combining their technical and market specifications with the relative partners' extensive experience, four basic types of biogenic feedstock are selected and characterized. Moreover, some additional already tested types of feedstock are elected as substitutes, able to secure high-quality gasification and strengthen supply chains based on co-gasification potential. Samples from all selected feedstock types are characterized and compared against bibliographic data in order their representativeness to be checked. The stoichiometric analysis & characterization of selected feedstock has been carried out according to international solid fuels measurement standards.

At this point, it has to be mentioned that, within BioSFerA project, there was the intention to involve also in the feedstock selection the biodegradable fraction of airports & ports derived wastes. This would not only reduce the process feedstock cost but would also open up new possibilities in the immature and disproportionate waste management system of these very 'waste-productive' fields. However, due to COVID-19 outbreak, the access to these grounds proved impossible and therefore the wastes involvement at this stage of the project was abandoned. An alternative approach based on simulated waste fraction containing plastics and biogenic material, which resembles to airport/ship waste, will be re-investigated in next stages (Task 3.1). Since this issue had not yet been concluded when this deliverable was submitted, the analysis on biogenic wastes and composition was not performed. If needed, this will be added in deliverable 'D2.4: Determination of the main input parameters for the case studies', in which the basic aspects of the examined scenarios will be presented in detail.

2. Feedstock screening and selection

2.1. Biomass categorization and potential capacities in Europe

An internationally accepted classification of feedstock types as well as their traded forms and raw materials can be found in the ISO 17225-1:2014 standard on 'solid biofuels – fuel specifications and classes' [13]. This list represents the best starting-point for the discussion of woody-, herbaceous-, fruit- and aquatic biomass. Taking into consideration this data and aligned with the S2BIOM project findings, a classification of potentially BioSFerA suitable feedstock is set and a relevant list is generated.

Concerning the S2BIOM project and especially its platform [14], on which BioSFerA feedstock selection remarkably relied on, aims to support the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through developing strategies and roadmaps that will be informed by a 'computerized and easy to use' toolset (and respective databases) with updated harmonized datasets at local, regional, national and pan European level for EU28, Western Balkans, Moldova, Turkey and Ukraine. These databases comprise the sustainable supply and cost of lignocellulosic biomass from forestry, actual energy cropping, agricultural residues and secondary residues from wood and food industry as well as from waste. Data are provided for 2012, 2020 and 2030 for several potentials including: the technical potential, a base potential considering currently applied sustainability practices, and further potential levels that are determined considering changing sustainability restrictions.

The NUTS classification (Nomenclature of territorial units for statistics)[15] is a hierarchical system for dividing up the economic territory of the EU and the UK for the purpose of:

a) The collection, development and harmonisation of European regional statistics as well as,
b) Socio-economic analyses of the regions.
    - NUTS 0/NUTS 1: major socio-economic regions
    - NUTS 2: basic regions for the application of regional policies
    - NUTS 3: small regions for specific diagnoses

Supply and cost data are provided on NUTS 3 level per single category and expressed in tonnes (dry matter or as received). Based on this classification, a 3D illustration of which is shown in Figure 1, and depending on the analysis level that is targeted each time for the final identification of the potential feedstock capacities in Europe, a wide data gathering is achieved displaying all the needed information of the specific feedstock types around Europe.

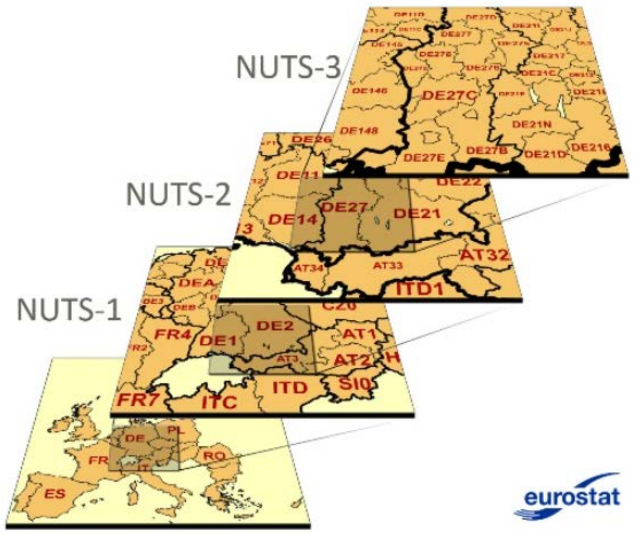


Figure 1. NUTS 2016 classification [15].

The set up of the S2BIOM database was based on different methods and guidelines for the biomass potential assessment as developed within the projects BEE, EUROPRUNING [8], EUWOOD [16], BIOMASS POLICIES [17]. Following these guidelines S2BIOM project managed to categorize the available residual biomass around Europe in forestry residues, secondary residues from wood industry, primary residues from agriculture, secondary residues from agriculture, biomass from municipal waste and waste from wood. A more detailed description of these categories (including their subcategories) is presented in Table 2.

Table 2. Overview of the potential categories and the potential types of residual biomass [10].

Category	Subcategory	Type
Primary residues from forests	Logging residues from final fellings &thinnings	Logging residues from final fellings from conifer and nonconifer trees
		Logging residues from thinnings from conifer and nonconifer trees
	Stumps from final fellings & thinnings	Stumps from final fellings from conifer and nonconifer trees
Secondary residues from wood industries	Saw mill residues	Sawdust (conifers/nonconifers)
		Other residues (conifers/nonconifers)
	Other wood processing industry residues	Residues from industries producing semi-finished wood based panels
		Residues from further wood processing
	Secondary residues from pulp and paper industry	Bark
		Black liquor
Agricultural residues	Straw/stubbles	Cereals straw
		Maize stover
		Sunflower straw

		Rice straw
		Oil seed rape straw
		Sugarbeet leaves
	Woody pruning & orchards residues	Residues from olive trees plantations
		Residues from vineyards
		Residues from fruit tree plantations
		Residues from citrus tree plantations
		Residues from nuts plantations
Secondary residues from industry utilizing agricultural products	By-products and residues from food and fruit processing industry	Olive-stones
		Rice husk
		Cereal bran
		Pressed grapes dregs
		Other food processing residues
Municipal waste	Biodegradable municipal waste	Biowaste separately and unseparately collected
Waste from wood	Post consumer wood	Hazardous and Non hazardous post consumer wood

From the previous overview of residual biomass and according to EN standards, (European Standards for solid biofuels like EN15234 and EN14961), it can be observed that the classification of solid biofuels is based on the origin and source. Woody biomass includes trees, bushes, and shrubs while herbaceous biomass includes plants that have non-woody stem and which die back at the end of the growing season. Figure 2 summarizes gives an insight detail view of the woody biomass classification based on plantation, by-products and final used wood [18].

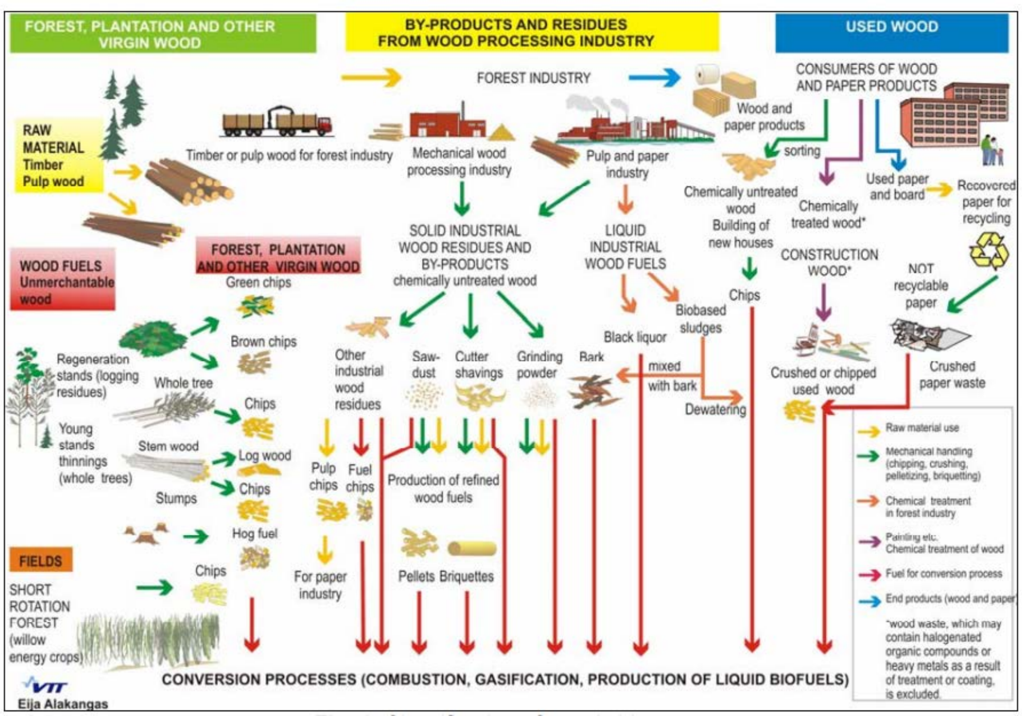
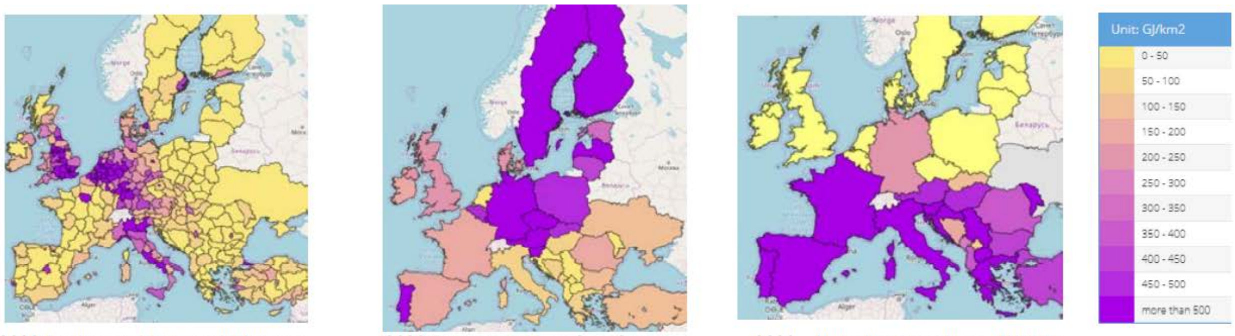


Figure 2. Woody biomass classification [18].

Based on the categorization developed in Table 2, BioSFerA project targets to determine the most appropriate feedstock, able to cover the project needs but mainly to support the technology upscaling from the technical as well as the financial point of view. The predictive potential of biogenic residues in Europe, indicates that there is suitable ground in terms of capacity in order sustainable supply chains to be built and efficient full-scale gasification plants that could potentially benefit from. (Figure 3)



2030-Biodegradable municipal waste – Biowaste separately collected

2030-Primary residues from forests – Logging residues from final fellings & thinnings – conifer trees

2030 - Agricultural residues – Woody pruning & orchards residues – vineyards

Figure 3. 2030 technical potential energy value- area weighted [19],[10].

Taking advantage of the wide consortium scattering around Europe as well as their experience on supply chains and logistics models for agro-biomass and waste, a preliminary feedstock placement around Europe was carried out and presented in Table 3.

Table 3.Potential feedstock relied on the experience of the consortium.

Region of Europe	Country	Candidate feedstock	Representative partners
North	Finland	Forestry residues	VTT/SFW
South-East	Greece	Agricultural residues (olive tree, fruit tree, vineyard), Biowastes (ports/airports)	CERTH/NTUA
South-West	Spain	Agricultural residues (olive tree, straw, vineyard)	CARTIF/CSIC
South-Middle	Italy	Biowastes, Agricultural residues (olive tree, straw, vineyard)	RINA-C/ENVIPA
Central	Belgium-Netherlands	Biowastes (ports/airports), Agricultural residues (vineyard)	KPRT/BBEPP

A more focused screening for the specific countries and the relative feedstock has been performed and the results are presented in Table 4. It should be mentioned, that for the specific screening the administrative level of analysis was the NUTS 0 level (which corresponds to the national level for a statistical analysis). In this step of the orientation of the potential feedstock types, an analysis at national level is expected to navigate the feedstock selection in terms of capacity and sustainability.

At first glance, the initial estimates concerning feedstock types and capacities around Europe (Table 3) seem to be confirmed. As seen in Table 4, all of the Mediterranean countries present very high concentrations of agricultural residual biomass, while Nordic countries and especially Finland exhibit high numbers of forestry residues.

Table 4.Results from the first screening of the specific feedstock types around Europe [14].

CATEGORY	SPAIN	ITALY	GREECE	FINLAND
Administrative level: NUTS 0				
Agricultural residues	**Weight: Absolute (kton dm)**			
Woody pruning & orchards residues				
Residues from vineyards	**617**	**737**	93	0
Residues from olive tree plantations	**2955**	**1334**	**1165**	0
Residues from citrus tree plantations	565	220	73	0
Residues from fruit tree plantations	738	470	211	5
Straw/Stubbles				
Cereal straw	**14210**	**6448**	**2021**	**3279**
Maize stover	**1666**	**5692**	1227	0
Sunflower straw	1932	435	208	0
Rice straw	867	1556	255	0
Oil seed rape straw	139	11	0	100
By-products & residues from food and fruit processing industry				
Olive stones	**633**	**327**	**182**	0
Rice husk	191	297	51	0
Cereal bran	**2852**	**1838**	**394**	**519**
Primary residues from forests				
Logging residues from final fellings &thinnings				
Logging residues from final fellings from nonconifer trees	859	2261	156	774
Logging residues from thinnings from nonconifer trees	312	534	155	705
Logging residues from final fellings from conifer trees	1801	356	197	**5629**
Logging residues from thinnings from conifer trees	1248	432	197	**3454**
Stumps from final fellings & thinnings				
Stumps from final fellings from nonconifer trees	1339	3444	0	1070
Stumps from final fellings from conifer trees	2655	463	131	7274
Primary production from lignocellulosic biomass crops				
Short rotation coppice				
SRC Willow	272	1024	0	0
Municipal waste				
Biodegradable municipal waste				
Biowaste unseperately collected	7599	4772	1781	612
Biowaste seperately collected	1900	7159	198	408

In particular, the Mediterranean countries, always in respect of their size, present accumulations of both olive tree prunings and olive stones. A fact quite expectable, since Spain, Italy and Greece consist the top three olive producers in the world. Furthermore, these countries also specialized in the wine sector and this is the reason why the residues from vineyards come up with high numbers. Finally, the Mediterranean countries show particular fertility in the long season cultivations especially in wheat, barley, oats, rye and maize. One of the main reasons is the microclimate that prevails in these areas and ultimately creates these vast amounts of cereal straw (along with the cereal bran which in essence is a basic by-product of the food and fruit processing industry).

Regarding Finland, the highest quantities of residual biomass are found on the logging residues (final fellings & thinnings) from conifer trees. Countries of Scandinavia and the Nordic Region are offered ideally for forest valorization. Forestry residues as well as residues from the wider wood industry (e.g. sawdust) are sourced in a potentially sustainable way. On the other hand, the grain sector for Finland is not as competitive as it is for the Mediterranean countries. The productivity of agricultural land differs somewhat from European growing conditions due to Finland's northerly location. Moreover, the productivity of agricultural land is weaker and the growing season is clearly shorter.

2.2. Criteria for feedstock selection

Selection criteria have been discussed within the consortium, considering on the one hand the technical requirements that would ensure smooth and efficient process all along the value chain, and on the other hand the market requirements that would pave the way for a higher TRL towards commercialization.

2.2.1. Technical assessment

The biomass feedstock has physical and compositional differences: heating value, moisture, ash content, bulk density or chemical composition. For example, low ash and moisture feedstock contents mean higher heating values and are subsequently preferred from the technical point of view since they lead to higher process efficiencies. With high biomass moisture content, the overall calorific value of the produced gas decreases due to the energy required to evaporate the additional water before combustion and gasification takes place. Biomass should be preheated or dried up to moisture content between 10-20% or lower, before it enters the gasifier. Circulating and bubbling fluidized bed reactor types both work optimally within the moisture range of 10-15%, even if they are functional also in higher water concentrations [20].

Moreover, particle size distribution and bulk densities should be considered, especially when talking about gasifier feeding system and its fluidized conditions. Smaller particle sizes exhibit higher total gas yields, lower char/ tar yields and more homogeneous product composition in overall. Furthermore, feedstock with smaller particles have higher porosity and larger specific surface area, which results in higher chemical reaction rates [21]. In general, the feedstock physical properties, like moisture content and bulk density, can be improved by means of pretreatment (i.e. drying, chopping, chipping, pelleting, etc.), since these kinds of processes don't affect chemical composition. In BioSFerA project, it will be attempted the feedstock preparation in a form that is already appropriate to be gasified in the piloting tests (e.g. pellets) and to produce reliable and reproducible gasification results. Preprocessing is required to avoid feeding problems in the bench- and pilot scale tests. Preprocessing requirements are lower in a commercial scale unit, and therefore the costs related to pelletizing can be avoided.

Another crucial issue concerning the technical feedstock characteristics, is its inorganic content [22], [23]. Many of the problems in thermochemical processes are related to its quantity and behavior. The compositional differences in the inorganic matter influence destiny of elements in the gasification process and also the behavior of the produced ashes. A high concentration of alkali metals (Na, K) leads to a low melting/sintering point of ash. The sintered ash limits the maximum gasification temperature and taking into consideration that in low gasification temperatures excessive tar formation can be observed, it can be realized that melted ash and ash handling in general can be proved a critical problem. The ash fusion temperature gives an indication of the extent of ash agglomeration and clinkering within the gasifier. Therefore, the selected fuels for the gasification process should preferably have low ash content and more specifically, below 5%. Low gasification temperature also leads into formation of larger amounts of inert char. In the DFBG process this changes the energy balance between the two reactors as more combustible char is fed into the oxidizing reactor.

Other parameters that should be taken into attention are the sulfur, nitrogen and chlorine feedstock content. Sulfur content must be considered as a key element, not only because of its interactions with other elements in the gasifier bed, but also by its H2S-release to the product gas, which is a highly toxic gas. On the other hand, the microbes involved in the biological part of the BioSFerA project are assumed to be tolerable towards sulfur compounds, meaning that feedstock with relative high sulfur content (e.g. sunflower husk) which would be avoided from other catalytic-based BtL technologies, will not be excluded. Nitrogen also could be useful for the microbes in certain forms, but potential HCN production would demand special treatment. All these parameters will be better clarified within WP3 activities, where bench scale tests, concerning gasification but also the gas fermentation integration, will take place.

Table 5. Main technical parameters for biogenic feedstock

Technical criteria
Heating value
Moisture content
Elemental composition (gasification behavior)
Ash content & composition (e.g. alkali metals)
Sulfur, Chlorine, Nitrogen content
Bulk density & particle size distribution

2.2.2. Market assessment

Wood-based fuels represent a main source of bioenergy. Major share of wood fuels is derived from the by-products of the forest industry, including black liquor derived from the pulp-making process as well as bark, sawdust and other industrial wood residues. VTT has estimated that in 2020, the availability of forest biomass residues in terms of cost and market placement will be divided as follows [24]:

- logging residues from final felling based on cost level 11-14 €/MWh
- stumps and roots based on cost level 14-18 €/MWh
- forest wood from young stands and first thinning based on cost level 18-25 €/MWh
- sawdust lies on the range of 16-18 €/MWh

In the forestry sector, residue bark from coniferous species, like spruce and pine, is considered as the most promising source, while in the agricultural sector wheat straw leads the potential and maybe represents the most important lignocellulose residue in EU [25]. The costs of straw collection at field is estimated to be in the range of 30-50 €/ton dry matter corresponding to 10-15 €/MWh. However, the costs of storage and transportation may very easily overcharge and significantly burden the reported prices. The power plants which have used straw are generally able to pay a lower price than for wood feedstock (< 20 €/MWh).

Concerning the raw biomass processing, pelletizing is the most widely used process for the production of high density, solid energy carriers from biomass. Wood pellets are usually made from by-products of the forest industry, mostly produced from sawdust and wood shavings compressed under high pressure using no glue or other additives. They are a woody biofuel shaped in a cylindrical form with length, typically 3.15 to 40 mm, with a diameter of about 6 or 8 mm, and broken ends. The main advantages of the biomass pellets, compared to the raw biomass, are their higher energy density, homogeneous quality, improved storage properties and better applicability for different uses like gasification. A typical energy content is 16.5 MJ/kg with a mass density of 650 kg/m^3. The production costs of wood pellets depend on the feedstock source and on the requirements of drying but can be estimated to vary in the range of 20-40 €/MWh [26].

The global wood pellet production for 2018 is estimated around 50 million tons. USA is the largest producer (12 million tns), followed by Canada (4 million) while within the EU28, that has the lion's share in global pellet production (30%), Germany (3.8 million) and Sweden (2.3 million) are the main sources [27]. Regarding China, the production seems to expand rapidly, but considering the size of the country and the fact that is a country of mainly small producers, it is very complicated to obtain accurate statistics. Concerning the consumption (industrial, commercial & residential), the EU28 remains by far the largest consumer in the world, presenting a 2 million tones growth in pellets utilization with the industrial use of pellets being led by the UK. The residential and commercial use of pellets is led by Denmark, with the country possessing the highest rate of pellet consumption per inhabitant mainly through district heating. EU pellet imports being sourced mostly from the US and Canada, as well as from bordering European countries (mainly Russia).

Moreover, wood chips can be used for energy purposes. They can be either sourced from recovered/waste wood or from harvesting residues such as branches, tops, thinning or other inferior wood not suitable for material or pulp and paper production. Although typical energy content and density (12.5 MJ/kg & 220 kg/m^3) are lower than for wood pellets, international trade is still feasible especially for shorter trade distances. For markets in Germany or Scandinavian countries like Sweden and Denmark, the main sourcing areas are Baltic states and Russia. On the other hand, Italy imports from Balkan countries as well as Spain and France [28].

Table 6. Main market parameters for biogenic feedstock

Market criteria
Availability & sustainable sourcing
Transport costs, storability and storage costs
Seasonality impact
Pre-treatment requirements
Compatibility with the Energy Policies (e.g. RED II)

Finally, it can be concluded that the technical standards which permit co-processing and blending of the mentioned biogenic residues as well as biogenic wastes fraction, will not only enhance the sustainability of the existing supply chains among Europe but will also create new ones, and subsequently lower the reported feedstock prices by offering suitable for processing feedstock blends, more competitive in the energy market. Feedstock-flexible plants, supported by stable supply chains can encounter seasonality issues and highly reduce the corresponding logistics related costs (i.e. transport & storage costs).

2.3. Final feedstock types selection

Based on the first screening of the specific feedstock types around Europe in terms of capacities (Table 4), and taking into consideration the desired technical & market criteria, as developed in section 2.2, an attempt has been made to involve the most promising types of feedstock from each residual biomass category (forestry residues, agricultural residues, municipal wastes) and from various European regions. Aim of this strategy is on the one hand to involve the widest possible spectrum of biogenic residues, and on the other hand, to maximize the territorial impact of the study by handling different feedstock and supply chains all around Europe (Figure 4). In particular, they have been selected:

- **Olive and vineyard prunings from Greece & Spain respectively**
- **Cereal straw from Italy**
- **Logging residues from final fellings & thinnings/ wood residues from Finland**
- **Airports & ports biogenic wastes all around Europe**

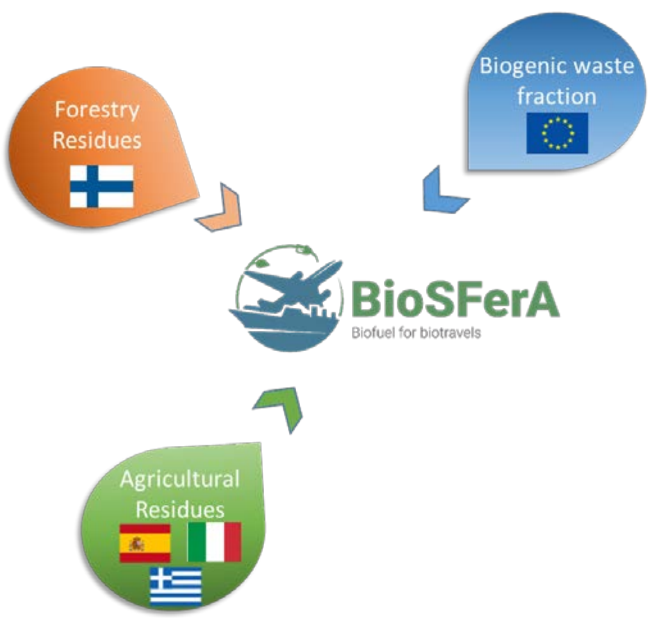


Figure 4. The wide spectrum of BioSFerA feedstock selection

The elected types of feedstock are available in large quantities around Europe and their average technical & market specifications, as obtained from literature and previous relative projects, meet the aimed requirements. Moreover, some of the elected fuels, such us pellets from olive prunings, as well as their potential blendings are quite innovative feedstock with limited gasification applications. Concerning municipal wastes, as also mentioned in section 1.2, airports & ports derived wastes are the targeted BioSFerA feedstock, but COVID-19 outbreak made this choice difficult. An alternative approach, involving simulated waste fraction to represent the airport/port wastes is on discussion, and the implementation of it may be followed in the first experimental stages of the project (Task 3.1).

2.3.1. Prunings

The focus for estimating the biomass potential from permanent crops will be on the pruning material and not on the trees and stumps that can be removed at the end of a plantation lifetime. Pruning is part of normal practice to enhance and maintain the production of the main fruit and is therefore a cyclical activity delivering a stable amount of biomass every year. Permanent crops in Europe are usually arranged in classes: olive, vineyard, fruits, citrus, nuts (dry fruits) and others. However, some countries are specialized in the production of fruits, olives and grapes, mostly in the Mediterranean area and mild climatic areas. Among the larger producers of permanent crops products, in Spain, Italy and Greece olive and vineyard are the most prevailing crops, offering a greater sustainability potential in comparison with the other permanent crops. **Based on the above mentioned points and on the available literature data [29] regarding their quality characteristics, it was chosen to focus the BioSFerA research on olive and vineyard prunings**. Indicatively it is referred that the low heating value of the olive tree prunings can range between 14-17 MJ/kg (d.b.), with a moisture content around 18% a.r. and ash content around 4% d.b., while the low heating value for the vineyard pruning can range between 12-18 MJ/kg (d.b.), with a moisture content around 17% a.r. and ash content around 3% on a dry basis [30]. Moreover, according to previous results from European projects, like the uP_running [31] and AGROinLOG [32], the prunings from these two permanent crops hold another notable advantage compared to the most of fruit tree prunings, which lies on the fact they do not present high concentrations of sulfur and other metals that can put in danger the steady process operation.

Trying to choose the best case scenario for these two types of prunings, and relied on Figure 5 and Figure 6 which are extracted from the S2BIOM platform , it was decided to examine the olive tree prunings for the case of Greece and respectively vineyards for the case of Spain. Greece is selected for the olive tree prunings since the olive oil sector is amongst the leaders of the Greek agricultural economy and therefore exhibits mature transport & storage facilities, while vineyards for the case of Spain because there is already an existing profitable value chain which utilizes vineyards prunings in order to produce both pellets and energy. For this reason, it was elected preferably Spain in order to focus on vineyards and not Italy. Finally, it should be highlighted the possibility of blending (e.g. vineyards and olive tree prunings), which will remarkably facilitate the concept flexibility and create more sustainable supply chain systems.

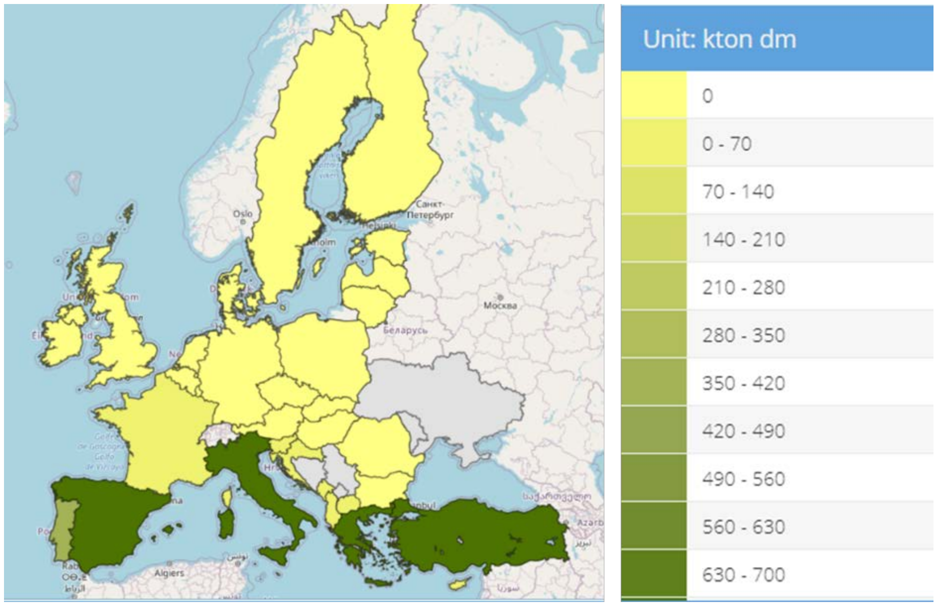


Figure 5. General illustration of the residual biomass potential from the olive tree plantations for NUTS0 administrative level around Europe [14].

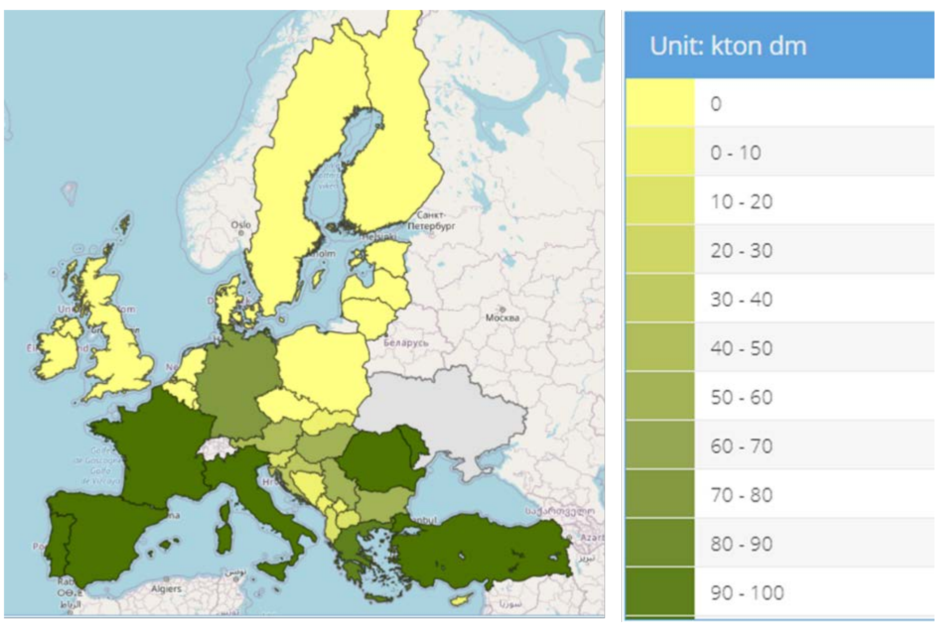


Figure 6. General illustration of the residual biomass potential from the vineyards for NUTS0 administrative level around Europe [14].

2.3.2. Straw

Relied on the results presented in Table 4 and Figure 7,extracted again from the S2BIOM platform, and after taking into account that Italian cereal cultivation plays a significant role as one of the driving sectors of the national economy, it was decided to focus on cereal straw for the case of Italy [33]. This decision was taken based on the fact that there is a remarkable experience from Italian partners that CERTH was collaborated in past projects, concerning the design and the implementation of a feasible value chain based on the cereal straw.

Wheat, barley, oat and rye are the most popular cereal crops that are cultivated in over 100 countries in the world. Straw is a term used for all harvestable residues after wheat and barley grain have been collected by grain harvesting, and includes major parts of the stem and leaves. For off-field utilization, straw is collected in packs or bales, which are produced by self-propelled baling machines. If straw is not collected but left in the field, it can be ploughed into the field or left as a mulch layer that covers the top soil [34]. Currently cereal straw are used as feedstuff, as fertilizer, in the pulp and paper industry, for production of nano-materials and for production of biofuels. One of the main reasons that cereal straw presents a wide range of uses is its physical, chemical and thermochemical properties. Based mainly on literature surveys [35] it is observed that a typical moisture content for the cereal straws varied from 10-17%, while the ash content varied from 1.6-4.5 % and the low heating value varied from 17- 20 MJ/kg (d.b.). At the same wavelength is also the sunflower husk which in pellet form is quite competitive with the pellet from the cereal straw. This is an option that will not be excluded from the BioSFerA study since it will be quite interesting to monitor the behavior of such a mixture in the case that sunflower can support sustainable real case scenarios, as they will be developed within Task 2.4. Sunflower derived residues can be found in decent quantities especially in Ukraine, while France is following [36].

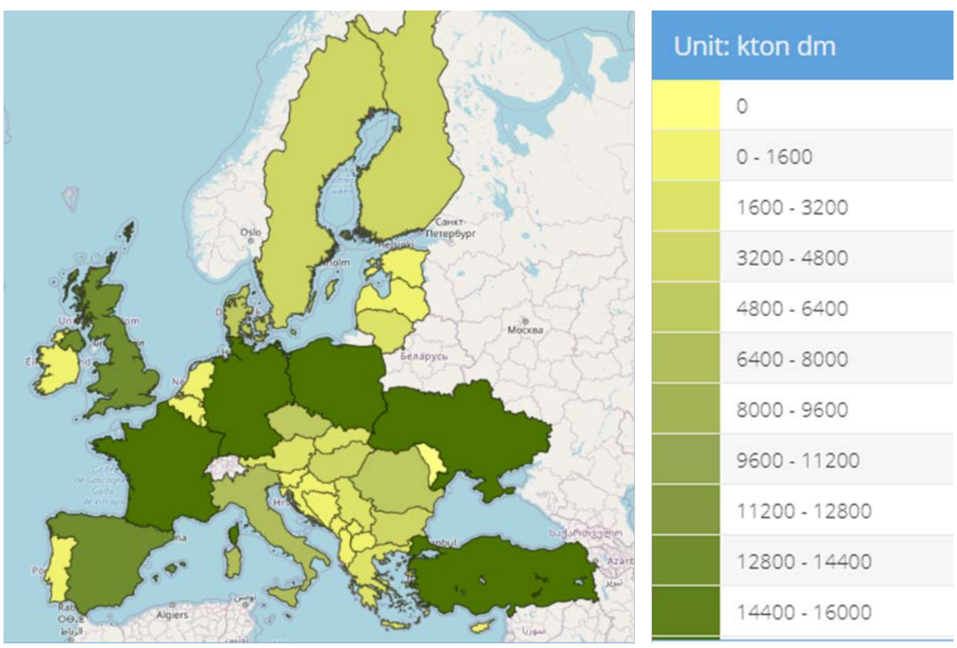


Figure 7. Distribution of cereal straw for NUTS0 administrative level around Europe [14].

2.3.3. Logging residues from final fellings & thinnings/wood residues from conifer trees

Concerning the logging residues from final fellings and thinnings from conifer tress, Finland was selected to represent the countries from North Europe and to cover this residual biomass category, since it is quite clear from Figure 8 & Figure 9 as well as from Table 4, that the largest amount of forestry potential is concentrated in Nordic countries.

In Finland, forests are a natural and abundant source of bioenergy, from which vast amounts of wood-based fuels are produced annually either as primary residues derived from silvicultural and harvesting operations or as by-products of the forest industry [24], [37].

Logging residues represent a share of 16% of the final Finland's wood-based fuels that are used for energy generation. Logging residues consist of tree tops, branches, needles/leaves, unmerchantable stem wood, belong to the first category of the primary produced residues which appear to be an attractive fuel source. A typical composition of logging residue is ash content around 1.5-3 % (d.b.), a moisture content around 11.3% and a low heating value at 19.6 MJ/kg on a dry basis.

However, there is a major share of wood fuels (64 %), including bark, sawdust and other industrial wood residues that can be further pressed into wood pellets. Wood waste is mostly the result of wood processing industries like sawmills, plywood, panels, and other wood products supplies, which may generate significant amount of by-product. Indicatively, wood bark is generated as a by-product of the wood processing industry originates from softwoods and is usually used to fuel boilers in forestry plants for heating stations. While, sawdust is generated during the production processes of timber sawmills and used for the final production of wood pellets. Unfortunately, it is quite difficult to estimate the annual production of the above-mentioned by-products. However, according to statistics in 2017, the volume of such by-products was 11.7 million m^3 in total , 7,7 million m^3 of which was bark and the rest were sawdust (2.8 million m^3) and industrial chips (1.2 million m^3) [24], [38],[39]

Nevertheless, logging residues from conifer trees (including their further secondary residues like bark and sawdust) in pellet forms were not selected only for their physical, chemical and thermochemical properties. Apart from their qualitative characteristics, it is considered feasible to develop a real case scenario based on forestry residues since previous studies in Finland focused successfully on the logistics and the development of a profitable value chain based on the annual residual biomass.

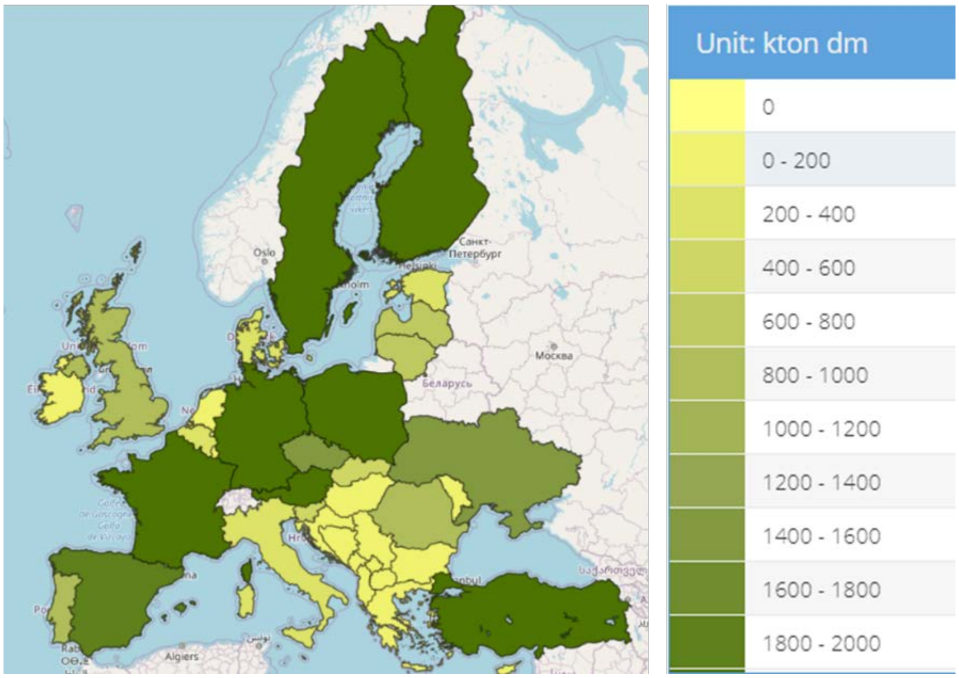


Figure 8. Logging residues from final fellings from conifer trees for NUTS0 administrative level [14].

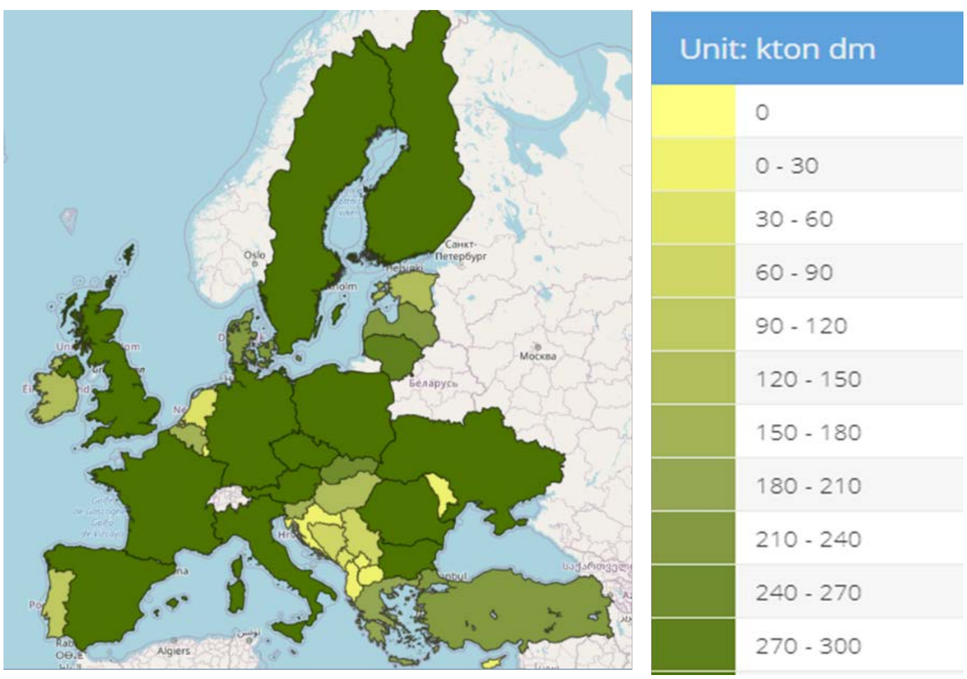


Figure 9.Logging residues from thinnings from conifer trees for NUTS0 administrative level [14].

3. Selected feedstock characterization & stoichiometric analysis

Biomass feedstock depending on their origin present differences as regards their moisture and ash content, low and high heating value, bulk densities and their chemical (elemental and mineral) composition. To identify these differences and to check their representativeness, different measurement standards are used internationally during the stoichiometric analysis of a fuel. These reference standards are presented in Table 7.

Table 7. Reference standard for the characterisation test.

Test	Reference Standard
Ash Content	UNE-EN ISO 18122
Elemental Analysis (CHN)	UNE-EN ISO 16948
Calorific Value	ISO/DIS 18125
Sulphur and Chlorine content	UNE-EN ISO 16994
Ash Composition- Major elements (Al, Ca, Fe, Mg, K, Si and Na)	UNE-EN ISO 16967
Ash Composition- Minor elements (Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn))	UNE-EN ISO 16968

For the needs of BioSFerA project, four different tests were carried out by CERTH depending on the previous types of the final feedstock selection. Specifically, two different samples of olive tree prunings from the wide region of Greece were collected and sent for further characterization, along with one sample from vineyard prunings and one from cereal straw derived directly from Spain and Italy respectively (Figure 10). Moreover, the results from previous tests on crushed bark pellets, performed by VTT have been attached in order to finalize the characterization of the main BioSFerA feedstock selection.

Figure 10. The fuels that have been selected for the needs of BioSFerA project.

A series of analyses were carried out for the characterization based on the above-mentioned reference standards, in order to determine the material properties and evaluate its potential use in gasification processes. All of them are characterized for their calorific, ash and moisture content as well as for its carbon, oxygen, hydrogen, nitrogen and sulfur concentration by means of proximate and ultimate analysis. Moreover, the major as well as the minor elements are also determined and presented.

As it has already been mentioned, within BioSFerA concept it will be attempted the feedstock preparation in a form that is appropriate (i.e. pellets) to avoid feeding problems in the bench- and pilot scale tests. Therefore, the moisture content, that is measured from the samples of the selected feedstock within this deliverable, is not representative for the feedstock that it will be used within lab and pilot activities (i.e. pellets with low moisture content) and for this reason is not attached in Table 8, but only in the annexes.

In Table 8, the results from the proximate and ultimate analysis of all the above-mentioned fuels are presented. In addition, the results of crushed bark pellet that have been performed by VTT partners in the framework of previous studies are also presented. All samples exhibit similar composition. The main differences between the samples lie in the ash percentage, the nitrogen content and the heating value. From all the tested samples, crushed bark pellets present the highest calorific value, while olive prunings the highest ash content.

Table 8. Proximate analysis, Ultimate analysis and Calorific value - Olive and vineyard prunings, cereal straw and crushed bark pellet (d.b.: dry basis, N.D.: Not Detected)

Sample		Olive prunings (Southern Greece)	Olive prunings (Central Greece)	Vineyard prunings (Spain)	Cereal straw (Italy)	Crushed bark pellet (Finland)
Parameter	**Units**	**Measured values**			**Given values**	
Ash	**% (d.b.)**	4.20	5.00	3.70	4.50	3.70
C	**% (d.b.)**	49.05	50.03	48.47	47.51	51.50
H	**% (d.b.)**	7.78	6.97	5.99	7.39	5.80
N	**% (d.b.)**	0.36	1.21	0.84	0.10	0.30
O	**% (d.b.)**	38.55	36.71	40.92	40.44	38.64
S	**% (d.b.)**	0.06	0.08	0.08	0.06	0.06
CL	**% (d.b.)**	N.D.	0.20	0.07	0.08	N.D.
High Heating Value	**MJ/Kg (d.b.)**	19.42	20.46	18.99	18.08	20.69
Low Heating Value	**MJ/Kg (d.b.)**	17.74	18.95	17.69	16.48	19.42

Besides the five fuels that have been tested and their results are presented above, the results from three additional fuels that have already been tested and can potentially be involved in the bench scale tests of Task 3.1 are presented in Table 9. In particular, the analyses for forest residues, crushed straw pellet as well as clean wood pellets (sawdust) are attached. At first glance, the remarkably high ash content of crushed straw pellets should be mentioned compared to the impressively low ash content of sawdust pellets which seems to be a really 'clean' fuel and a notable option.

Table 9. Proximate analysis, Ultimate analysis and Calorific value – Forest residue and Crushed straw pellet all from Finland (d.b.: dry basis, N.D.: Not Detected)

Sample		Forest residue (Finland)	Crushed straw pellet (Finland)	Clean wood pellets (sawdust) (Finland)
Parameter	**Units**	**Given values from past measurements**		
Ash	**% (d.b.)**	2.60	6.30	0.50
C	**% (d.b.)**	52.20	43.60	50.70
H	**% (d.b.)**	5.70	5.60	5.90
N	**% (d.b.)**	0.50	0.80	0.10
O	**% (d.b.)**	38.96	43.59	42.80
S	**% (d.b.)**	0.04	0.11	N.D.
CL	**% (d.b.)**	N.D.	N.D.	N.D.
High Heating Value	**MJ/Kg (d.b.)**	20.80	18.50	20.29
Low Heating Value	**MJ/Kg (d.b.)**	19.64	17.32	19.00

Table 10 and Table 11 display the results from the determination of major and minor elements respectively. In Table 10, the major elements are shown for the five main samples while Table 11 presents the minor elements. Concerning the major elements, CaO (calcium oxide) and K_2O (potassium oxide) are the dominant elements for all the samples, while in crushed bark pellets and cereal straw remarkable concentrations of SiO_2 (silicon dioxide) are observed.

Table 10. Major elements as oxides - Olive and vineyard prunings, cereal straw, crushed bark pellet (d.b.: dry basis)

Sample	Olive prunings (Southern Greece)	Olive prunings (Central Greece)	Vineyard prunings (Spain)	Cereal straw (Italy)	Crushed bark pellet (Finland)
Oxide (% ash d.b.)	**Measured**				
SiO_2	4.41	5.03	3.41	13.73	28.00
Fe_2O_3	1.04	0.84	0.71	0.55	4.00
Al_2O_3	1.02	0.70	0.73	0.55	8.00
CaO	29.37	31.08	30.17	13.20	28.00
MgO	6.36	7.22	9.55	2.71	4.00
Na_2O	1.45	0.67	0.54	1.13	2.00
K_2O	22.11	19.05	26.86	31.23	6.00

Concerning the minor elements, it should be noticed the considerably high concentration of copper (Cu) in both samples of the olive tree prunings, as well as remarkable concentrations of manganese (Mn) and Zinc (Zn). This can be explained by considering the fertilizers and the agricultural practices that most of the farmers follow.

Table 11. Minor elements - Olive and vineyard prunings, cereal straw (d.b.: dry basis, N.D.: Not Detected)

Sample	Olive prunings (Southern Greece)	Olive prunings (Central Greece)	Vineyard prunings (Spain)	Cereal straw (Italy)
Compound (mg/kg d.b.)	**Measured values**			
Cadmium (Cd)	0.01	N.D.	N.D.	0.04
Cobalt (Co)	0.36	0.34	0.24	0.12
Chromium (Cr)	0.88	0.76	0.22	0.92
Copper (Cu)	39.90	17.69	4.96	4.62
Manganese (Mn)	21.75	30.35	23.94	41.10
Nickel (Ni)	0.34	0.55	0.22	0.39
Lead (Pb)	0.53	0.18	0.04	0.15
Zinc (Zn)	34.18	19.14	22.48	27.68

In general, olive prunings, vineyard prunings and cereal straw have high potassium (K) content. High potassium content easily leads to low sintering point of the ashes. Low sintering point requires that the gasification temperature is decreased, and because of this, more solid and unreactive char is formed in the gasifier.

If these high potassium types of feedstock are used in the Dual Fluidized Bed Gasifier (DFBG) process, more solid char and tars are expected to be generated. The char is fed into the oxidizing reactor where high temperature heat is produced and transferred into the hot circulating sand between the two sand beds. As more char is combusted with these high potassium feedstock types, the energy balance in the process changes. This have an influence especially in the process modelling part in WP6 and in piloting tests in WP4. In the initially planned system, more oxygen is also needed in the reforming part, because more tars need to be reformed.

4. Conclusions

Within this deliverable, the BioSFerA feedstock selection & characterization has been performed. An attempt has been made to involve the most promising types of feedstock from each residual biomass category (forestry residues, agricultural residues, municipal wastes) and from various European regions. Aim of this strategy was on the one hand to involve the widest possible spectrum of biogenic residues, and on the other hand, to maximize the territorial impact of the study by handling different feedstock and supply chains all around Europe.

The three main axes on which the feedstock selection was largely based were the availability (capacities), the technical requirements & the market specifications. An extended screening of biogenic residues capacities around Europe took place, utilizing the S2BIOM database and a general feedstock placement around Europe was performed. Utilizing literature data as well as taking advantage of the experience of the consortium in technical matters (e.g. gasification), but also supply chains and logistics models for agro-biomass, the most important technical & market criteria have been identified. After taking into consideration the alignment with the three selected indicators (i.e. capacity, market competitiveness, technical performance), the following types of feedstock were selected to get the BioSFerA project underway:

- **Olive and vineyard <u>prunings</u>** from Greece & Spain respectively
- **Cereal <u>straw</u>** from Italy
- **Logging residues from final fellings & thinnings/ clean <u>wood</u> residues** from Finland
- **Airports & ports biogenic <u>wastes</u>** from all around Europe

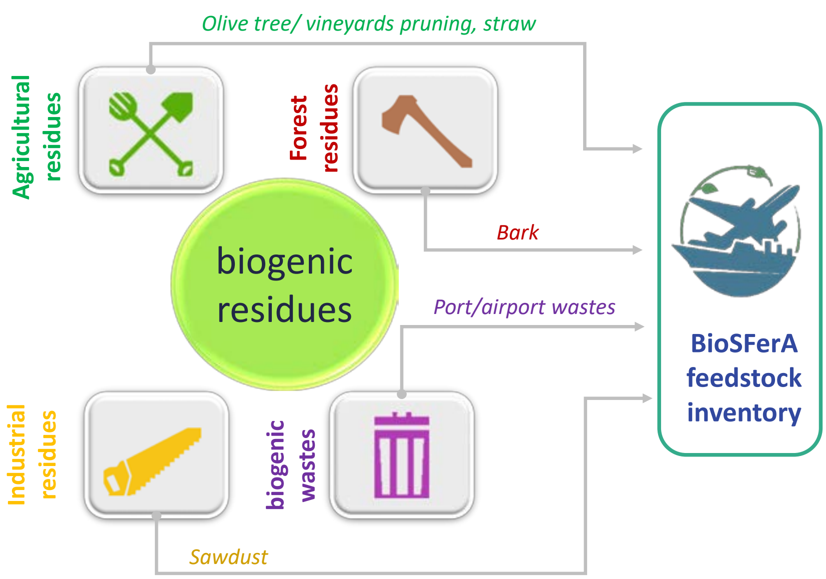


Figure 11. BioSFerA contribution to biogenic residues valorization from different categories

Samples for Greek olive prunings, Spanish vine prunings as well as Italian straw have been secured and sent to CERTH facilities for the fuel characterization that includes ultimate & proximate analysis and ash composition. The corresponding characterization of wood residues (e.g. bark & sawdust) as well as forestry residues was provided by VTT. Concerning airports & ports biogenic wastes, due to COVID-19 outbreak, the access to these grounds proved impossible and therefore the wastes involvement at this stage of the project was abandoned. An alternative approach based on simulated waste fraction containing plastics and biogenic material, which resembles to airport/ship waste, will be re-investigated in the forthcoming Tasks.

The selected feedstock types, as they emerged from the present document, will be the basis for the bench scale gasification tests (Task 3.1), the development of sustainable real-case scenarios (Task 2.4) as well as the process basic definition (Task 2.5). Finally, it has to be mentioned, that in BioSFerA project it will be attempted the feedstock preparation in pellets form in order to avoid feeding problems in the bench- and pilot- scale tests. Preprocessing requirements in a potential commercial scale would be significantly lower and the preprocessing costs as well.

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Annexes

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Fossil Fuels Technology Laboratory
ANALYSES CERTIFICATE

Certificate Number: 65	**Date of Issue: 03/08/2020**	**Page 1 from 4**

Name of Customer:	**GAVIDOU VASILIKI**
Address of Customer:	**AIGIALIAS 52, MAROUSI, ATTIKI, 151 25 – MAROUSI**
Date of sample:	**20/07/2020**

TABLE OF CONTENTS

1. APPICATION FORM – ANALYSIS SAMPLES

1.1 **NUMBER OF APPLICATION FORM: 743**

1.2 **RECEPTION DATE OF SAMPLES & APPLICATION FORM: 20/07/2020**

1.3 **METHODS OF SAMPLING**: Sampling was not carried out by the laboratory, but it was carried out by the customer and the method suitability is an exclusive responsibility of the customer.

1.4 **SAMPLES DESCRIPTION: 1 SAMPLE OF BIOMASS – (Straw of cereals_Italy)**

1.5 **CODE OF SAMPLES: B20200720BIOSFERA**

1.6 **SAMPLES CONDITION: GOOD**

1.7 **TESTS:** In the above sample (**20/07/2020**) the following tests were carried out:

A) Sample Preparation of Biomass - ISO 14780 - Solid biofuels - Sample Preparation (TO_21) - **KAPOUSIDIS P.**

B) Determination of Total Moisture of Biomass - ISO 18134-1 - Solid biofuels -Determination of moisture content - Oven dry method - Part 1: Total moisture - Reference method (TO_16) - **KAPOUSIDIS P.**

- *The laboratory takes the responsibility of the analyses made to the specific submitted samples. The reported results are relative to these samples only and the certificate does not constitute product authorisation by the Laboratory.*
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ANALYSES CERTIFICATE

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C) Proximate Analysis of Biomass (Moisture - Ash) - ISO 18134-3 - Solid biofuels - Determination of moisture content - Oven dry method - Part 3: Moisture in general analysis sample & ISO 18122 - Solid biofuels - Determination of ash content (TO_02) - **EVANGELOPOULOU A.**

D) Determination of Total Content of Carbon, Hydrogen and Nitrogen of Biomass - ISO 16948 - Solid biofuels - Determination of total content of carbon, hydrogen and nitrogen (TO_15) - **EVANGELOPOULOU A.**

E) Determination of Sulfur and Chlorine of Biomass - ISO 16994 - Solid biofuels - Determination of total content of sulfur and chlorine & ASTM D 516 - Standard Test Method for Sulfate Ion in Water (TO_07) - **KONTODIMOS I.**

F) Determination of Calorific Value of Biomass - ISO/DIS 18125 - Solid biofuels - Determination of calorific value (TO_05) - **DALLAS P.**

G) Determination of Bulk Density of Biomass - ISO 17828 - Solid Biofuels - Determination of bulk density - **KAPOUSIDIS P.**

1.8 **Date of analyses: 20/07/2020, 22/07/2020, 23/07/2020, 24/07/2020, 27/07/2020**

1.9 **Preparation of samples:** Sample preparation is described in the relevant technical directive.

1.10 **Moisture determination:** Total moisture of the sample is determined in air atmosphere, while the inherent moisture is nitrogen-atmosphere determined.

2. RESULTS

The results are listed below.

3. COMMENTS – CONCLUSIONS

Quality Supervisor	Technical Supervisor
E. Karlopoulos	P. Amarantos

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Certificate Number: 65 **Date of Issue: 03/08/2020** **Page 3 from 4**

Sample Analayses Report

	Certificate Number: 65
Sample receipt	20/7/2020
Dates of analyses	20/07/2020, 22/07/2020, 23/07/2020, 24/07/2020, 27/07/2020
Code of samples	B20200720BIOSFERA
Description of samples	1 Sample of Biomass - Straw of cereals_Italy

Total Moisture (ISO 18134-1)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Total Moisture	as received	%	9,7	0,11

Proximate Analysis (ISO 18134-3, ISO 18122)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Inherent Moisture		%	4,9	0,05
Ash	dry basis	%	4,5	0,13
Ash	as received	%	4,0	0,12

Determination of Total Content of Carbon, Hydrogen and Nitrogen (ISO 16948)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Carbon	dry basis	%	47,51	
Hydrogen	dry basis	%	7,39	
Nitrogen	dry basis	%	0,10	

Determination of Total Sulfur (ISO 16994 and ASTM D 516)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Sulfur	dry basis	%	0,06	

Determination of Total Chlorine (ISO 16994 and ASTM D 516)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Chlorine	dry basis	%	0,08	

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Certificate Number: 65 **Date of Issue: 03/08/2020** **Page 4 from 4**

Determination of Calorific Value (ISO/DIS 18125)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
High Heating Value	dry basis	cal/gr	4319,3	
Low Heating Value	dry basis	cal/gr	3937,0	
High Heating Value	as received	cal/gr	3900,8	
Low Heating Value	as received	cal/gr	3499,0	

Comments

The determination of Bulk Density, according to the method ISO 17828, can not be done, because the sample size is over 100mm.
The analyzes were carried out as part of the "BIOSFERA PROJECT (KOH.051014)".

On behalf of FFTL

Panayiotis Amarantos
Technical Supervisor

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SUPPLEMENT OF ANALYSES CERTIFICATE

Supplement of no. 65-03/08/2020 Analyses Certificate **Page 1 from 4**
Date of issue of Supplement: 22/09/2020

Name of Customer:	**GAVIDOU VASILIKI**
Address of Customer:	**AIGIALIAS 52, MAROUSI, ATTIKI, 151 25 – MAROUSI**
Date of sample:	**20/07/2020**

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1. APPICATION FORM – ANALYSIS SAMPLES

1.1 **NUMBER OF APPLICATION FORM: 743**

1.2 **RECEPTION DATE OF SAMPLES & APPLICATION FORM: 20/07/2020**

1.3 **METHODS OF SAMPLING**: Sampling was not carried out by the laboratory, but it was carried out by the customer and the method suitability is an exclusive responsibility of the customer.

1.4 **SAMPLES DESCRIPTION: 1 SAMPLE OF BIOMASS – (Straw of cereals_Italy)**

1.5 **CODE OF SAMPLES: B20200720BIOSFERA**

1.6 **SAMPLES CONDITION: GOOD**

1.7 **TESTS:** In the above sample (**20/07/2020**) the following tests were carried out:

A) Determination of major elements (Al, Ca, Fe, Mg, P, K, Si, Na and Ti) - ISO 16967 - Solid biofuels - Determination of major elements - Al, Ca, Fe, Mg, P, K, Si, Na and Ti - **STOGIANNIS P.**

B) Determination of Minor Elements of Biomass (As, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, V και Zn) - ISO 16968 - Solid biofuels - Determination of minor elements - **STOGIANNIS P.**

C) Determination of particle size distribution (Amount of fines & Diameter) - ISO 17827-1 - Solid biofuels - Determination of particle size distribution for uncompressed fuels - Part 1: Oscillating screen method using sieves with apertures of 3,15mm and above & ISO 17827-2 -

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Date of issue of Supplement: 22/09/2020

Solid biofuels - Determination of particle size distribution for uncompressed fuels - Part 2: Vibrating screen method using sieves with aperture of 3,15mm and below - **KAPOUSIDIS P.**

1.8 **Date of analyses: 22/09/2020**

1.9 **Preparation of samples:** Sample preparation is described in the relevant technical directive.

1.10 **Moisture determination**: Total moisture of the sample is determined in air atmosphere, while the inherent moisture is nitrogen-atmosphere determined.

2. RESULTS

The results are listed below.

3. COMMENTS – CONCLUSIONS

Quality Supervisor	Technical Supervisor
E. Karlopoulos	P. Amarantos

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Supplement of no. 65-03/08/2020 Analyses Certificate **Page 3 from 4**
Date of issue of Supplement: 22/09/2020

Sample Analayses Report

Supplement of no. 65-03/08/2020 Analyses Certificate

Sample receipt	20/7/2020
Dates of analyses	16/09/2020
Code of samples	B20200720BIOSFERA
Description of samples	1 Sample of Biomass - Straw of cereals_Italy

Determination of Oxides of Elements (AAS) (ISO 16967)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Al_2O_3	dry basis	%	0,55	
CaO	dry basis	%	13,20	
Fe_2O_3	dry basis	%	0,55	
K_2O	dry basis	%	31,23	
MgO	dry basis	%	2,71	
Na_2O	dry basis	%	1,13	
SiO_2	dry basis	%	13,73	

Determination of minor elements (AAS) (ISO 16968)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Cadmium (Cd)	dry basis	ppm	0,04	
Cobalt (Co)	dry basis	ppm	0,12	
Chromium (Cr)	dry basis	ppm	0,92	
Copper (Cu)	dry basis	ppm	4,62	
Manganese (Mn)	dry basis	ppm	41,10	
Nickel (Ni)	dry basis	ppm	0,39	
Lead (Pb)	dry basis	ppm	0,15	
Zinc (Zn)	dry basis	ppm	27,68	

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SUPPLEMENT OF ANALYSES CERTIFICATE

Supplement of no. 65-03/08/2020 Analyses Certificate — **Page 4 from 4**
Date of issue of Supplement: 22/09/2020

Comments
The determination of oxides of elements (AAS) was performed on the ash of fuel sample. The determination of minor elements (AAS) was performed on the fuel sample. The determination of Particle Size Distribution, according to the method ISO 17827, can not be done, because of the sample size .

On behalf of FFTL
Panagiotis Amarantos
Technical Supervisor

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ANALYSES CERTIFICATE

Certificate Number: 75	**Date of Issue: 22/09/2020**	**Page 1 from 5**

Name of Customer:	**GAVIDOU VASILIKI**
Address of Customer:	**AIGIALIAS 52, MAROUSI, ATTIKI, 151 25 – MAROUSI**
Date of sample:	**10/07/2020**

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1. APPICATION FORM – ANALYSIS SAMPLES

1.1 **NUMBER OF APPLICATION FORM: 742**

1.2 **RECEPTION DATE OF SAMPLES & APPLICATION FORM: 13/07/2020**

1.3 **METHODS OF SAMPLING**: Sampling was not carried out by the laboratory, but it was carried out by the customer and the method suitability is an exclusive responsibility of the customer.

1.4 **SAMPLES DESCRIPTION: 1 SAMPLE OF BIOMASS – (Olive tree prunings. The sample was recovered on 10/07/2020 from the Golemi estate in the area of Sparta.)**

1.5 **CODE OF SAMPLES: B20200710BIOSFERA**

1.6 **SAMPLES CONDITION: GOOD**

1.7 **TESTS:** In the above sample (**10/07/2020**) the following tests were carried out:

A) Sample Preparation of Biomass - ISO 14780 - Solid biofuels - Sample Preparation (TO_21) - **KAPOUSIDIS P.**

B) Determination of Total Moisture of Biomass - ISO 18134-1 - Solid biofuels -Determination of moisture content - Oven dry method - Part 1: Total moisture - Reference method (TO_16) - **KAPOUSIDIS P.**

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Certificate Number: 75 | **Date of Issue: 22/09/2020** | **Page 2 from 5**

C) Proximate Analysis of Biomass (Moisture - Ash) - ISO 18134-3 - Solid biofuels - Determination of moisture content - Oven dry method - Part 3: Moisture in general analysis sample & ISO 18122 - Solid biofuels - Determination of ash content (TO_02) - **EVANGELOPOULOU A.**

D) Determination of Total Content of Carbon, Hydrogen and Nitrogen of Biomass - ISO 16948 - Solid biofuels - Determination of total content of carbon, hydrogen and nitrogen (TO_15) - **EVANGELOPOULOU A.**

E) Determination of Sulfur and Chlorine of Biomass - ISO 16994 - Solid biofuels - Determination of total content of sulfur and chlorine & ASTM D 516 - Standard Test Method for Sulfate Ion in Water (TO_07) - **KONTODIMOS I.**

F) Determination of Calorific Value of Biomass - ISO/DIS 18125 - Solid biofuels - Determination of calorific value (TO_05) - **DALLAS P.**

G) Determination of Bulk Density of Biomass - ISO 17828 - Solid Biofuels - Determination of bulk density - **KAPOUSIDIS P.**

H) Determination of major elements (Al, Ca, Fe, Mg, P, K, Si, Na and Ti) - ISO 16967 - Solid biofuels - Determination of major elements - Al, Ca, Fe, Mg, P, K, Si, Na and Ti - **STOGIANNIS P.**

I) Determination of Minor Elements of Biomass (As, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, V και Zn) - ISO 16968 - Solid biofuels - Determination of minor elements - **STOGIANNIS P.**

J) Determination of particle size distribution - ISO 17827-1 - Solid biofuels - Determination of particle size distribution for uncompressed fuels - Part 1: Oscillating screen method using sieves with apertures of 3,15mm and above & ISO 17827-2 - Solid biofuels - Determination of particle size distribution for uncompressed fuels - Part 2: Vibrating screen method using sieves with aperture of 3,15mm and below - **KAPOUSIDIS P.**

1.8 **Date of analyses: 13/07/2020, 22/07/2020, 23/07/2020, 27/07/2020, 16/09/2020**

1.9 **Preparation of samples:** Sample preparation is described in the relevant technical directive.

1.10 **Moisture determination**: Total moisture of the sample is determined in air atmosphere, while the inherent moisture is nitrogen-atmosphere determined.

2. RESULTS

The results are listed below.

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3. COMMENTS – CONCLUSIONS

Quality Supervisor	Technical Supervisor
E. Karlopoulos	P. Amarantos

- *The laboratory takes the responsibility of the analyses made to the specific submitted samples. The reported results are relative to these samples only and the certificate does not constitute product authorisation by the Laboratory.*
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Certificate Number: 75 | **Date of Issue: 22/09/2020** | **Page 4 from 5**

Sample Analayses Report

	Certificate Number: 75
Sample receipt	10/7/2020
Dates of analyses	13/07/2020, 22/07/2020, 23/07/2020, 27/07/2020, 16/09/2020
Code of samples	B20200710BIOSFERA
Description of samples	1 Sample of Biomass - Olive tree prunings. The sample was recovered on 10/07/2020 from the Golemi estate in the area of Sparta.

Total Moisture (ISO 18134-1)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Total Moisture	as received	%	17,6	0,16

Proximate Analysis (ISO 18134-3, ISO 18122)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Inherent Moisture		%	2,3	0,04
Ash	dry basis	%	4,2	0,12
Ash	as received	%	3,4	0,10

Determination of Total Content of Carbon, Hydrogen and Nitrogen (ISO 16948)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Carbon	dry basis	%	49,05	
Hydrogen	dry basis	%	7,78	
Nitrogen	dry basis	%	0,36	

Determination of Total Sulfur (ISO 16994 and ASTM D 516)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Sulfur	dry basis	%	0,06	

Determination of Total Chlorine (ISO 16994 and ASTM D 516)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Chlorine	dry basis	%	N.D.	

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Certificate Number: 75 | **Date of Issue: 22/09/2020** | **Page 5 from 5**

Determination of Calorific Value (ISO/DIS 18125)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
High Heating Value	dry basis	cal/gr	4637,8	
Low Heating Value	dry basis	cal/gr	4236,6	
High Heating Value	as received	cal/gr	3823,9	
Low Heating Value	as received	cal/gr	3390,6	

Determination of Oxides of Elements (AAS) (ISO 16967)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Al_2O_3	dry basis	%	1,02	
CaO	dry basis	%	29,37	
Fe_2O_3	dry basis	%	1,04	
K_2O	dry basis	%	22,11	
MgO	dry basis	%	6,36	
Na_2O	dry basis	%	1,45	
SiO_2	dry basis	%	4,41	

Determination of minor elements (AAS) (ISO 16968)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Cadmium (Cd)	dry basis	ppm	0,01	
Cobalt (Co)	dry basis	ppm	0,36	
Chromium (Cr)	dry basis	ppm	0,88	
Copper (Cu)	dry basis	ppm	39,90	
Manganese (Mn)	dry basis	ppm	21,75	
Nickel (Ni)	dry basis	ppm	0,34	
Lead (Pb)	dry basis	ppm	0,53	
Zinc (Zn)	dry basis	ppm	34,18	

Comments

N.D.: Not Detected
The determination of Bulk Density, according to the method ISO 17828, can not be done, because the sample size is over 100mm.
The determination of Particle Size Distribution, according to the method ISO 17827, can not be done, because of the sample size .
The determination of oxides of elements (AAS) was performed on the ash of fuel sample.
The determination of minor elements (AAS) was performed on the fuel sample.
The analyzes were carried out as part of the "BIOSFERA PROJECT (KOH.051014)".

On behalf of FFTL

Panagiotis Amarantos
Technical Supervisor

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ANALYSES CERTIFICATE

Certificate Number: 77	**Date of Issue: 22/09/2020**	**Page 1 from 6**

Name of Customer:	**GAVIDOU VASILIKI**
Address of Customer:	**AIGIALIAS 52, MAROUSI, ATTIKI, 151 25 – MAROUSI**
Date of sample:	**03/08/2020**

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1. APPICATION FORM – ANALYSIS SAMPLES

1.1 **NUMBER OF APPLICATION FORM: 752**

1.2 **RECEPTION DATE OF SAMPLES & APPLICATION FORM: 06/08/2020**

1.3 **METHODS OF SAMPLING**: Sampling was not carried out by the laboratory, but it was carried out by the customer and the method suitability is an exclusive responsibility of the customer.

1.4 **SAMPLES DESCRIPTION: 1 SAMPLE OF BIOMASS – (Olive tree prunings. The sample was recovered on 03/08/2020 from the area of Sparta. This is crushed material collected from the area of Agios Konstantinos during the growing season 2019.)**

1.5 **CODE OF SAMPLES: B20200803BIOSFERA**

1.6 **SAMPLES CONDITION: GOOD**

1.7 **TESTS:** In the above sample **(03/08/2020)** the following tests were carried out:

A) Sample Preparation of Biomass - ISO 14780 - Solid biofuels - Sample Preparation (TO_21) - **KAPOUSIDIS P**.

B) Determination of Total Moisture of Biomass - ISO 18134-1 - Solid biofuels -Determination of moisture content - Oven dry method - Part 1: Total moisture - Reference method (TO_16) - **KAPOUSIDIS P**.

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C) Proximate Analysis of Biomass (Moisture - Ash) - ISO 18134-3 - Solid biofuels - Determination of moisture content - Oven dry method - Part 3: Moisture in general analysis sample & ISO 18122 - Solid biofuels - Determination of ash content (TO_02) - **EVANGELOPOULOU A.**

D) Determination of Total Content of Carbon, Hydrogen and Nitrogen of Biomass - ISO 16948 - Solid biofuels - Determination of total content of carbon, hydrogen and nitrogen (TO_15) - **EVANGELOPOULOU A.**

E) Determination of Sulfur and Chlorine of Biomass - ISO 16994 - Solid biofuels - Determination of total content of sulfur and chlorine & ASTM D 516 - Standard Test Method for Sulfate Ion in Water (TO_07) - **KONTODIMOS I.**

F) Determination of Calorific Value of Biomass - ISO/DIS 18125 - Solid biofuels - Determination of calorific value (TO_05) - **DALLAS P.**

G) Determination of Bulk Density of Biomass - ISO 17828 - Solid Biofuels - Determination of bulk density - **KAPOUSIDIS P.**

H) Determination of major elements (Al, Ca, Fe, Mg, P, K, Si, Na and Ti) - ISO 16967 - Solid biofuels - Determination of major elements - Al, Ca, Fe, Mg, P, K, Si, Na and Ti - **STOGIANNIS P.**

I) Determination of Minor Elements of Biomass (As, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, V και Zn) - ISO 16968 - Solid biofuels - Determination of minor elements - **STOGIANNIS P.**

J) Determination of particle size distribution (Amount of fines & Diameter) - ISO 17827-1 - Solid biofuels - Determination of particle size distribution for uncompressed fuels - Part 1: Oscillating screen method using sieves with apertures of 3,15mm and above & ISO 17827-2 - Solid biofuels - Determination of particle size distribution for uncompressed fuels - Part 2: Vibrating screen method using sieves with aperture of 3,15mm and below - **KAPOUSIDIS P.**

1.8 **Date of analyses: 06/08/2020, 11/082020, 12/08/2020, 13/08/2020, 16/09/2020**

1.9 **Preparation of samples:** Sample preparation is described in the relevant technical directive.

1.10 **Moisture determination:** Total moisture of the sample is determined in air atmosphere, while the inherent moisture is nitrogen-atmosphere determined.

2. RESULTS

The results are listed below.

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Certificate Number: 77	Date of Issue: 22/09/2020	Page 3 from 6

3. COMMENTS – CONCLUSIONS

Quality Supervisor	Technical Supervisor
E. Karlopoulos	P. Amarantos

- *The laboratory takes the responsibility of the analyses made to the specific submitted samples. The reported results are relative to these samples only and the certificate does not constitute product authorisation by the Laboratory.*
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ANALYSES CERTIFICATE

Certificate Number: 77 | **Date of Issue: 22/09/2020** | **Page 4 from 6**

Sample Analayses Report

	Certificate Number: 77
Sample receipt	3/8/2020
Dates of analyses	06/08/2020, 11/08/2020, 12/08/2020, 13/08/2020, 16/09/2020
Code of samples	B20200803BIOSFERA
Description of samples	1 Sample of Biomass - Olive tree prunings. The sample was recovered on 03/08/2020 from the area of Sparta. This is crushed material collected from the area of Agios Konstantinos during the growing season 2019.

Total Moisture (ISO 18134-1)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Total Moisture	as received	%	6,3	0,12

Proximate Analysis (ISO 18134-3, ISO 18122)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Inherent Moisture		%	6,0	0,22
Ash	dry basis	%	5,0	0,16
Ash	as received	%	4,7	0,15

Determination of Total Content of Carbon, Hydrogen and Nitrogen (ISO 16948)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Carbon	dry basis	%	50,03	
Hydrogen	dry basis	%	6,97	
Nitrogen	dry basis	%	1,21	

Determination of Total Sulfur (ISO 16994 and ASTM D 516)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Sulfur	dry basis	%	0,08	

Determination of Total Chlorine (ISO 16994 and ASTM D 516)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Chlorine	dry basis	%	0,20	

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Fossil Fuels Technology Laboratory
ANALYSES CERTIFICATE

Certificate Number: 77 **Date of Issue: 22/09/2020** **Page 5 from 6**

Determination of Calorific Value (ISO/DIS 18125)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
High Heating Value	dry basis	cal/gr	4888,3	
Low Heating Value	dry basis	cal/gr	4527,8	
High Heating Value	as received	cal/gr	4579,9	
Low Heating Value	as received	cal/gr	4205,3	

Determination of Bulk Density (ISO 17828)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Bulk Density	as received	kg/m^3	201	

Determination of Oxides of Elements (AAS) (ISO 16967)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Al_2O_3	dry basis	%	0,70	
CaO	dry basis	%	31,08	
Fe_2O_3	dry basis	%	0,84	
K_2O	dry basis	%	19,05	
MgO	dry basis	%	7,22	
Na_2O	dry basis	%	0,67	
SiO_2	dry basis	%	5,03	

Determination of minor elements (AAS) (ISO 16968)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Cadmium (Cd)	dry basis	ppm	N.D.	
Cobalt (Co)	dry basis	ppm	0,34	
Chromium (Cr)	dry basis	ppm	0,76	
Copper (Cu)	dry basis	ppm	17,69	
Manganese (Mn)	dry basis	ppm	30,35	
Nickel (Ni)	dry basis	ppm	0,55	
Lead (Pb)	dry basis	ppm	0,18	
Zinc (Zn)	dry basis	ppm	19,14	

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Determination of particle size distribution (ISO 17827-1 & ISO 17827-2)

Part	Measurement Unit	Measurement
-1 mm	%	1,13
>1 - 2 mm	%	2,30
> 2 - 3,15 mm	%	1,52
>3,15 - 8 mm	%	47,61
>8 - 16 mm	%	23,17
>16 - 31,5 mm	%	11,77
>31,5 - 45 mm	%	12,51
>45 - 63 mm	%	0,00
>63 mm	%	0,00
Total	%	100,00
Spoilage	%	0,02

Part	Measurement Unit	Measurement
<1 mm	%	1,13
<2 mm	%	3,43
<3,15 mm	%	4,94
<8 mm	%	52,55
<16 mm	%	75,72
< 31,5 mm	%	87,49
<45 mm	%	100,00
<63 mm	%	100,00

Unit	Measurement Unit	Measurement
Median value of a PSD	mm	7,74
95% of particles	mm	<45

Comments

N.D.: Not Detected
The determination of oxides of elements (AAS) was performed on the ash of fuel sample.
The determination of minor elements (AAS) was performed on the fuel sample.
The analyzes were carried out as part of the "BIOSFERA PROJECT (KOH.051014)".

On behalf of FFTL

Panayotis Amarantos
Technical Supervisor

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Name of Customer:	**GAVIDOU VASILIKI**
Address of Customer:	**AIGIALIAS 52, MAROUSI, ATTIKI, 151 25 – MAROUSI**
Date of sample:	**01/09/2020**

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1. APPICATION FORM – ANALYSIS SAMPLES

1.1 **NUMBER OF APPLICATION FORM: 756**

1.2 **RECEPTION DATE OF SAMPLES & APPLICATION FORM: 01/09/2020**

1.3 **METHODS OF SAMPLING**: Sampling was not carried out by the laboratory, but it was carried out by the customer and the method suitability is an exclusive responsibility of the customer.

1.4 **SAMPLES DESCRIPTION: 1 SAMPLE OF BIOMASS – (Pellets from vine pruning_Spain)**

1.5 **CODE OF SAMPLES: B20200901BIOSFERA**

1.6 **SAMPLES CONDITION: GOOD**

1.7 **TESTS:** In the above sample **(01/09/2020)** the following tests were carried out:

A) Sample Preparation of Biomass - ISO 14780 - Solid biofuels - Sample Preparation (TO_21) - **KAPOUSIDIS P.**

B) Determination of Total Moisture of Biomass - ISO 18134-1 - Solid biofuels -Determination of moisture content - Oven dry method - Part 1: Total moisture - Reference method (TO_16) - **KAPOUSIDIS P.**

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C) Proximate Analysis of Biomass (Moisture - Ash) - ISO 18134-3 - Solid biofuels - Determination of moisture content - Oven dry method - Part 3: Moisture in general analysis sample & ISO 18122 - Solid biofuels - Determination of ash content (TO_02) - **EVANGELOPOULOU A.**

D) Determination of Total Content of Carbon, Hydrogen and Nitrogen of Biomass - ISO 16948 - Solid biofuels - Determination of total content of carbon, hydrogen and nitrogen (TO_15) - **EVANGELOPOULOU A.**

E) Determination of Sulfur and Chlorine of Biomass - ISO 16994 - Solid biofuels - Determination of total content of sulfur and chlorine & ASTM D 516 - Standard Test Method for Sulfate Ion in Water (TO_07) - **KONTODIMOS I.**

F) Determination of Calorific Value of Biomass - ISO/DIS 18125 - Solid biofuels - Determination of calorific value (TO_05) - **DALLAS P.**

G) Determination of Bulk Density of Biomass - ISO 17828 - Solid Biofuels - Determination of bulk density - **KAPOUSIDIS P.**

H) Determination of major elements (Al, Ca, Fe, Mg, P, K, Si, Na and Ti) - ISO 16967 - Solid biofuels - Determination of major elements - Al, Ca, Fe, Mg, P, K, Si, Na and Ti - **STOGIANNIS P.**

I) Determination of Minor Elements of Biomass (As, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, V και Zn) - ISO 16968 - Solid biofuels - Determination of minor elements - **STOGIANNIS P.**

J) Determination of particle size distribution (Amount of fines & Diameter) - ISO 17827-1 - Solid biofuels - Determination of particle size distribution for uncompressed fuels - Part 1: Oscillating screen method using sieves with apertures of 3,15mm and above & ISO 17827-2 - Solid biofuels - Determination of particle size distribution for uncompressed fuels - Part 2: Vibrating screen method using sieves with aperture of 3,15mm and below - **KAPOUSIDIS P.**

1.8 **Date of analyses: 01/09/2020, 03/09/2020, 08/09/2020, 10/09/2020, 16/09/2020**

1.9 **Preparation of samples:** Sample preparation is described in the relevant technical directive.

1.10 **Moisture determination**: Total moisture of the sample is determined in air atmosphere, while the inherent moisture is nitrogen-atmosphere determined.

2. RESULTS

The results are listed below.

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3. COMMENTS – CONCLUSIONS

Quality Supervisor	Technical Supervisor
E. Karlopoulos	P. Amarantos

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Sample Analayses Report

	Certificate Number:	79
Sample receipt	1/9/2020	
Dates of analyses	01/09/2020, 03/09/2020, 08/09/2020, 10/09/2020, 16/09/2020	
Code of samples	B20200901BIOSFERA	
Description of samples	1 Sample of Biomass - Pellets from vine pruning_Spain	

Total Moisture (ISO 18134-1)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Total Moisture	as received	%	8,3	0,14

Proximate Analysis (ISO 18134-3, ISO 18122)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Inherent Moisture		%	3,3	0,13
Ash	dry basis	%	3,7	0,12
Ash	as received	%	3,4	0,11

Determination of Total Content of Carbon, Hydrogen and Nitrogen (ISO 16948)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Carbon	dry basis	%	48,47	
Hydrogen	dry basis	%	5,99	
Nitrogen	dry basis	%	0,84	

Determination of Total Sulfur (ISO 16994 and ASTM D 516)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Sulfur	dry basis	%	0,08	

Determination of Total Chlorine (ISO 16994 and ASTM D 516)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Chlorine	dry basis	%	0,07	

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Determination of Calorific Value (ISO/DIS 18125)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
High Heating Value	dry basis	cal/gr	4537,5	
Low Heating Value	dry basis	cal/gr	4225,9	
High Heating Value	as received	cal/gr	4163,2	
Low Heating Value	as received	cal/gr	3829,1	

Determination of Bulk Density (ISO 17828)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Bulk Density	as received	kg/m^3	191	

Determination of Oxides of Elements (AAS) (ISO 16967)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Al_2O_3	dry basis	%	0,73	
CaO	dry basis	%	30,17	
Fe_2O_3	dry basis	%	0,71	
K_2O	dry basis	%	26,86	
MgO	dry basis	%	9,55	
Na_2O	dry basis	%	0,54	
SiO_2	dry basis	%	3,41	

Determination of minor elements (AAS) (ISO 16968)

Unit	Basis	Measurement Unit	Measurement	Uncertainty of measurement
Cadmium (Cd)	dry basis	ppm	Δ.Α.	
Cobalt (Co)	dry basis	ppm	0,24	
Chromium (Cr)	dry basis	ppm	0,22	
Copper (Cu)	dry basis	ppm	4,96	
Manganese (Mn)	dry basis	ppm	23,94	
Nickel (Ni)	dry basis	ppm	0,22	
Lead (Pb)	dry basis	ppm	0,04	
Zinc (Zn)	dry basis	ppm	22,48	

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Determination of particle size distribution (ISO 17827-1 & ISO 17827-2)

Part	Measurement Unit	Measurement
-1 mm	%	0,34
>1 - 2 mm	%	0,51
> 2 - 3,15 mm	%	0,61
>3,15 - 8 mm	%	22,13
>8 - 16 mm	%	33,56
>16 - 31,5 mm	%	16,12
>31,5 - 45 mm	%	7,84
>45 - 63 mm	%	9,05
>63 mm	%	9,85
Total	%	100,00
Spoilage	%	0,01

Part	Measurement Unit	Measurement
<1 mm	%	0,34
<2 mm	%	0,85
<3,15 mm	%	1,46
<8 mm	%	23,59
<16 mm	%	57,14
< 31,5 mm	%	73,26
<45 mm	%	81,10
<63 mm	%	90,15

Unit	Measurement Unit	Measurement
Median value of a PSD	mm	14,30

Comments

N.D.: Not Detected
The determination of oxides of elements (AAS) was performed on the ash of fuel sample.
The determination of minor elements (AAS) was performed on the fuel sample.
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On behalf of FFTL

Panagiotis Amarantos
Technical Supervisor

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