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FORBIOENERGY - Forest Bioenergy in the Protected Mediterranean Areas

Quality requirements for the biomass from the protected areas

Work package 3 - Testing

Activity A.3.9. - Quality requirements for the biomass from the protected areas

Methodology for the planning sustainability and quality requirements for biomass from protected areas

Partner in charge: PP4 Regional development agency Green Karst ltd.

Deliverable 3.9.1 – Quality requirements for the biomass from the protected areas

Responsible Partner:

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PP3 – Slovenian Forestry Institute

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1 INTRODUCTION

Many forests in the Mediterranean region are either included in a protected area or make part of the Natura 2000 network. Nevertheless, they represent a great opportunity for the production of sustainable energy from biomass. The Mediterranean basin has a recognized potential for electricity and heat production using primary forest biomass and sub-products from sawmills. Moreover, in order to efficiently use the available resources, locally grown biomass used locally, minimises logistical requirements and reduces emissions. Forestry practices have to be compatible with sustainable forestry practices.

The usual forms of biomass to be combusted are firewood, wood pellets and chips and wood from sawmills and wood processing industry by-products. Primarily the material originates from forests, park areas and green cut. In the Mediterranean countries there is also a market of solid biomass fuels of agricultural origin such as olive stones, olive tree pruning, almond, pine nut, pistachio and hazelnut shells and chopped pine cone. But since the bulk of the biomass usually originates from agricultural operations and not protected areas, the main focus will be put on the traditional combustion fuels based on wood materials.

Within the activity 3.9 the we will define the possibilities of using existing traceability protocols for forest management certification system, standard for the solid biofuels to be used in the foreseen or existing district biofuels heating systems and standards or best available technologies for the combustion systems. This is to supplement the contents of the activity 3.8 in which the sustainable wood-energy supply chain was planned.

The sustainability criteria for the forest management in the protected areas was already taken into account in the frame of the document titled “Forest management plan of the Biomass district in the protected areas”. The traceability standards which can be obtained, will be described. Furthermore, properties of the solid biofuels and quality standards that are in use for the solid biofuels will be identified and listed, along with the information how they can be acquired in the field of exploitation of the biomass for energy purpose. In the last part the types of combustion systems will be described and European standards on biomass heating systems will be defined in order to ensure the respect good outdoor air quality in areas using biomass from the protected areas.

The activity is divided in two parts:

- **Overview of the existing traceability protocols, quality standards for solid biofuels and combustion technologies** with recommendations for the key actors to use them when establishing new wood-energy supply chain within the biomass district in protected area.

- **A feasibility study of the chosen wood-energy supply chain established under 3.8 in the protected areas** in the view of the possibility to implement traceability protocols, acquire standards for the solid biofuels from the chosen biomass district and choose or propose a combustion system that is in compliance with the standards for biomass heating systems**.** Each

country involved in the project will prepare a case study for at least one biomass district (BD) in their protected area.

2 OBJECTIVE

The objective of this activity is to study and propose to be put in use traceability protocols and quality standards for slid biofuels within the sustainable wood-energy supply chain established for the chosen biomass districts (defined in the deliverable 3.4.1) through:

- identification of the existing certifications systems on the national level for wood origin traceability protocols,
- identification of the existing certifications systems for standards on the national level for solid biofuels,
- identification of stakeholders along the wood-energy supply chain who are interested in either of the certification systems,
- identification of a suitable site for the biomass storage,
- identification of the type of power plant the most suitable for the biomass coming from the chosen biomass district with technical characteristics, appropriate to ensure the environmental sustainability of biomass transformation.

3 RECOMMENDATIONS FOR PARTNERS IN PREPARATION OF THIS DOCUMENT:

1. We recommend that partners work in selected biomass district – if possible, for district where also Forest management plan will be prepared.
2. When preparing a case study, use the data that were collected through all tasks of the ForBioEnergy project (WP3).
3. We recommend you prepare one document for your district area with two parts:
    a. Overview – more general part
    b. Case study – with concrete possibilities for the standards which are or can be implemented for the chosen biomass district

4 GUIDELINES 3.9.1 – Quality requirements of biomass from the protected areas

4.1 CHAIN OF CUSTODY AND SUSTAINABLE FOREST MANAGEMENT CERTIFICATION

Wood energy supply chains planned in the frame of the ForBioEnergy project are all established based on an assumption that ecosystems preservation and biodiversity conservation in the protected areas are the basic ideas and understood as an axiom from the beginning of the process. So, the sustainability and conservation principle are embedded into the process from the beginning, through planned and carried project activities:

- "Impact assessment of increased biomass use in the short, medium and long term in the protected areas" and
- "Forest Management Plan of the Biomass District in the protected areas".

This forms a solid base in sense of a strong insurance of the compliance with sustainability standards. Sustainability and sustainable development in general are defined as a development which is balanced between its economic aspect or interests, ecologic sustainability or resource availability and socio-cultural aspect of preserving overall wellbeing of the society in general.

Sustainable forest management (SFM) was further defined in the frame of the "FOREST EUROPE" criteria and indicators were developed and endorsed in the frame of one of the first regional policies. The first set of criteria and indicators was adopted in Lisbon 1998. The actual set of Updated Pan-European indicators for Sustainable forest Management was endorsed by the ministers at the 7th Ministerial Conference in Madrid in 2015. The current set of criteria and indicators provides guidance for developing policies and help assess progress on SFM. There is a qualitative part, aligning the specific policies and instruments under each Criterion, and the related quantitative indicators. The criteria are as follows:

SFM Pan-European Criteria 1: Maintenance and appropriate enhancement of forest resources and their contribution to global carbon cycles.

SFM Pan-European Criteria 2: Maintenance of forest ecosystems' health and vitality.

SFM Pan-European Criteria 3: Maintenance and encouragement of productive functions of forests (wood and non-wood).

SFM Pan-European Criteria 4: Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems.

SFM Pan-European Criteria 5: Maintenance, conservation and appropriate enhancement of protective functions in forest management (notably soil and water).

SFM Pan-European Criteria 6: Maintenance of other socio-economic functions and conditions

The SFM idea, developed and synthesized in the Pan-European criteria, is comprised in the two wide spread chain of custody certificates, namely, FSC and PEFC certificate.

4.1.1. FOREST STEWARDSHIP COUNCIL (FSC) CHAIN OF CUSTODY CERTIFICATION

Picture 1: Forest Stewardship Council (https://info.fsc.org/)

The FSC Chain of Custody Certification standard version 3-0 was became effective on the 1st of April 2017.

Before a forest owner or manager can certify their forest, the ten FSC principles for responsible forest management must be met. These rules apply to all forest types and were set to ensure environmentally appropriate, socially beneficial, and economically viable forest management. The rules apply worldwide, across all ecosystems and cultural, political, and legal systems, with specific guidance provided for local interpretation.

The FSC 10 principles (https://ic.fsc.org/en) are listed below.

PRINCIPLE 1: The Organization shall comply with all applicable laws, regulations and nationally-ratified international treaties, conventions and agreements.
PRINCIPLE 2: The Organization shall maintain or enhance the social and economic wellbeing of workers.
PRINCIPLE 3: The Organization shall identify and uphold Indigenous Peoples' legal and customary rights of ownership, use and management of land, territories and resources affected by management activities.
PRINCIPLE 4: The Organization shall contribute to maintaining or enhancing the social and economic wellbeing of local communities.
PRINCIPLE 5: The Organization shall efficiently manage the range of multiple products and services of the Management Unit to maintain or enhance long term economic viability and the range of environmental and social benefits.

PRINCIPLE 6: The Organization shall maintain, conserve and/or restore ecosystem services and environmental values of the Management Unit, and shall avoid, repair or mitigate negative environmental impacts.
PRINCIPLE 7: The Organization shall have a management plan consistent with its policies and objectives and proportionate to scale, intensity and risks of its management activities. The management plan shall be implemented and kept up to date based on monitoring information in order to promote adaptive management. The associated planning and procedural documentation shall be sufficient to guide staff, inform affected stakeholders and interested stakeholders and to justify management decisions.
PRINCIPLE 8: The Organization shall demonstrate that, progress towards achieving the management objectives, the impacts of management activities and the condition of the Management Unit, are monitored and evaluated proportionate to the scale, intensity and risk of management activities, in order to implement adaptive management.
PRINCIPLE 9: The Organization shall maintain and/or enhance the High Conservation Values in the Management Unit through applying the precautionary approach.
PRINCIPLE 10: Management activities conducted by or for The Organization for the Management Unit shall be selected and implemented consistent with The Organization's economic, environmental and social policies and objectives and in compliance with the Principles and Criteria collectively.

FSC certification scheme offers **two different certifications,** one for forest owners and managers and the other for those who manufacture or sell forest products covering the different demands of forest and supply chain management respectively.

The obtained **FSC FOREST MANAGEMENT CERTIFICATION** confirms that the forest is being managed in a way that preserves the natural ecosystem and benefits the lives of local people and workers, at the same time ensuring it sustains economically viability. To own this certification, FSC members have agreed upon a set of criteria that forest managers or owners have to meet.

- MAINTAINING AREAS OF ENVIRONMENTAL AND SOCIAL VALUE

The criteria protect people and plant and animal species that live in and around, and depend upon, the forest - certificate holders must respect Indigenous Peoples' land rights and enhance forest workers' rights. Also, areas of high conservation value (i.e. significant concentration of plant or animal species; rare, threatened, or endangered ecosystems; or areas of rare or outstanding biological, ecological, or social value) have to be protected.

- FOREST MANAGEMENT CERTIFICATION: THE PROCESS

The forest management processes and their environmental, social, and economic impact is evaluated through an in-depth review against the FSC Principles and Criteria. Certification is valid for five years, and subject to annual checks.

- SUPPLYING CONTROLLED WOOD

Meeting this standard means that the wood materials have not been harvested illegally, in violation of traditional or civil rights, or in a way that threatens high conservation value areas.

Controlled wood cannot be taken from forests being converted to plantation or non-forest use, or from forests containing genetically modified trees.

- FOREST RESTORATION

FSC promotes responsible management of the world's existing forests and prevents the need for forest restoration in certified areas. In regions with degraded or vanished forests, FSC certification gives directions to forest restoration projects, assist in proper balanced multi-stakeholder decision-making processes, and incentivize economic returns to investors.

- ZERO-DEFORESTATION

FSC ensures sourcing of forest materials that has minimum negative impacts on forests. Companies are committing to 'deforestation-free' policies. It is equally important that certification scheme goes beyond deforestation and maintains the quality of forests, preventing forest degradation. Certification works for large and small companies, and is controlled by independent, specialized, third-party bodies.

The FSC-certified forest sources ensure the best practice and responsible sources standards are followed. FSC certification contributes to forests remain preserved environments today and for the coming generations to come, and enable the consumers to make ethical and responsible choices.

CHAIN OF CUSTODY CERTIFICATION

FSC chain of custody certification verifies that FSC-certified material has been identified and separated from non-certified and non-controlled material as it makes its way along the supply chain from the raw material to the end products bought by consumers. To obtain the chain of custody certification, the business must meet FSC-STD-40-004 Chain of Custody Certification standard.

- ASSURANCE FOR CONSUMERS AND A GATEWAY TO NEW MARKETS

FSC chain of custody certification allows companies to use the FSC label, giving consumers information on responsible sourcing and production. Certification also includes compliance with public and private sector procurement policies – such as the EU Ecolabel and US Green Building Leadership in Energy and Environmental Design (LEED).

- TYPES OF CHAIN OF CUSTODY CERTIFICATION

There are **two types** of certification, depending on the scale and type of the business:

- For organizations processing or selling forest products: certification of single businesses or facilities, or of multiple sites under multi-site or group certification (this could be for large companies that operate multiple sites, or smaller enterprises that choose to group together to achieve collective certification).

- For projects: one-off certification issued to individual objects or buildings that are totally or partially made using FSC-certified components.

- ALTERNATIVE ROUTES TO CERTIFYING FOREST PRODUCTS

The FSC 100% label signifies that a product is made entirely from FSC-certified forest material. The FSC Mix label allows to supplement the certified wood with non-certified materials. However, this non-certified material needs to adhere to a certain standard: either the reclaimed wood standard or the controlled wood standard.
The FSC Recycled label denotes that a product is made entirely from recycled or reclaimed material, subject to requirements concerning the purchasing, verification, and classification of the reclaimed material. At least 85 per cent of reclaimed material must be verified as having been recycled following consumer use to qualify for the FSC Recycled label.

There is a link to the national offices, regional and sub-regional offices on the international FSC webpage, available on the FSC webpage (https://www.fsc.org/). The accreditation process is carried out through a certification body, first an audit is carried out, followed by a certification after achieving full FSC requirements.

4.1.2. PROGRAMME FOR THE ENDORSEMENT OF FOREST CERTIFICATION (PEFC)

PEFC™
PEFC/01-00-01

Picture 2: Programme for the Endorsement of Forest Certification (PEFC, https://www.pefc.org/)

The Programme for the Endorsement of Forest Certification (PEFC) is an international non-profit, non-governmental organization, acting as a third-party certification. The entire forest supply chain is covered under the standardisation umbrella, and promotes good practice for forest management and ensures that timber and non-timber forest products respect ecological, social and ethical standards. PEFC is the certification system commonly chosen by small, non-industrial private forests and family- and community-owned forests. PEFC offers the possibility of group and regional certification, which makes small land owners able to obtain recognition in the market. PEFC certification is also listed as a possible certificate by numerous public and private timber procurement policies.

PEFC certification procedure includes the following demands (www.pefc.org):

- maintaining or enhancing biodiversity
- protecting ecologically important forest area
- prohibition of forest conversions; exclusion of certification of plantations established by conversions
- prohibition of the most hazardous chemicals and GMOs
- protecting workers' rights and welfare, and encouraging local employment
- recognizing the principle of free, prior and informed consent (FPIC), the UN Declaration on Indigenous Peoples' Rights, and ILO Convention 169 on Indigenous and Tribal Peoples
- respect for property and land tenure rights as well as customary and traditional rights
- abiding by applicable laws
- safeguarding the basic rights of workers
- requires companies to demonstrate compliance with social, health and safety requirements in the frame of Chain of Custody certification.
- level of Stakeholder Engagement Equally High for All Standards
- requires all national standards to be independently developed with the open participation of all interested parties
- requires that all standards undergo public consultation at national and international level and third-party assessment
- demands and implements regular revisions of national certification systems.
- builds its understanding of sustainable forest management on broad societal consensus expressed in international and intergovernmental processes
- supports the implementation of governmental agreements through a voluntary, market-based mechanism
- follows globally accepted ISO Guidelines for certification and accreditation.

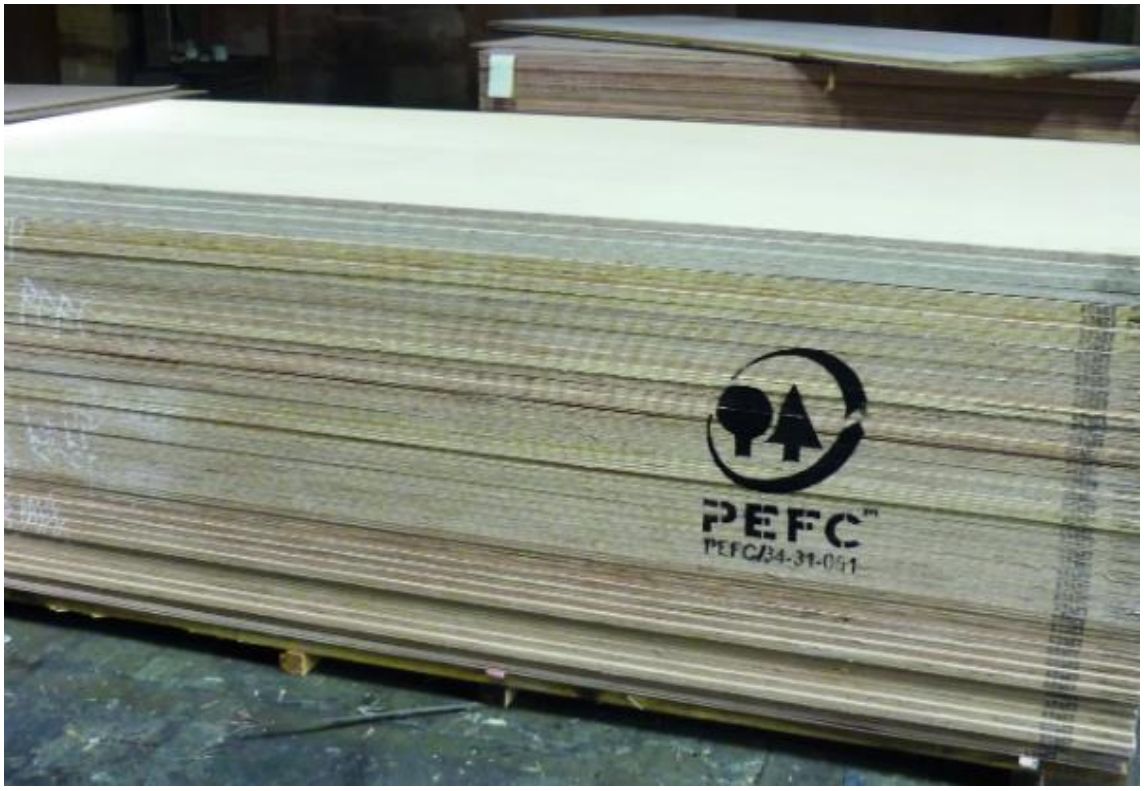
SUSTAINABLE FOREST MANAGEMENT

To certify a certain forest management as sustainable for different forest types in different regions of the world which carry out different sustainable management strategies, PEFC emphasizes a "bottom-up" approach, in which national certification systems are developed independently and are endorsed by PEFC. To be endorsed they need to prove compliance with PEFC's Sustainability Benchmarks, globally recognized principles, guidelines and criteria developed by international and intergovernmental bodies with broad consensus from interested stakeholders. These processes are ongoing and are supplemented by additional requirements developed through multi-stakeholder processes facilitated by PEFC.

By requiring that local stakeholders be involved in both standard-setting and decision-making on it before a system can be endorsed, PEFC ensures that standards are adapted to meet local cultural, socio-economic, physical, biological, climatic, and geopolitical realities while at the same time meeting internationally-recognised benchmarks for sustainable forest management.

CHAIN OF CUSTODY OF FOREST BASED PRODUCTS

PEFC's Chain of Custody certification is a mechanism for tracking material from the forest to the final product. It ensures that the wood, wood fibre or non-wood forest produce in the final product or product line can be traced back to certified forests. It functions as an essential part of the PEFC system which ensures that claims about products originating in sustainably managed forests are credible and verifiable throughout the whole supply chain. It provides a commercial advantage when the PEFC logo is used on products, making them the preferred choice of responsible consumers.



Picture 3: PECF certified semi-finished product (https://www.pefc.org/).

Chain of Custody certification is carried out by accredited certification bodies that verify compliance of the wood flow accounting system.

There are two mechanisms for tracing the origins of forest-based products, tailored to the different situations and needs of certified companies:

- The percentage-based method – this mechanism allows mixing certified and non-certified raw material during the production or trading process. The percentage of the certified raw material must be known and communicated to the company's customers

  (average percentage). It is also possible to for the company to sell as certified the proportion of its production which equals the percentage of certified raw material used (volume credit).

- The physical separation method – this mechanism requires separating certified and non-certified raw material during all phases of production/trading process to ensure that certified raw material is not mixed with non-certified raw material.

A safeguard mechanism has been developed to prevent wood from controversial sources (illegal logging) being used and certified. Through risk analyses, external assessments and onsite inspections the legality of the uncertified wood is ensured. The safeguard checks are scrutinized by the independent certifiers during their annual audits and provide companies with a "double safeguard measure" for their procurement.

The Chain of Custody standard specifies as controversial sources those activities that do not comply with local, national, or international legislation, in particular relating to the following areas:

- forestry operations and harvesting, including conversion of forest to other uses,
- management of areas with high environmental and cultural values designed and covered by the legislation,
- protected and endangered species, including requirements of CITES,
- health and labour issues relating to forest workers,
- property, tenure and use rights of indigenous peoples,
- payment of taxes and royalties,
- areas utilizing genetically modified organisms.

GROUP FOREST MANAGEMENT CERTIFICATION PROCEDURES

As in many countries forest ownership is fragmented to many small family or community-owned forests, group certification is an alternative approach to individual certification, allowing several forest owners to become certified as a group and share the financial costs, as well as the administrative and organizational responsibilities.

In this type of certification, an entity represents the individual forest owners, with overall responsibility for ensuring conformity with the forest management standard in the certified area. Individual forest owners who voluntarily join the group, are then:

- required to comply with all the requirements,
- cooperate and assist in the forest certification implementation,
- obliged to carry out relevant corrective and preventive actions established by the group entity.

4.2 STANDARDS FOR SOLID BIOFUELS

Wood fuels are defined as all types of *biofuels* originating from *woody biomass,* where the original composition of the wood is preserved and unaltered from its original form (FAO unified bioenergy terminology (UBET)),

Wood fuels are specified by:

a) origin and source
b) major traded forms and properties

There are basically three different origins and sources of wood fuels:

- **Wood from forests and plantations**: wood from forests, parks, fast-growing tree plantations, shrub species and similar. As potential of timber from forests, used for energy purposes, only small diameter wood, part of logging residues (tops, branches) and part of the low-quality round wood is considered. In case of fast-growing trees and shrubs' plantations, all wood is considered as potential.

- **By-products and residues from the wood processing industry**: these biofuels are either chemically untreated (e.g. residues from crust removal, sawing, sifting, moulding or pressing) or residues of chemically treated wood, if they don't contain heavy metals or halogenated organic compounds originating in use of wood preservatives or coatings.

- **Used timber**: used wood which has served its basic purpose and is considered as waste. It can only be used if it doesn't contain heavy metals or halogenated organic compounds originating in use of wood preservatives or coatings.

There are several trade forms of wood fuels that are available also in mediterranean area:

A) Firewood
B) Wood chips
C) Wood Pellets
D) Wood briquettes

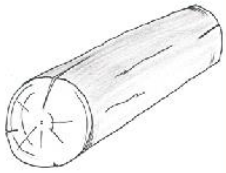
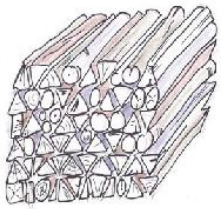
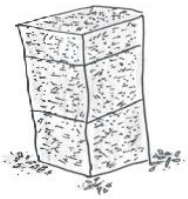
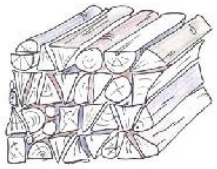
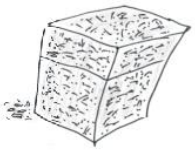
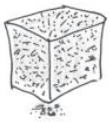
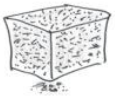
USEFUL MEASUREMENT UNITS:

Cubic meter [m^3]: used as a unit of measurement for volume, completely filled with wood (without empty spaces in-between). It is commonly used for round wood without crust.

Stacked meter [stacked m^3]: is a unit of measure used for stacked wood.

Bulk cubic meter [bulk m^3]: unit used to measure bulk fire wood or bulk woodchips quantity.

Conversion factors between different units and different types of wood fuels ease the comparison between different types of fuels, their prices and final heating cost.

Kubični metri (m^3)	Prostorninski metri (prm)	Nasuti kubični metri drv (nm^3)	Nasuti kubični metri sekancev (nm^3)
 **1 m^3**	 1,4 prm	 2,0 nm^3	 2,5 nm^3
 0,7 m^3	 **1 prm**	 1,4 nm^3	 1,8 nm^3
 0,5 m^3	 0,7 prm	 **1 nm^3**	 1,25 nm^3
 0,4 m^3	 0,5 prm	 0,8 nm^3	 **1 nm^3**

Picture 4: indicative values for commonly used conversion factors between different types of solid biomass fuels (Source: Kocjan D. et al. (2016). Ogrevanje z lesnimi gorivi – Koristni podatki).

Main characteristics of wood fuels

Bulk density: is defined as the mass of the solid fuel, divided by the volume of the container filled by the wood fuel. It is expressed as [kg/stacked m^3] or [kg/bulk m^3], depending on whether the wood fuel is stacked (wood) or loose (fire wood or chips). The bulk density or the density of plowing depends on the size and homogeneity of the particles which influence the gaps between pieces which can be larger or smaller, depending on the size and shape of the wood particles (pellets, chips, fire wood) and storage time.

Net Caloric Value [NCV]: indicates the amount of heat generated by combustion of fuel if the flue gases are cooled only to the temperature of the dew point of the steam in the flue gas. Released water is considered as a vapor, the heat energy necessary to change the water into steam was deducted (latent heat of water evaporation at 25° C).

Moisture content
Water in wood can be defined as "water content" and "humidity".

Humidity, U [%]: expresses the mass of water in wood in reference to the mass of absolutely dry wood.

$$U = \frac{m_w - m_0}{m_0} * 100$$

Water content, W [%]: expresses the mass of water in wood in reference to the weight of fresh wood. This measure directly influences the quality of a certain product - fuel.

$$W = \frac{m_w - m_0}{m_w} * 100$$

m_w – mass of fresh wood (on the market)
m_0 – mass of absolutely dried wood

Table 1: heating value of wood according to the length of storage/drying. (Source: Kocjan D. et al. (2016). Ogrevanje z lesnimi gorivi – Koristni podatki)

	Freshly cut wood	Wood stored for couple of months	Wood stored for a year or more	Absolutely dry wood
Water content (%)	50 – 60	25 – 35	15 - 20	0
Heating (H_i) (kWh/kg)	2,0	3,4	4,3	5,14

In the following *Table 2* the information is given on heating values for different solid biomass fuels, and for different tree species and relation to the heating oil equivalents. The values are given according to the tree species, reference and literature.

Table 2: values for heating, volume, and oil equivalents for different tree species and solid biomass fuel types, all at 10% water content (w%) (Source: http://wcm.gozdis.si/en/unit-converter)

TREE SPECIES 1 tone	FIREWOOD (stacked m^3)	WOOD CHIPS (bulk m^3)	WOOD PELLETS (t)	HEATING VALUE (Hi) (kWh/kg)	HEATING OIL EQUVALENT (l)
BEECH	2,06	4,34	0,95	4,68	437
OAK	2,06	4,34	0,95	4,68	437
BIRCH	2,35	4,94	0,95	4,68	437
POPLAR	3,42	7,20	0,95	4,68	437
LARCH	2,60	5,48	0,96	4,73	442
SPRUCE	2,99	6,30	0,96	4,73	442
PINE	2,85	6,00	0,96	4,73	442

As can be concluded from the *Table 2*, the heating values and the heating oil equivalent differ only among the coniferous and deciduous trees, and not between tree species within this two groups.

4.2.1. FIRE WOOD

Firewood is defined as sawn, when needed also chopped wood for energy purposes, used in ovens, fireplaces or central heating boilers for fulfilling heating needs of individual houses or apartments.

Firewood is usually 15 to 100 cm of length, in the next forms:

- wood log - sawn and split to the length between 15 and 50 cm
- split firewood - sawn and split to the length of 50 cm or longer
- roundwood - sawn but un-split wood of 50 cm of length or longer

Storage conditions directly influence the quality of firewood, mainly water content and consequently also heating value; hence it is important to follow the recommendations for storage to ensure the best possible conditions:

- storage areas should be sunny and dry;

- the wood stack should be raised at least 10 cm above ground, to allow air circulation and reduce floor moisture influence;
- freshly cut logs should not be stored indoors or covered with tarpaulins (which prevent water evaporation).
- after summer period, the stack should be protected from rain with a cover;
- the drying is more effective when wood is chopped since the smaller the cuts are, the bigger is the surface area and speed of drying.

Picture 5: firewood stacks (http://www.woodstovewizard.com/).

Firewood quality is influenced by production technology, processing, storage conditions and final use of timber. The following factors directly influence the wood quality:

- tree species,
- share of rotten wood (overall wood preservation),
- water content,
- the size of individual pieces.

According to the **international standard EN ISO 17225-5: 2014**, the firewood is divided into two main groups:

- group A: firewood higher quality: water content below 25 %, higher share of chopped wood, share of rotten wood must be below 5%. This wood is suitable for use in fireplaces and furnaces. The group is further divided into A1 and A2 groups. In A1 the share of split wood exceeds 90 %, and no rotten wood is allowed.

- group B wood is suitable for use in central heating boilers since the water share can reach 35% and there is no condition regarding split or rotten wood share.

Table 3: quality grades for firewood, according to EN ISO 17225-5: 2014 standard.

QUALITY CLASSES	A1	A2	B
Biomass source	Timber wood, unpolluted wood residues	Whole trees, timber wood, wood processing residues	Whole trees, timber wood, wood processing residues
Diameter (cm)	≤ 2 do > 15		> 5 do > 15
Length (cm)	≤ 20 do ≤ 100		≤ 20 do ≤ 100
Water content (%)	≤ 20 do ≤ 25		≤ 20 do ≤ 35
Share of split wood (%)	≥ 90	≥ 50	No demand
Share of rotten wood (%)	0	≤ 5	If rotten wood share is ≥ 10% the info has to be given

4.2.2. WOOD CHIPS

Wood chips are small wood pieces, the size typically varies between 30- and 50-mm. They are usually produced by mechanical processing from low-quality wood or branches.

Picture 6: wood chips (http://www.treetamersinc.com/wood-chips-mulch/).

There are two specific groups of wood chips:

Rough wood chips are much longer and robust. Their typical length is from 50 to 150 mm. They are mainly intended for industrial use and not to smaller individual users.

Green wood chips: are made from fresh logging / wood processing residues, therefore the proportion of needles and leaves is higher, as well as the water content.

Wood chips production

Wood materials for the wood chip production must be cut in time, to enable storage and drying of round wood on airy and sunny site. Before chipping, moisture content of round wood should be less than 35% to ensures long-term storability of wood chips. One cubic meter of wood corresponds to about 2.5 m³ of loose wood chips.

Woodchippers are machines designed for processing of wood directly into chips. They are either stationary, built-in on a truck or trailer or carried on a tractor attachment. Depending on the performance, they are either small (capacity up to 30 loose m^3/h), medium (from 30 to 100 loose m^3/h) and large (capacity more than 100 nm^3/h). Large modern chippers are able to produce large amounts of chips within a short period of time.

Picture 7: Large wood chipper producing wood chips on the road side.

Wood chips storage is again very important since it influences the production costs and the quality of chips. Storage is subject to the following recommendations:

- round wood for wood chips production is recommended to be dried for at least 6 months on a sunny, airy location, covered with a tarpaulin to allow air circulation. Thus, the chips reach water content below 30%,
- the chips must arrive and leave warehouse according to the system "first in - first out", the chips that were first brought to the warehouse are the first to leave it,
- the chip piles should not exceed 10 m in height or 7 m, in case the chips contain impurities (crust, leaves and needles),
- in the store next to the boiler room only smaller quantities of chips are stored (e.g. weekly stock),

- green chips should not be stored in closed spaces or for a longer period; due to higher water content, the overall mass losses are quick and the quality deteriorates.

Wood chips quality is determined by the water content, tree species, wood quality, presence of rotting material, particles size distribution and the share of various impurities such as plastic, earth and similar. All named factors influence the heating value, the bulk density and the ash content.

Standard EN ISO 17225-4 classifies chips into two groups:

- chips for domestic (individual) use: are classified into quality classes A (A1 and A2) and B (B1 and B2). Chips classified in class B can be made from not chemically contaminated wood waste and used wood.
- chips for industrial use

Table 4: quality grades for woodchips, according to EN ISO 17225-4 standard.

QUALITY CLASSES	A1	A2	B1	B2
Particle size (mm)	According to Table 4			
Water content (%)	< 10 < 25	< 35	Has to be determined	
Ash share (%)	< 1,0	< 1,5	< 3,0	
Bulk density (kg/m^3)	> 150 > 200 > 250	> 150 > 200 > 250 > 300	Minimal value has to be determined	
Key chemical elements with limit values determined			N, S, Cl, As, Cd, Cr, Cu, Pb, Ni, Zn	

According to different classes, the origin of the wood can be either from round wood or whole trees, (from forest, plantation and other non-forest areas), logging residues, and chemically untreated wood residues (as by-products from wood processing industry).

Particle size is an important parameter for wood chips use, namely the share of chips of the largest dimensions is important since it corresponds to technical criteria for conveyor belts or worms of the heating systems. Also, the share particles below 3.15 mm must be reported since this size represent a threat to the health of employees working in warehouses and in the vicinity of transport facilities and are exposed to emissions of dust particles.

Table 5: Size classes for wood chips (Source: Kocjan D. et al. (2018). Ogrevanje z lesnimi gorivi – Lesni sekanci).

SIZE CLASSES	SIZE OF MAIN FRACTION (mm)	SHARE OF FINE FRACTION (%)	ROUGH FRACTION – SHARE AND SIZE (%, mm)
P 16	3,15 < P < 16	< 12	< 6 %, > 31,5 mm
P 31	3,15 < P < 31,5	< 8	< 6 %, > 45 mm
P 45	3,15 < P < 45	< 8	< 6 %, > 63 mm

4.2.3 WOOD PELLETS

Pellets are standardized concentrated biofuel produced from wood biomass - from saw dust, wood shavings and sometimes also from logwood. They are cylindrical, up to 10 mm in diameter and up to 40 in length.

Picture 8: wood pellets (https://kwhsupply.com/product/bulk-wood-pellets/).

Pellet production: pellets are produced under high pressure. The wood material is milled, dried and pressed through a cylindrical holes' matrix. Friction causes a slowdown in flow through the openings (pressure and temperature increase), consequently raw material particles are compressed and pellets are formed. The pressing and the heat both cause bonding of the wood particles in presence of natural lignin. Manufacturers can improve quality (e.g. persistence) by adding up to 2% of natural additives (e.g. corn starch). Pellets should not contain chemical additives.

The process results in a homogenous, solid fuel with high energy density. One ton of pellets corresponds to 5,000 kWh heat which is about 500 litres heating oil.

Storage and distribution: to maintain the quality it is important that pellets are stored in closed, dry storage. Pellet are still most commonly sold pre-packaged in PVC bags (15 kg) stacked on a pallet. However, the number of producers who sell pellets in big bags or bulk, to be transported by truck and directly heaped into the silos is increasing. For this kind of logistics ventilation of the storage room is important.

Pellet quality: the following indicators determine the pellet quality:

- Water content is directly related to the pellets' combustion efficiency – the greater the water content, the smaller the burning value and lower combustion efficiency.
- Ash content in pellets for home use should be kept to a minimum, since ash quantity shortens the intervals between the needed ash tank emptying. In addition, higher ash proportion is associated with possible boiler malfunctions. The ash content depends mainly on the raw materials used; typically, a slightly higher proportion of ash is characteristic for wood of deciduous trees; the proportion of ash significantly increases if the rind and other impurities are mixed into raw material.
- Slag formation depends primarily on the percentage of ash content. The higher the ash content, the greater the possibility of slag formation.
- Mechanical durability is important from the consumer perspective; lower mechanical stability increases fine particles share in the storage area, and in the worst case, these particles can cause malfunction of the conveyor belt which delivers pellets into the boiler. The emissions of fine particles can also be problematic for air quality issues.
- Bulk density importantly influences the transport and storage costs since the greater the bulk density, the more energy is accumulated per volume unit, which lowers the transport and storage costs.

EN ISO 17225-2 quality standard classifies the pellets into two groups:

- pellets for domestic (individual) and
- pellets for industrial use.

Pellets for home use are classified into quality classes A1, A2 in B.

Table 6: Pellets for home use are classified into quality classes A1, A2 in B (Source: Kocjan D. et al. (2018). Ogrevanje z lesnimi gorivi – Peleti).

QUALITY CLASSES FOR HOME USE	A1	A2	B
Diameter (mm)	6 ± 1 8 ± 1		
Length (mm)	3,15 - 40		
Water content (%)	≤ 10		
Mechanical stability (%)	≥ 97,5		≥ 96,5
Bulk density (kg/m^3)	≥ 600		
Fine particles share (%)	≤ 1		
Ash content (%)	≤0,7	≤ 1,2	≤ 2

Pellets for industrial use are divided into quality classes I1, I2 in I3**.**

Table 7: Pellets for industrial use, divided into quality classes I1, I2 in I3 (Source: Specifications of biomass products traded on the Graceful Globe Biomass Exchange).

QUALITY CLASSES FOR INDUSTRIAL USE	I1	I2	I3
Diameter (mm)	6 ± 1		
Length (mm)	3,15 - 40		
Water content (%)	≤ 10		
Mechanical stability (%)	97,5 ≤ 99,0	97 ≤ 99,0	96,5 ≤ 99,0
Bulk density (kg/m^3)	≥ 600		
Fine particles share (%)	≤ 4	≤ 5	≤ 6
Ash content (%)	≤1,0	≤ 1,5	≤ 3

4.3 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC) SYSTEMS

A simplified QA/QC system should be adopted by the single stages in the established wood biomass energy production chain, in order to follow and assure the implementation of the sustainability, operation standards, storage and compliance with the end users quality requirements. Commitment of producers, suppliers and end-users is essential in order to assure the requirements are known, respected and the end product is in compliance with the installation and end-user quality requirements.

According to the Quality Management system definition (ISO 9001), it generally consists of Quality Planning (QP), Quality Control (QC), Quality Assurance (QA) and Quality Improvement (QI). The planning and the improvement part are not in focus here since they are not in the scope of the planned wood energy supply chain. But at least some basic Quality Control (QC) and Quality Assurance (QA) are important also in the local chains and so we should focus on providing the important input on an adjusted scale.

Fuel quality assurance (QA) provides confidence that quality requirements will be fulfilled as specified in the contract, which is then proven through quality control (QC) which checks the quality requirements for solid biofuels. QA/ QC in the supply chain aims increases confidence regarding quality of solid biofuels and information flows in the supply chain.

End-user requirements about quality level and its constancy vary considerably according to scale of heating system. For small-scale end-users the required fuel specifications are stricter or narrower, according to the combustion device specifications. Large-scale end-users with wider furnace adaptability can accept also lower quality wood fuels.

A simplified version of the standard procedure, according to the Standard EN 15234-1:2011 - Solid biofuels - Fuel quality assurance is proposed to be adopted by each wood energy supply chain. This Standard defines the procedures to fulfil the quality requirements (quality control) and describes measures to ensure adequate confidence that the biofuel specification is fulfilled (quality assurance). It covers the whole chain, from supply of raw materials to point of delivery to the end-user. It includes solid Wood fuels origin from the following sources: agriculture and forestry, vegetable waste from agriculture and forestry, vegetable waste from the food processing industry, wood waste, with the exception of wood waste which may contain halogenated organic compounds or heavy metal, fibrous vegetable waste from virgin pulp production and from the production of paper from pulp, if it is co-incinerated at the place of production and heat generated is recovered, cork waste.

The following areas should be defined to fulfil the QA/QC requirements:

- Traceability of raw material
- Production requirements
- Transportation, handling and storage after production
- Final fuel specification

For the needs of the present Template, the traceability of raw material can be covered with either of the proposed schemes for sustainable forest management.

Production requirements and quality standards for each of the covered solid biofuels, namely fire wood, wood chips and wood pellets, are described in chapters 4.2.1, 4.2.2. and 4.2.3, and standards defining quality levels are named.

Furthermore, biofuels specification should be decided according to the scale and boiler specifications, steps in the production chain should be defined and documented, factors influencing fuel quality and company performance should be analysed, Critical Control Points (CCP) identified and proper measures selected to give confidence to customers.

Storage, handling and transportation are all procedures that can contribute to or deteriorate the final quality of wood fuel. Recommendations for storage are given in the chapters 4.2.1, 4.2.2. and 4.2.3. The chosen approach to these operations should be foreseen and written QA/QC system.

Attention should be, based on EN 15234-1, put on:
weather and climatic conditions (primarily due to moisture content), storage size, construction and conditions, possible contamination, suitability and cleanliness of equipment, effects of transportation on solid biofuels (amount of dust, mechanical durability …)

Fuel analysis and specification
The solid biofuel properties should be specified in the product declaration following the requirements in the appropriate parts of the EN 14961 series. It is important to emphasise that the whole responsibility for correct and accurate information is on the producers/suppliers' side, regardless of the method used.

A simple quality control by the end user – buyer can be done by water content measurements and particle size measurements. The water content can be easily and frequently determined by commercial moisture meters or humimeters, as presented in picture 9.

(https://www.europages.co.uk/Wood-Chip-Moisture-Meter-humimeter-BLL-/MESSTECHNIK-SCHALLER-GMBH/cpid-5434249.html)

(https://www.lmine.com/index.php?main_page=index&cPath=33_409_428)

Picture 9: Particle size can be checked by the use of test sieves of different sizes, to determine particle size classes.

4.3.1. **FUEL VS. HEAT ACQUISITION**

For the purpose of setting quality requirements for biomass from the protected areas in a local forest- wood-energy chain, two approaches can be chosen in the supply chain:

a) A contract between the end user and the supplier from the local chain foresees the acquisition of solid wood fuel of a certain quality to be burned in the boiler

In this case an agreement or a document citing the single production stages and demands for standards and quality assurance for each of them has to be defined and respected among the supplier and the end user. The end user is recommended to establish a simple control system for a quick and regular check of the most effective quality parameters.

b) A contract between the end user and the supplier from the local chain foresees the acquisition of heat, provided by the supplier.

In this case the end user is free of all quality checks and responsibilities of meeting the agreed fuel quality standards, the responsibility is on the supplier. The user actually buys the heat produced and used, and it is the sole responsibility of the supplier to produce it in the most economic as well as environmentally friendly way.

5 CASE STUDY

A system – an existing system or a planned one, based on the activity A.3.8. – Planning sustainable forest – wood – energy supply chain should be chosen and its specifics taken into account in setting criteria and demands on quality assurance and quality check.

A system planned under A.3.8 should be described and the main critical points, influencing quality of fuel reaching the end user should be further described in detail. When planning a system or planning biomass fuels for an existing one, national legislation on emission of substances has to be taken into account. The legislation defines criteria for the scale of the burning device, the type of fuels which can be used, limit values for different emissions.

The proposed and planned criteria and demands on quality assurance and quality check should be thus based on following the single national legislative limits and recommendations (i.e. the Decree on the emission of substances into the atmosphere from medium-sized combustion plants, gas turbines and stationary engines in case of Slovenia).

We propose to describe, according to the contents of the present template, the following contents:

- the availability in possibility to use one of the forest certification schemes,
- the chosen fuel type and the needed quality class based on the boiler requirements
- the transportation and storage conditions
- the boiler requirements and its compliance with the state regulations on emissions from the small or medium medium-sized combustion plants; usually a state decree on the emissions
- a system of quality insurance for the fuel to meet the sustainability and habitat preservation criteria

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Specifications of biomass products traded on the Graceful Globe Biomass Exchange http://biomass.exchange/wp-content/uploads/files/biomass_products.pdf

European Standards:

- EN 14961 series of standards

EN 14961-1:2010 Solid biofuels – Fuel specification and classes – Part 1: General requirements
EN 14961-2:2011 Solid biofuels – Fuel specification and classes – Part 2: Wood pellets for non-industrial use
EN 14961-4:2011 Solid biofuels – Fuel specification and classes – Part 4: Wood chips for non-industrial use
EN 14961-5:2011 Solid biofuels – Fuel specification and classes – Part 5: Firewood for non-industrial use

- EN 15234-1:2011 - Solid biofuels - Fuel quality assurance

Forest Bioenergy in the Protected Mediterranean Areas

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FORBIOENERGY - Forest Bioenergy in the Protected Mediterranean Areas

Quality requirements for the biomass from the protected areas

Appendix 1 – study report Croatia

Work package 3 - Testing

Activity A.3.9. - Quality requirements for the biomass from the protected areas

Methodology for the planning sustainability and quality requirements for biomass from protected areas

Authors: Park prirode Velebit

REGIONE SICILIANA
ASSESSORATO REGIONALE DELL'AGRICOLTURA, DELLO SVILUPPO RURALE E DELLA PESCA MEDITERRANEA
DIPARTIMENTO REGIONALE DELLO SVILUPPO RURALE E TERRITORIALE

Municipality of Petralia Sottana

ENV4LAND

GOZDARSKI INŠTITUT SLOVENIJE
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RDA Green Karst

amufor municipios forestales valencianos

Cámara Valencia

Zadar County

VELEBIT
Park prirode • Nature park

Programme Cofinanced by the European Regional Development Fund
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Content:

1 Chain of custody and sustainable forest management certification

Wood energy supply chains planned in the frame of the ForBioEnergy project are all established based on an assumption that ecosystems preservation and biodiversity conservation in the protected areas are the basic ideas and understood as an axiom from the beginning of the process.

In another words forest management is defined as sustainable management which took in consideration economic interests, ecological sustainability, access to natural resources and in the same time respects socio-cultural characteristics with the aim to keep welfare of society.

Sustainable forest management has been developed over decades through the certification model in forestry. This is in the same time market instrument and the instrument of promotion sustainable and responsable forest management (ecologically, economicaly, sociologicaly). It provides transparent forest management for customers and other stakeholders.

Certification has three key moments:
Standard – the assembly of in advance determined criterias which have to bi fulfilled ih the proces of certification to gain positive asessment
Certification procedure – is the line of activities of **the** certification body which through audit/ estimates in advance determined criterias determines whether the standard is accomplished.
Acreditation of certification body – is procedure where national, or in some cases international acreditation body assess the qualification and independance of bodies involved in certification proces.
Today there is to basic types of certification

Forest Management certification – FM it is certification of forest area and quality of forest management and it is concerned of raw materials, services and products which could have certification mark.

Chain of Custody certification – CoC it is certification of production chain where every part of production chain is monitored and certified and in which the ownership over products of certificated forest is changable.

Today thera are to leader international certificates The Forest Stewardship Council (FSC) and Programme for the Endorsment of Forest Certification.

1.1 Forest stewardship council (FSC) chain of custody certification

FSC certification model is today the most important because of its global imapct, number of certified enterpreunersundertaker and robust criterias.

FSC scheme facilitatea two kind of certification, one for owners and forest managers, and the other for subjects which process or distribute forest products.

FSC FOREST MANAGEMENT CERTIFICATION confirms that forest management keeps ecosystems and welfare of forest workers and in the same time preserves economic sustainability.

FSC® CoC (chain of custody) certification is confirmation of the chain of care for sustainable development of globalforest resources and elological balance in general. The chain of custody follows certified material through the production process from forest do the final customers, including all intermedium stages. All owners in production chain must have FSC® certificate and in this case the final product could be marked with prescribed FSC® labes.

Figure 1. *The FSC Chain of Custody Certification standard version 3-0 is applied since April 1st 2017..*

There are two types of FSC® CoC

- One is for organisation which process or distribute forest products – there are certificates for single legal subject or prodaction process. They could be acommodated to production processes which take place on sevaral places or in more groups and is suitable to big companies which oprates on many places. This certificat also can use small enterpreuneres if they are organised togather and can gain collective certificate.
- The other certificate is for one building or object which is all or partly made od FSC certified components

FSC 100 % label indicates that the product is completely made of FSC certified materials.

FSC Mix label indicates replacement of certified wood material with non-certified materials, which also hold-up to certain controlled and demanded standards.

FSC Recycled label indicates that the product is all made of recycled or resued materials. At least 85 % of reclaimed material must be verified as having been recycled following consumer use to qualify for the FSC Recycled label.

Before the owner or forest manager gain FSC certificate the certification, procedure must be applied, where is estimated whether the FSC principles are met. These principles are applied all over the world in various eco, cultural, political and legal systems, with a specific guidance needed for local interpretation of principles.

The FSC 10 principles (https://ic.fsc.org/en) are listed below.
PRINCIPLE 1: The Organization shall comply with all applicable laws, regulations and nationally ratified international treaties, conventions and agreements.
PRINCIPLE 2: The Organization shall maintain or enhance the social and economic wellbeing of workers.
PRINCIPLE 3: The Organization shall identify and uphold Indigenous Peoples' legal and customary rights of ownership, use and management of land, territories and resources affected by management activities.
PRINCIPLE 4: The Organization shall contribute to maintaining or enhancing the social and economic wellbeing of local communities.
PRINCIPLE 5: The Organization shall efficiently manage the range of multiple products and services of the Management Unit to maintain or enhance long term economic viability and the range of environmental and social benefits.
PRINCIPLE 6: The Organization shall maintain, conserve and/or restore ecosystem services and environmental values of the Management Unit, and shall avoid, repair or mitigate negative environmental impacts.
PRINCIPLE 7: The Organization shall have a management plan consistent with its policies and objectives and proportionate to scale, intensity and risks of its management activities. The management plan shall be implemented and kept up to date based on monitoring information in order to promote adaptive management. The associated planning and procedural documentation shall be sufficient to guide staff, inform affected stakeholders and interested stakeholders and to justify management decisions.
PRINCIPLE 8: The Organization shall demonstrate that, progress towards achieving the management objectives, the impacts of management activities and the condition of the Management Unit, are monitored and evaluated proportionate to the scale, intensity and risk of management activities, in order to implement adaptive management.
PRINCIPLE 9: The Organization shall maintain and/or enhance the High Conservation Values in the Management Unit through applying the precautionary approach.
PRINCIPLE 10: Management activities conducted by or for The Organization for the Management Unit shall be selected and implemented consistent with The Organization's economic, environmental and social policies and objectives and in compliance.

Preparation process of FSC Standard for some area is consist of next steps:
1. Identification in interested parties,
2. Establishing of National working group,
3. Review of existing standards in the country /near by regions
4. Interpretation of all relevant FSC principles and criteria's for FSC for country/region
5. Screening of national legislative,
6. The first draft of stadard,

7. Consultations with interested parties/national initatives
8. The second draft of standard
9. Testing of standard na terenu,
10. The third draft of standard,
11. Final standard,
12. FSC National working group represents the final standard for acceptance to FSC.
FSC certificate is acommodated to vaste forest areas all around the world.

Only 4 % of small and/or low productive forest areas has FSC certificate.[1] At the moment there is looking for inovative ways to increase this percentage up to 2020 in cooperation with small forest owners and local communities in various parts of the world.

FSC New Approach has a goal to stay internationally recognizable and local relevant. There is various preparation which include discussions of national working groups, working shops etc. The goal is up 2020 develop tools for responsible forest management adjusted to small forest areas worldwide. FSC is looking for new concept to define simplified standard for small forest owners. For Europe in Chech 2018 the seminar took place where were represent benefits of FSC certification to small forest owners.

In Europe there is more than 78 million of ha corticated areas, Republic Croatia certificated in October 2002 according SFC scheme all forest in state ownership which are managed by Croatia forest LTD (about 2 million oh ha). FSC certificate is monitored regularly and it is continually prolonged and today certificate last up to 2020.

Certification of all area of state forest was the great success on global level and it was confirmation of Croatian policy to sustainable forest management.

Croatian wood Ltd has the certificate since 2002 for 2. 024.460.62 ha of wood and is certified for production of rough wood, fuel wood, twigs and wood in chips and particles *Combined Forest Management and Chain of Custody.*

FSC® CoC (chain of custody) certification helps to subjects on the market promotion in ecologically aware sectors which is increasing. Today in Croatia 341 legal entity have FSC® CoC certificate for their products.

Many Croatian companies which distribute their products (with forest origin) on the international market, particularly on the European market very often FSC® certificate as important condition for purchasing of their products. Also on many public procurements one of conditions is FSC® CoC certificate and this model is also more and more present in Croatia.

[1] FSC New Approaches Project: 2018 Report & 2019 Plans, page 2/11

Table 1. The number of FSC certificate holders based in the Republic of Croatia and Lika –Senj County.

Product type	No. certificate holder in Croatia (on national level)	No. certificate holder Lika –Senj County
W1 –rough wood	226	6
W2 –wood charcoal	1	0
W3 –wood in chips and particles	241	6
W4 –impregnated/treated wood	15	0
W5 –solid wood (sawn,chipped peeled,	242	5
W6 –products from planinig mill	56	1
W7 –vaneer	82	1
W8 –wood panels	32	0
W9 –engeneered wood products	103	1
W10 –wood package and similar	40	0
W11 –wood for construction	120	2
W12–Indoor furniture	79	2
W13 –Outdoor furniture and gardening	46	0
W14 –Musical instruments	1	0
W15 –recerational goods	5	0
W16 –household articles	5	0
W17 –stationery of wood	9	0
W18 –Other manufactured wood products	14	0
W19 –Other wood products n.e.c.	14	0

Source: https://info.fsc.org/certificate.php#result, May 2019.

In Lika –Senj County 6 legal entities have FSC certificate (Otočac, jezerane and Udbina) . Thera are also state owned forests (Managing by Croatian wood Ltd) and 2-3 other companies which have their branches in the County, but they are registered in other parts of Croatia.

1.2 Programme for Endorsement of Forest Certification (PEFC)

PEFC™ Programme for Endorsement of Forest Certification is independent organisation for maintains comprehensive databases to ensure easy access to relevant information about certificate holders, logo & label users, certified products, accredited certification bodies, and PEFC-endorsed national certification scheme.

Organization is started on initiative of representatives more than 12 million small forest owners. It is not completely international initiative because is developed primarily for European forestry, but its openness and readiness to mutual acceptance of other programs gives PEFC international character.

In Europe its certificate have about 12 million small forest owners which are not satisfied with FSC certificate scheme which is more adjusted for vast forest areas (for small forets owner FSC certificatin is to expensive and uneconomic).

Obtaining PEFC Sustainable Forest Management certification demonstrates that management practices meet requirements for best practice in sustainable forest management, including:

- **Biodiversity** of forest ecosystems is maintained or enhanced
- The range of **ecosystem services** that forests provide is sustained
    - they provide food, fibre, biomass and wood
    - they are a key part of the water cycle, act as sinks capturing and storing carbon, and prevent soil erosion
    - they provide habitats and shelter for people and wildlife; and
    - they offer spiritual and recreational benefits
- Chemicals are substituted by **natural alternatives** or their use is minimized
- **Workers' rights** and welfare are protected
- **Local employment** is encouraged
- **Indigenous peoples' rights** are respected
- Operations are undertaken within the **legal framework** and following best practices

PEFCC (Pan-European Forest Certification Council) is established as managing body, responsible for coordination of the certification program on national levels of state members. State PEFC bodies are responsible for establishing national certification program. The main protagonist of FSC are NGO while IN PEFC companies and forest owners are more included. The power od PEFC is the fact that it is established as result od international initiative, has developed clear criteria and indicators agreed through involvement of many countries. The biggest disadvantage is lacf of support of international ecological organizations because according to them this program does not guarantee improvement of forest management.

PEFC has measurable indicators, and its certificate offer to forest owners assurance that they have completey sustainable forest management (ecological, economical and social). Documetation of sustainable management is created on two levels. On regional level documentation gives integral picture of regional forest management which estimates whether some region fulfill conditions for certification. On the level of forest owners they should make commitment that they will follow PEFC guidance on national level to gain PEFC certificate.

National systems of PEFC certification can apply for confirmation and right to use PEFC labels to PEFC international body . After its approval national PEFC managing bodies establish standards and manage the proces of certification.

PEFC system of certification has the key role in certification of small forest areas. There is possibility to obtain group certificate, where more forest owners have one group certificate. This ensure better financial results, better acces to education and developed (more demanding) markets.

Figure 10. *Programme for the Endorsement of Forest Certification (PEFC)*

Certification scheme are important for the next areas:

1. Certification of the companies which manage plantations or natural forests
2. Certification of the Chain of Custody for companies which use forest products (wood processing, paper industry, distributors)
3. Increasing of the trust of customers
4. Recognition on the international market (official Internet data nase of certified companies)
5. Protection of forest resources
6. Image improvement
7. Posibility to compete for green procurement

PEFC™ Forest Management - PEFC™ FM is itenede for organizations (companies) which manage with own forest resoureces and want to prove to their customers dat they manage with forests on sustainable way.In a case that organization want to sell sawn wood it must to obtain also PEFC™ CoC certificate.

In many countries ownerships over forests belong to small families or local communities and gaining of collective (group) certificate is alternative to individual certificate because in that case several forest owners share financial, administrative and operational obligations. In this type of certification one body represents individual forest owners and has responsibility for follow up of determined forest managing standard. Individual forest owners who are willingly gained to the group they must:

- To accept all requested demands of forest managing standard
- To cooperate and help in the implementation of forest managing standard
- To obligate to follow all-important corrections and preventive activities determined by the managing body which possess group certificate.

PEFC Chain of Custody (PEFC™ Chain of Custody - PEFC™ CoC) is created for organizations (companies) which in their working operations PEFC™ certificated materials and which want to sell their products with PEFC™ labels.

PEFC™ CoC represents the mechanism which follows production chain from certified forest to final product and assure PEFC label guarantee to the customers responsible forest managing.

PEFC certificate is adjusted to local, cultural, socio-economical, biological, climatological and geopolitical circumstances and in the same time assure internationally recognised conditions of sustainable forest managing.

The Chain of Custody propose and manage certification bodies. There are two mechanisms which follow origin of the products based on usage of the forest and which adjusted on various conditions and needs of companies which use PEFC certificate.

- The percentage-based method – this mechanism allows mixture of certified and uncertified of raw materials in the process of production and distribution. The percentage of certified raw material must be recognized ang the customers must be informed. Also it is possible that company sell certain amount of such products as certified products ih there is equal % of certified and uncertified raw materials.

- The physical separation method – this mechanism demands separation of certified and non certified raw materials in all phases of production or distribution.

There is developed mechanism (risk analysis, external and inspection on te site) Razvijen je mehanizam (analiza rizika, vanjsko vrednovanje external estimation, and on-site inspection) with the aim to prevent that illegally cutted wood is used and certified. These mechanisms monitor independent certificators during their annual audit and assure to the companies double protection of their interests.

At the beginning od 2017. 7 companies in Croatia had PEFC certifite, while today this certificate have 8 companies (May 2019.). Cerificate is obtained for various groups of products.

Fire wood and wood charcoal	4
Sawn wood and sleepers	5
Construction wood	3
Wood based panels	2
Wood processors (firms)	3
Pulp	2
exterior products	1
Other	1
energy	0
Non wood products	0

Source: www.pfc.org (May, 2019.)[2]

[2] Source: https://www.pefc.org/find-certified/advanced?mode=advanced&company_name=&certificate_number=&logo_license_number=&product_name=&cb_notification=&country=HR+%28Croatia%29&certificate_status=Valid&industry_sector=&product_category=14325&page=1

Any of this companies if not resident in Lika –Senj County or Nature park Velebit. Some of these companies are customers of Croatian Forests FM Gospić and Senj.

Both schemes of certification have the sane goal and it is sustainable forest managing, they use the same mechanism – independent third party which estimates compliance to previously determined standard. Both schemes demand minimal compliance with the same system of international norms (ISO) and there is understanding that sustainable forestry demands preservation of forest services – economic, social and ecological. Therefore both schemes try to accomplish coherence of economical, ecological and social goals through participation and consensus.

PEFC works through support of completely independent national forestry certification schemes which are capable to act independently out of PEFC schemes. PEFC accreditation of certification bodies if completely in charge of national accreditation organization, WHILE FSC approach is more centralized and involve development of international system of accreditation of certification bodies.

FSC demands more explicitly need for public discussion during the forest operations. FSC demands set up conditions for forest management according the estimation of social impact and asks consultations with people and various groups which are directly interested. PEFC less explicitly demand forest management where are used the best local forestry experiences and knowledge of local communities, NGO.

FSC strictly forbid use of GMO while PEFC have no attitude to GMO. Instead PEFC define general principles which cover genetic diversity.

Biomass trade and logistic centers

According to all previously said it is visible that private forests in Lika –senj county in protected area or on the other forest areas in the County are not certified.

Present production chain where raw material from state forest goes directly to customers there is no interest for biomass trade and logistic centres. Other reason is low production of private forests, they are scattered in the state forests and there is the lack of spatial information. For any improvement of managing and production of private forests the priority is to determine ownership of private forests, support new associations of private forest owners and determine interests of forest owners to use services of biomass trade and logistic centers. Only than is possible to estimate optimal number and plan of such centers.

2 Standards for solid biofuels

Wood pellet market in Europe is developed through the goals of Europe 2020 concerned of renewable energy resources. EU state members agreed to increase for 20 % production of energy from RES, 10% from biomass up to 2020 and to reduce for 20 % emission of greenhouse gases. Wood pellet has a key role in gaining those goals. Production capacities in EU are

insufficient for such increasing demand and many wood pellet distributors are turning to the near market of new EU members (Croatia) and to the markets of Bosnia and Herzegovina and Serbia with long tradition of forestry and wood processing.

According to the European Biomass Association, it is expected that demand for wood pellets in the European Union could reach as much as 80 million tons per year by 2020.

Wood fuels are defined as all types of *biofuels* originating from *woody biomass,* where the original composition of the wood is preserved and unaltered from its original form (FAO unified bioenergy terminology (UBET).

Wood fuels are specified by:

c) origin and source
d) major traded forms and properties

There are basically three different origin and sources of wood fuels:

- Wood from forests and plantations: wood from forests, parks, fast-growing tree plantations, shrub species and similar. As potential of timber from forests, used for energy purposes, only small diameter wood, part of logging residues (tops, branches) and part of the low-quality round wood is considered. In case of fast-growing trees and shrubs' plantations, all wood is considered as potential.
- By-products and residues from the wood processing industry: these biofuels are either chemically untreated (e.g. residues from crust removal, sawing, sifting, moulding or pressing) or residues of chemically treated wood, if they don't contain heavy metals or halogenated organic compounds originating in use of wood preservatives or coatings.
- Used timber: used wood which has served its basic purpose and is considered as waste. It can only be used if it doesn't contain heavy metals or halogenated organic compounds originating in use of wood preservatives or coatings.

There are several trade forms of wood fuels that are available also in mediterranean area:

E) Firewood
F) Wood chips
G) Wood Pellets
H) Wood briquettes

USEFUL MEASUREMENT UNITS:

Cubic meter [m3]: used as a unit of measurement for volume, completely filled with wood (without empty spaces in-between). It is commonly used for round wood without crust.

Stacked meter [stacked m3]: is a unit of measure used for stacked wood.

Bulk cubic meter [bulk m3]: unit used to measure bulk fire wood or bulk woodchips quantity.

Conversion factors between different units and different types of wood fuels ease the comparison between different types of fuels, their prices and final heating cost.

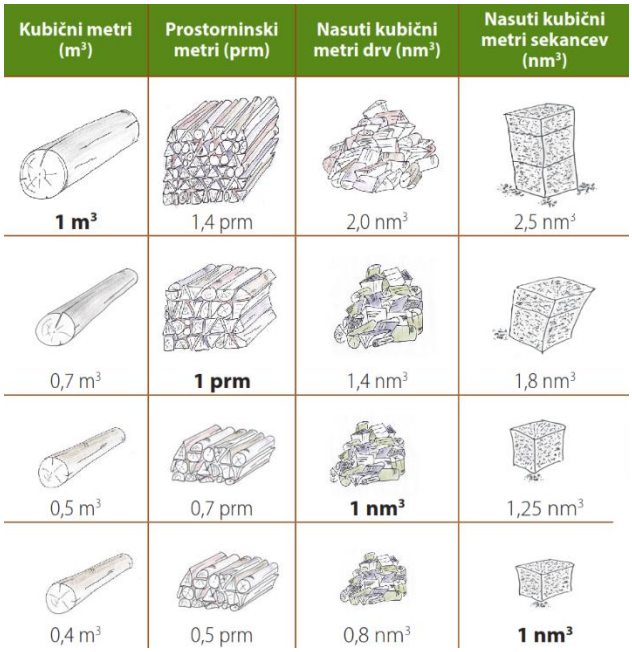

Figure 3. Indicative values for commonly used conversion factors between different types of solid biomass fuels (Source: *Template, Deliverable 3.9.1 – Quality requirements of biomass from the protected areas; ForBioEnergy project)*

Main characteristics of wood fuels

Bulk density: is defined as the mass of the solid fuel, divided by the volume of the container filled by the wood fuel. It is expressed as [kg/stacked m^3] or [kg/bulk m^3], depending on whether the wood fuel is stacked (wood) or loose (fire wood or chips). The bulk density or the density of plowing depends on the size and homogeneity of the particles which influence the gaps between pieces which can be larger or smaller, depending on the size and shape of the wood particles (pellets, chips, fire wood) and storage time.

Net Caloric Value [NCV]: indicates the amount of heat generated by combustion of fuel if the flue gases are cooled only to the temperature of the dew point of the steam in the flue gas. Released water is considered as a vapor, the heat energy necessary to change the water into steam was deducted (latent heat of water evaporation at 25° C).

Moisture content
Water in wood can be defined as “water content” and “humidity”.

Humidity, U [%]: expresses the mass of water in wood in reference to the mass of absolutely dry wood.

$$U = \frac{m_w - m_0}{m_0} * 100$$

Water content, W [%]: expresses the mass of water in wood in reference to the weight of fresh wood. This measure directly influences the quality of a certain product - fuel.

$$W = \frac{m_w - m_0}{m_w} * 100$$

m_w – mass of fresh wood (on the market)
m_0 – mass of absolutely dried wood

Table 2. Heating value of wood according to the length of storage/drying.

	Freshly cut wood	Wood stored for couple of months	Wood stored for a year or more	Absolutely dry wood
Water content (%)	50 – 60	25 – 35	15 – 20	0
Heating (H_i) (kWh/kg)	2,0	3,4	4,3	5,14

Source: *http://wcm.gozdis.si/en/unit-converter*

Tabl3 3. Values for heating, volume, and oil equivalents for different tree species and solid biomass fuel types, all at 10% water content (w%)

Tree species 1 tone	Firewood (stacked m^3)	Wood chips (bulk m^3)	Wood pellets (t)	Heating value (hi) (kwh/kg)	Heating oil equvalent (l)
beech	2,06	4,34	0,95	4,68	437
oak	2,06	4,34	0,95	4,68	437
birch	2,35	4,94	0,95	4,68	437
poplar	3,42	7,20	0,95	4,68	437
larch	2,60	5,48	0,96	4,73	442
spruce	2,99	6,30	0,96	4,73	442
pine	2,85	6,00	0,96	4,73	442

Source:*http://wcm.gozdis.si/en/unit-converter*

The heating values and the heating oil equivalent differ only among the coniferous and deciduous trees, and not between tree species within this two groups.

2.1 Firewood

Firewood is defined as sawn, when needed also chopped wood for energy purposes, used in ovens, fireplaces or central heating boilers for fulfilling heating needs of individual houses or apartments. Firewood is usually 15 to 100 cm of length. Stove logs are fire wood usually 200 mm or more of length.

Firewood quality is influenced by production technology, processing, storage conditions and final use of timber. The following factors directly influence the wood quality: tree species, share of rotten wood (overall wood preservation), water content, the size of individual pieces.

In production of fire wood after the cutting (chainsaw) roundwood is transported to working place where is cutted in forms according of demands of the market.

There are three phases of production:

1) **Selection** fire wood is chosen depends of tree species**,** kind of heeting needs
2) **Cutting of the roundwood:** 25 do 100 cm of length
3) **Splitting the logs by mechanical force**

Machines for firewood production

a) **sawing machines**: (circular or band saw)
b) **splitters**
c) **combine** (saw and splitter)

Pulpwood processing requires more power than coniferous wood processing, and all types of wood can be easily broken when they are fresh rather than dried.

According to international standard **HRN EN ISO 17225-5: 2014**, the firewood is divided into two main groups:

A. firewood higher quality: water content below 25 %, higher share of chopped wood, share of rotten wood must be below 5%. This wood is suitable for use in fireplaces and furnaces. The group is further divided into A1 and A2 groups. In A1 the share of split wood exceeds 90 %, and no rotten wood is allowed.
B. wood is suitable for use in central heating boilers since the water share can reach 35% and there is no condition regarding split or rotten wood share.

Table 4. Guality grades for firewood, according to HR EN ISO 17225-5: 2014 standard

QUALITY CLASSES	A1	A2	B
Biomass source	Timber wood, unpolluted wood residues	Whole trees, timber wood, wood processing residues	Whole trees, timber wood, wood processing residues
Diameter (cm)	≤ 2 do > 15		> 5 do > 15
Length (cm)	≤ 20 do ≤ 100		≤ 20 do ≤ 100
Water content (%)	≤ 20 do ≤ 25		≤ 20 do ≤ 35
Share of split wood (%)	≥ 90	≥ 50	No demand
Share of rotten wood (%)	0	≤ 5	If rotten wood share is ≥ 10% the info has to be given

Source: *Template, Deliverable 3.9.1 – Quality requirements of biomass from the protected areas; ForBioEnergy project*

Table 5. Quaity of firewood for various boilers

Boiler	Strength of boiler kW	Grid	Kind of heating	Dimensions of fire wood	Water content wt, %	Ash content ,%
Boiler on firewood	< 100	Unremovable	Manual	P330 – P1000	20	-

	< 150	Unremovable	Track carrier	P16 – P45	20-30	1,5

Source: Priručnik o gorivima iz drvne biomase, REGEA, 2012.

On the local level market of the fire wood is developed, and this biomass is traditionaly used for house heating in rural areas of County and all Croatia.

There is no mechanism of quality control of fire wood on local level. This is not the most important product and mostly producers are small local entrepreneurs and private forestowners. Partly this is result of managing in private forests but also on concentration of legislative on regulation biomass market for big producers through one production chain (Croatian woods Ltd – big plants; kogenerations, wood pellet factories).

Also every part of Croatia has some doinating tree species for fire wood. Local communities know about their quality and caloric valuje and know characteristic which are sign of wood quality.

On the fire wood market demand in nod decreased while the number od habitants in County is decreasing. There are no researches in Lika – county market there is the process of desapearing of middle class and increasing of energy costs. Part of households which were used oil for central heating today use fire wood for heating of houses or flats. Part of wealthier households use wood pellet for central heating.
Fire wood market is not regulated and custumers are not demanding. They mostly order and pay fire wood in cash. If it is needed thes dry wood in own gardens and storage it in coal cellar in houses, in basements (mostly in old buildings).

Producers of fire wood are small entrepreneurs which are situated in biger sommunities (Otčac, Gospić) and private forest owners which produce fire wood for themselves and for villages.

Figure 4. Firewood storage in town Gospić, June 2018. (author archive).

Storage conditions directly influence the quality of firewood, mainly water content and consequently also heating value; hence it is important to follow the recommendations for storage to ensure the best possible conditions:

- storage areas should be sunny and dry;
- the wood stack should be raised at least 10 cm above ground, to allow air circulation and reduce floor moisture influence;
- freshly cut logs should not be stored indoors or covered with tarpaulins (which prevent water evaporation).
- after summer period, the stack should be protected from rain with a cover;
- the drying is more effective when wood is chopped since the smaller the cuts are, the bigger is the surface area and speed of drying.

At winter logs start to loose water content, which is the greatest in March (about 10 %. During the hot summers, fresh cutted wood in December and straged under the roof can in June have water contetn of 20 % and is ready for market. Evaporation of water content if highest in April and is around 90l/m^3/month.

In Lika –Senj County storage conditions vary, from garedns in villages to regulated industrial plots in small manufacturers. But conditions of the storage at the moment have small infulence on prices of fire wood.

Figure 5. Firewood storage in town Gospić, June 2018. (author archive).

2.2 Chips

Wood chips are small wood pieces, the size typically varies between 30- and 50-mm. Wood chips usually is of trapezed shape and with small thicknes in comparison with other dimensions.

Wood chips can be green chips produced from fresh roundwoodand residues ih forest managing including branches od whips can be produced of all trees and includes also branches, leaves and bark.

New heating systems use mostly wood pellet and wood chip are equal to heating systems where the fuel is oil or gas. They are automatically turned off and on, keep regulated temperature and have automatically controled dosing of pellets. It is advantage in comparison with fire wood and wood briquettes. Chips is cheaper than pellet and it is also more economic fuel because it needs less energy for managing.

In Lika – Senj County chips is used in heating plants of Hrvatske šume, Forest Administration Gospić and cogeneration plants.

Figure 6. Wood chips. Source: Katalog proizvođača šumske biomase u Hrvatskoj, REGEA, 2012.

Chips production

Chips production is optimal option for heating systems. Increasing of demand in EU market and changes of croatian legistive helped in development of the energy wood market.

In phase of preparation begins with peeling of bark, wood is chopped in particles and afterward is selected according particles dimensions. Raw material is always ready for usage becaese is storaged near by cogeneration plants. For chips production are used choppers and it is first step in producing in cogeneration plants.

When in chips production pine is used than the procees starts with peeling f bark which is mechanised. Produced chips is transported (hydraulic transporters) in containers from which chips is sent in boilers. Produced heat in boilers is transported in ORC modul through termo oil. ORC plant produce electrical energy and low temperature heating energy in closed termodinamical cyclus according Organic Rankin Cyclus (ORC). The boiler is completely automatized with controlled circulation. Thermic oil is used a media tor transport of heating energy with working temperature up to do 320°C and working pressure up to 10 bars.

Choppers are machines for producing of chips. They are either stationary, built-in on a truck or trailer or carried on a tractor attachment. Depending on the performance, they are either small (capacity up to 30 loose m^3/h), medium (from 30 to 100 loose m^3/h) and large (capacity more than 100 nm^3/h). Large modern chippers are able to produce large amounts of chips within a short period of time.

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Figure 7. Europe Chippers C1175T, Cogeneration plant Lika energo eko Udbina.
Source: https://bib.irb.hr/datoteka/979851.Diplomski_filipovi_finalno.pdf

Wood chips storage is again very important since it influences the production costs and the quality of chips. Storage is subject to the following recommendations:

- round wood for wood chips production is recommended to be dried for at least 6 months on a sunny, airy location, covered with a tarpaulin to allow air circulation. Thus, the chips reach water content below 30%,
- the chips must arrive and leave warehouse according to the system "first in - first out", the chips that were first brought to the warehouse are the first to leave it,
- the chip piles should not exceed 10 m in height or 7 m, in case the chips contain impurities (crust, leaves and needles),
- in the store next to the boiler room only smaller quantities of chips are stored (e.g. weekly stock),
- green chips should not be stored in closed spaces or for a longer period; due to higher water content, the overall mass losses are quick and the quality deteriorates.

Tater content is the most important criteria for Quality of chips, because % of water content defines energy value of chips and is related to conditions for the chip's storage. The higher water content the higher is risk of mould. Green chips have more than 50 % of water content and is not suitable for longer storage is for usage in small or medium heating systems. In industrial boilers or in large heating systems green chips if regularly used and such plants are adopted for usage of green chips. Water content is also related with logistic costs of transport of raw material.

Figure 7. Europe Chippers C1175T, Cogeneration plant Lika energo eko Udbina.
Source: https://bib.irb.hr/datoteka/979851.Diplomski_filipovi_finalno.pdf

Standard HRN EN ISO 17225-4:2014 out chips in two classes:

1) Chips for domestic (individual) use: are classified into quality classes A (A1 and A2) and B (B1 and B2). Chips classified in class B can be made from not chemically contaminated wood waste and used wood.
2) Chips for industrial use

Table 6. Chips classes according EN ISO 17225-4 standard. Source: *Template, Deliverable 3.9.1 – Quality requirements of biomass from the protected areas; ForBioEnergy project*.

Class	A1	A2	B1	B2
Chips (mm)	According table 7.			
Water content (%)	< 10 < 25	< 35	Has to be determined	
Ash content (%)	< 1,0	< 1,5	< 3,0	
Density (kg/m^3)	> 150 > 200 > 250	> 150 > 200 > 250 > 300	Minimal value has to be determined	
Key chemical elements with determined limit value			N, S, Cl, As, Cd, Cr, Cu, Pb, Ni, Zn	

Size and shape of chips

Size and shape of chips (available in various sizes on the market) particles are very important parameter, namely the share of chips of the largest dimensions is important since it corresponds to technical criteria for conveyor belts or worms of the heating systems.

Volume density determined energy power and is important for estimation of storage capacities and transport capacities. Various density of different part of green trees influence on capacity of transport, storage and amount of chips needed for production of one unit of heating energy.

Ash content

From ash content can be determined the share of other materials (soil, dust, etc.), the share of bark (the bigger bark share there is higher ash content). Ash content in chips produced from peeled conifers s less than 0,5 %. Wood chips produced from mixture of coniferous with bark and leaf forest have ash content less than 1 %, depend of the bark content.

Higher ash content results with higher cost of storage and recycling of ash. In some cases, ash can cause the damage of boilers.

Impurity

In production of high-quality wood chips, the share of other particles must be very low (soil, sand, stones and other).

Table 7. Size classes for wood chips

SIZE CLASSES	SIZE OF MAIN FRACTION (mm)	SHARE OF FINE FRACTION (%)	ROUGH FRACTION – SHARE AND SIZE (%, mm)
P 16	3,15 < P < 16	< 12	< 6 %, > 31,5 mm
P 31	3,15 < P < 31,5	< 8	< 6 %, > 45 mm
P 45	3,15 < P < 45	< 8	< 6 %, > 63 mm

Source: *Template, Deliverable 3.9.1 – Quality requirements of biomass from the protected areas; ForBioEnergy project*

Table 8. Quality of chips for various boilers

Boiler	Strength of boiler kW	Grid	Kind of heating	Dimensions of fire wood	Water content wt, %	Ash content ,%

Boiler on chips	(30)150 – 1 000	Unremovable/Partialy removable	Track carrier	P16 – P45*	20-40	1,5-3,0
	> 1 000	Removable	Track carrier	P16 – P100*	30-55	3,0-10,0

Source: Priručnik o gorivima iz drvne biomase, REGEA, 2012.
* class of chips with respect to the dimensions of the cut parts

The main risk in chips storage is mould (health risk), loses of weight caused in the process of trimming and self-ignition without increasing of chips temperature. All is mostly caused when chips are stored very humid or when the process of drying is very slow.

- round wood for wood chips production is recommended to be dried for at least 6 months on a sunny, airy location, covered with a tarpaulin to allow air circulation. Thus, the chips reach water content below 30%,
- the chips must arrive and leave warehouse according to the system "first in - first out", the chips that were first brought to the warehouse are the first to leave it,
- the chip piles should not exceed 10 m in height or 7 m, in case the chips contain impurities (crust, leaves and needles),
- in the store next to the boiler room only smaller quantities of chips are stored (e.g. weekly stock),

Green chips should not be stored in closed spaces or for a longer period; due to higher water content, the overall mass losses are quick and the quality deteriorates.

In Lika –Senj County, Hrvatske šume, FA Gospić, produce chips for their heating plant in Gospić with mobile chopper and it is in storage near heating plant.

Cogeneration plants also produce chips in their industrial yards (raw material is transported from state forest, trunks are peeled, and chopped id stationed choppers.

Standard chips have 70% of beech and 30 % of pine.

2.3 Wood pellets

Pellets are standardized concentrated biofuel produced from wood biomass - from saw dust, wood shavings and sometimes also from logwood. They are cylindrical, 5 up to 40 mm in length with rough ends.

Production of wood pellets start with peeling of bark to remove all impurities.

Peeled wood (chucks) are transported, chopped in chips and transported furtherer in wood driers where heating energy dry chips (to humidity od 10 %). After drying chips is pressed through a cylindrical holes' matrix (in this process aerated water is used as help to wood starch

to link wood particles. After pressing wood pellet (temperature about 80 °C) is transported, cooled, and packed in 15 kg bags or in 1 tone bags. There is no additives in this process. Wood pellets have lower ash content, have less volume and therefore are easier for transport and storage.

The process results in a homogenous, solid fuel with high energy density. One ton of pellets corresponds to 5,000 kWh heat which is about 500 litres heating oil.

Humidity of pellet is less than 10 % (high energy value). Pellet has cylindrical shape, vary in diameter and are suitable for household heating systems small heating systems (6-8 mm in diameter) and bigger heating systems (10-12 mm in diameter). Because of their size and shape pellet is suitable for transport and filling boilers.

Storage and distribution: to maintain the quality it is important that pellets are stored in closed, dry storage. Pellet are still most commonly sold pre-packaged in PVC bags (15 kg) stacked on a pallet. However, the number of producers who sell pellets in big bags or bulk, to be transported by truck and directly heaped into the silos is increasing. For this kind of logistics ventilation of the storage room is important.

HR EN ISO 17225-2 quality standard divide pellets in two groups:

- Pellets for household use
- Pellets for industrial use

Table 9. Pellets for household use are divided in classes: A1, A2 and B.

QUALITY CLASSES FOR HOME USE	A1	A2	B
Diameter (mm)	6 ± 1 8 ± 1		
Length (mm)	3,15 – 40		
Water content (%)	≤ 10		
Mechanical stability (%)	≥ 97,5		≥ 96,5
Bulk density (kg/m3)	≥ 600		
Fine particles share (%)	≤ 1		
Ash content (%)	≤0,7	≤ 1,2	≤ 2

Source: *Template, Deliverable 3.9.1 – Quality requirements of biomass from the protected areas; ForBioEnergy project*

Table 10. Pellets for industrial use are divided in classes Peleti I1, I2 and I3**.**

QUALITY CLASSES FOR INDUSTRIAL USE	I1	I2	I3
Diameter (mm)	6 ± 1		
Length (mm)	3,15 – 40		
Water content (%)	≤ 10		
Mechanical stability (%)	97,5 ≤ 99,0	97 ≤ 99,0	96,5 ≤ 99,0
Bulk density (kg/m3)	≥ 600		
Fine particles share (%)	≤ 4	≤ 5	≤ 6

Ash content (%)	≤1,0	≤ 1,5	≤ 3

Izvor: *Template, Deliverable 3.9.1 – Quality requirements of biomass from the protected areas; ForBioEnergy project*

Table 11. Quality of pellets for various boilers

Boiler	Strength of boiler kW	Kind of heating	Dimension of fuel	Water content wt, %
Boiler on pellet	25-45	Track carrier	A1 pellet	25
	45-500	Track carrier	A1 pellet	

Source: Priručnik o gorivima iz drvne biomase, REGEA, 2012.

Boiler heating systems with more than 4W can be automatic or semi-automatic. Automatic biomass heating systems are equal to heating oil or gas heating systems. Pellet boilers can be adopted also to use fire wood.

On the market is great offer of various boilers which have manuals which contains specifications for each boiler (materials, heating power kW, recommendations of fuels etc.).

3 Quality assurance and quality control (QA/QC) systems

According to the Quality Management system definition (ISO 9001), it generally consists of Quality Planning (QP), Quality Control (QC), Quality Assurance (QA) and Quality Improvement (QI). The planning and the improvement part are not in focus here since they are not in the scope of the planned wood energy supply chain. But at least some basic Quality Control (QC) and Quality Assurance (QA) are important also in the local chains and so we should focus on providing the important input on an adjusted scale.

End-user requirements about quality level and its constancy vary considerably according to scale of heating system. For small-scale end-users the required fuel specifications are stricter or narrower, according to the combustion device specifications. Large-scale end-users with more can accept also lower quality wood fuels.

Introducing of QC system have to be understandable for all stakeholders (forest owners, producers, customers, heating systems producers), criteria and quality demands have to be clear and applicable in all parts of production chain.

Managing of quality is never ending process which demands continuous development (fuel production, plants, heating systems, logistic). Quality of biomass fuels have to be monitored by independent certified body. Also, it have to assure low production costs, decreasing of harmful emissions (par example emission of dust) to minimum gaining of customer trust in biomass fuel as ecologically fuel.

Quality control is organized in interest of wood pellet consumers. Wood pellet plants which produce pellet for export fulfil quality requirements because only i this case they can export pellet on controlled European market.

On local wood fuel market (fire wood, pellet) where demand is increasing while offer stagnated consumers quality demands are every day lower and lower. The best wood pellet is exported in EU countries while on local market could be find pellet of lower quality (more fine particles, torn bags etc.) with similar prices to best quality pellet. In small towns (Gospić, Otočac) wood pellet of Croatian producers could be bought in shopping centres (15 kg bags). But in period of market shortage (the end of heating season February, March, April) consumers rarely can be supplied with pellet even in shopping centres because the market shortage is present on all Croatian market.

The following areas should be defined to fulfil the QA/QC requirements:

- Traceability of raw material
- Production requirements
- Transportation, handling and storage after production
- Final fuel specification

Chain of Custody for raw material is covered with FSC certificate for forest management i Lika – Senj county (just as well in Croatia state forest)

Furthermore, biofuels specification should be decided according to the scale and boiler specifications, steps in the production chain should be defined and documented, factors influencing fuel quality and company performance should be analysed, Critical Control Points (CCP) identified and proper measures selected to give confidence to customers.

In period 2003-2006 The European Committee for Standardization (CEN) within the Technical Committee published 27 technical specifications (preforms) for solid biofuels (Alakangas, 2010). These specifications are completed and adopted as European norms (EN). Most norms are adopted in period 2009-2012. Afterward every state – member of CEN adopts European norm as state norm and withdraws national norms which are not compatible to European norms. In 2011 (14th December) is founded Technical committee 335 for Solid biofuels and 36 norms is accepted as Croatian norms (HR EN). Norms in area of solid biofuels covers products of agriculture and forestry, agriculture and forestry residues, food industry residues, wood industry residues, paper industry residues.

Table 12. Croatian standard TO 230 – Čvrsta biogoriva (solid biofuels, 2018.)

Label/Standard (Norm)	Name
HRN EN ISO 16559:2014	Solid biofuels – Terminology, definitions and descriptions (ISO 16559:2014; EN ISO 16559:2014)
HRN EN ISO 14780:2017	Solid biofuels- Sample preparation (EN 14780:2017)
HRI CEN/TR 15149-3:201	Solid biofuels – Determination of particle size distribution. Rotary screen method (CEN/TR 15149-3:2014)
HRN EN 15234-1:2011	Solid biofuels – Fuel quality assurance– General requirements (EN 15234-1:2011)

HRN EN 15234-2:2012	Solid biofuels – Fuel quality assurance. Wood pellets for non-industrial use (EN 15234-2:2012)
HRN EN 15234-3:2012	Solid biofuels – Fuel quality assurance. Wood briquettes for non-industrial use (EN 15234-3:2012)
HRN EN 15234-4:2012	Solid biofuels – Fuel quality assurance. Wood chips for non-industrial use (EN 15234-4:2012)
HRN EN 15234-5:2012	Solid biofuels – Fuel quality assurance. Firewood for non-industrial use (EN 15234-5:2012)
HRN EN 15234-6:2012	Solid biofuels – Fuel quality assurance. Non-woody pellets for non-industrial use (EN 15234-6:2012)
HRN CEN/TR 15569:2010	Solid biofuels – Guidance for quality assurance system (CEN/TR 15569:2009
HRN EN ISO 16948:2015	Solid biofuels – Determination of total content of carbon, hydrogen and nitrogen (ISO 16948:2015; EN ISO 16948:2015)
HRN EN ISO 16967:2015	Solid biofuels – Determination of major elements -- Al, Ca, Fe, Mg, P, K, Si, Na and Ti (ISO 16967:2015; EN ISO 16967:2015)
HRN EN ISO 16968:2015	Solid biofuels – Determination of minor elements (ISO 16968:2015; EN ISO 16968:2015)
HRN EN ISO 16993:2016	Solid biofuels – Conversion of analytical results from one basis to another (ISO 16993:2016; EN ISO 16993:2016)
HRN EN ISO 16994:2016	Solid biofuels – Determination of total content of sulphur and chlorine (ISO 16994:2016; EN ISO 16994:2016)
HRN EN ISO 16995:2015	Solid biofuels – Determination of the water-soluble chloride, sodium and potassium content (ISO 16995:2015; EN ISO 16995:2015)
HRN EN ISO 17225-1:2014	Solid biofuels – Fuel specifications and classes -- Part 1: General requirements (ISO 17225-1:2014; EN ISO 17225-1:2014)
HRN EN ISO 17225-2:2014	Solid biofuels – Fuel specifications and classes -- Part 2: Graded wood pellets (ISO 17225-2:2014; EN ISO 17225-2:2014)
HRN EN ISO 17225-3:2014	Solid biofuels – Specification of fuels and its classes – Part 3 part: Wood briquettes (ISO 17225-3:2014; EN ISO 17225-3:2014)
HRN EN ISO 17225-4:2014	Solid biofuels – Specification of fuels and its classes –Part 4: Wood chips (ISO 17225-4:2014; EN ISO 17225-4:2014)
HRN EN ISO 17225-5:2014	Solid biofuels – Fuel specifications and classes -- Part 5: Graded firewood (ISO 17225-5:2014; EN ISO 17225-5:2014)
HRN EN ISO 17225-6:2014	Solid biofuels – Fuel specifications and classes -- Part 6: Graded non-woody pellets (ISO 17225-6:2014; EN ISO 17225-6:2014)
HRN EN ISO 17225-7:2014	Solid biofuels – Fuel specifications and classes -- Part 7: Graded non-woody briquettes (ISO 17225-7:2014; EN ISO 17225-7:2014)
HRN EN ISO 17827-1:2016	Solid biofuels – Determination of particle size distribution for uncompressed fuels -- Part 1: Oscillating screen method using

	sieves with apertures of 3,15 mm and above (ISO 17827-1:2016; EN ISO 17827-1:2016)
HRN EN ISO 17827-2:2016	Solid biofuels – Determination of particle size distribution for uncompressed fuels -- Part 1: Oscillating screen method using sieves with apertures of 3,15 mm and less (ISO 17827-1:2016; EN ISO 17827-1:2016)
HRN EN ISO 17828:2016	Solid biofuels – Determination of bulk density (ISO 17828:2015; EN ISO 17828:2015)
HRN EN ISO 17829:2015	Solid biofuels – Determination of length and diameter of pellets (ISO 17829:2015; EN ISO 17829:2015)
HRN EN ISO 17830:2016	Solid biofuels – Particle size distribution of disintegrated pellets (ISO 17830:2016; EN ISO 17830:2016)
HRN EN ISO 17831-1:201	Solid biofuels – Determination of mechanical durability of pellets and briquettes -- Part 1: Pellets (ISO 17831-1:2015; EN ISO 17831-1:2015)
HRN EN ISO 17831-2:2016	Solid biofuels – Determination of mechanical durability of pellets and briquettes -- Part 2: Briquettes (ISO 17831-2:2015; EN ISO 17831-2:2015)
HRN EN ISO 18122:2015	Solid biofuels – Determination of ash content Određivanje udjela pepela (ISO 18122:2015; EN ISO 18122:2015)
HRN EN ISO 18123:2015	Solid biofuels – Determination of the content of volatile matter (ISO 18123:2015; EN ISO 18123:2015)
HRN EN ISO 18125:2017	Solid biofuels – Determination of calorific value ISO 18125:2017; EN ISO 18125:2017)
HRN EN ISO 18134-1:2015	Solid biofuels – Determination of moisture content -- Oven dry method -- Part 1: Total moisture -- Reference method (ISO 18134-1:2015; EN ISO 18134-1:2015)
HRN EN ISO 18134-2:2015	Solid biofuels – Determination of moisture content -- Oven dry method -- Part 2: Total moisture -- Simplified method (ISO 18134-2:2017; EN ISO 18134-2:2017)
HRN EN ISO 18134-3:2015	Solid biofuels –- Determination of moisture-Oven dry method Part 3 Moisture in general analysis sample (ISO 18134-3:2015; EN ISO 18134-3:2015)
HRN EN ISO 18135:2017	Solid biofuels – Sampling Uzorkovanje (ISO 18135:2017; EN ISO 18135:2017)
HRN EN ISO 18846:2016	Solid biofuels – Determination of fines content in quantities of pellets (ISO 18846:2016; EN ISO 18846:2016
HRN EN ISO 18847:2016	Solid biofuels – Determination of particle density of pellets and briquettes (ISO 18847:2016; EN ISO 18847:2016)
HRN EN ISO 19743:2017	Solid biofuels – Determination of content of heavy extraneous materials larger than 3,15 mm (ISO 19743:2017; EN ISO 19743:2017)

3.1 Fuel analysis and specification

The solid biofuel properties should be specified in the product declaration following the requirements in the appropriate parts of the EN 14961 series. It is important to emphasise that the whole responsibility for correct and accurate information is on the producers/suppliers' side, regardless of the method used.

A simple quality control by the end user – buyer can be done by water content measurements and particle size measurements. The water content can be easily and frequently determined by commercial moisture meters or humimeters.

Table 13. Average chemical content of wood (BIOEN program of usage of biomass energy. previous results and future activities)

Element	wood
	content %
carbon, C	31,5
hydrogen H,	3,9
sulfur, S:	0,01
oxygen, O	28,3
nitrogen, N:	0,03
chlorineCl	-
Flour, F	-
Water H2O	35,00
ash	1,0

Source: Prosječni kemijski sastav drveta prema BIOEN – program korištenja energije biomase: prethodni rezultati i buduće aktivnosti, Energetski institut „Hrvoje Požar", 1998.

Directive about limit values of emission (LVE) of polluting particles in the air from stationary source prpopose limit values for heating systems/plants (Uredba o graničnim vrijednostima emisija (GVE) onečišćujućih tvari u zrak iz stacionarnih izvora[3]).
Heating plants which use biomass are devided in several categories, depends on energy production

According Directive, Heating plants which use biomass are divided in more categories according the energy production, **Table 14.**

HEATING PLANT	SOLID BIOFUEL AND BIOMASS FUEL
Small	> 0,1 do 1 MW
Medium	>1 do 50 MW
Large	>50 MW

In all kind of stokers can be used liquid, solid, gas and biomass fuels.

[3] Directive about limit values of emission (LVE) of polluting particles in the air from stationary source *(Uredba o graničnim vrijednostima emisija onečišćujućih tvari u zrak iz stacionarnih izvora)*, Gazzete (NN) No. 21/07, 151/09

Table 15. LVE for small heating systems powered on biomass fuels

	LVE
Quenching of chimneys	1
Heating loss in waste gas	17%
Carbon monoxide	1000 mg/m^3
Volume oxygen content %	11% (wood, biomass)

Table 16. LVE for medium heating systems powered on biomass fuels

	LVE
Heating loss in waste gas	17%
Solid particles	150 mg/m^3
Sulfur oxides expressed as SO_2	2000 mg/ m^3
Carbon monoxide	500 mg/m^3
Nitrogen oxides expressed as NO_2	500 mg/m^3 vrtložno izgaranje: 300 mg/m^3
Volume oxygen content %	11% (drvo, biomasa)

Table 17. LVE for new big heating systems powered on biomass fuels, with 6 % volume oxygen content

	HEATING POWER MW	LVE, mg/m^3
Sulfur oxides expressed as SO_2, biomass	>100	200 200
Nitrogen oxides expressed as NO_2, biomass	>50 do 100 >100 do 300 >300	400 300 200
Solid particles	>50 do 100 > 100	50 30
Carbon monoxide		250

Table 18. LVE for existing big heating systems powered on solid fuels and biomass fuels, with 6 % volume oxygen content

	HEATING POWER MW	LVE, mg/m^3
Sulphur oxides expressed as SO_2	>50 do 100 >100 do 500	2000

	>500	2000 – 400 (linear lowering) 400
Nitrogen oxides expressed as NO_2	>50 do 500 >500	600 500
Solid particles	< 500 ≥ 500	100 50
Carbon monoxide		250

Table 19. Characteristic and influence on environment of heating energy production from biomass fuels and pellet production.

Influense	Importance yes/no	Receptor and path in put or why the influence is not important or explanation why the impact is not significant
Emission in the air	NO	Combustion of any kind of fuel have direct imapct on the air (emission of pollutions) and indirect impact on the soil and surface water (precipitation of pollutions). LVE depends of the power of plants and on kind of fueland it is estimated that this pollution is not significant. In pellet production there is no emission in the air but aerated water from drier.
Emission in underground and surface waters	NO	In production process there is no technological water, and drainage of sanitary and rainfall water must be organized. Air emission control prevents precipitation of pollutions and prevents indirect impact on underground and surface waters.
Precipitation of pollutions from the air in the soil	NO	Air emission control prevents precipitation pollutants in the soil. Correct ash managing prevents excessive direct influence on the soil (ash have to be recycled or taken care of by responsible person).
Emission of the powdered substance	YES/NO	Heating plants with boilers have tunnels which over economiser and multicyclone push particles to the chimney. On pellet cooling plant have to be filter of high efficiency. All transport for chips, sawn dust must be closed and bent transporters are used. Multicyclone purifier of gases is planted to reduce floating ash. Floating ash must be removed from multicyclone purifier and automatically transported. The efficiency of the electrostatic dehumidifier depends on the temperature of the

		gas, the humidity of the gas, the speed of the gases, the output voltage of the electrode, the laminar flow of gases throughout the cross section and the voltage stability. In addition to the above requirements for efficient effluent treatment, a continuous production process is necessary.
Ash	YES/NO	In processes of using biomass fuels in energy production ash is appeared in boiler and floating ash appeared in multicyclone. Boiler ash have to be separately collected and have to recycled (cement, added in compost, etc). If it is not possible ash have to be collected and taken care.

3.2 Fuel vs. Heat acquisition

For the purpose of setting quality requirements for biomass from the protected areas in a local forest- wood-energy chain, two approaches can be chosen in the supply chain

- Aqusition of biomass fuels
- Aqusition of heating energy

In Lika – Senj County acquisition of biomass fuels prevails. In both cases contacts regulate obligations between suppliers and consumers.
In acquisition of heating energy at the moment prevails purchasing heating energy on the market (heating plant of Hrvatske šume, FA Gospić, in Gospić) and there is still no heating energy which is by product in cogeneration plants because existing cogenerations use heating energy for pellet production.

4 Case study

In the area of Nature Park (NP) Velebit Park and on wider administrative area Lika – Senj County is visible existing two parallel and completely different system of forest managing which are originated on forest ownership.
On one side is completely regulated (legislative and operations) forest state management. On the other side is forest management in private forests which is legislatively regulated but in praxis does not function in a way to gave maximum benefits to local community and to private owners.
This case study considers present dual system of forest management in NP Velebit and Lika – Senj County and possible consequences on NP Velebit.
In biomass district (cover economic units which are partly or all in the limits of NP Velebit and which is also under administration several municipalities (Otočac, Gospić, Perušić, Karlobag, Lovinac) is a few settlements and small number of inhabitants.

In 45 settlements inside protested area lived 7.907 inhabitants (population census 2011) 25,64 % older than 64 years and only 15,30 % younger than 14.[4] In Gračac were 3.063 inhabitants or 38,74 % of total number of inhabitants of inhabitants in protected area. Today, we can estimate that the situation is even worst (depopulation and immigration).

In Biomass district, all protected area as well in all Lika –Senj County Croatian Forests (Hrvatske šume) Ltd are monopolist on the market supply of biomass because of the vast forest area managing and the amount of produced biomass. (Croatian Forests Ltd through Forest Administration (FA) Gospić and Senj manage 318.731,79 ha of forest and forest areas were 269.610,39 ha is under forest (in Lika –Senj County). Annual cutting edge (income) is 792.177 m^3 of biomass.

Production of cordwood in FA Gospić and Senj is the most important resource of biomass and is basic for fire wood production, wood pellet and heating energy (cogenerations and heating plants). FA Gospić and Senj produce 14,57 % of cord production on national level (2019).

Croatian Forests Ltd is 100 % is in state ownership and its purpose is to manage state owned forests in Croatia.

Operational activities of the company are mostly centralised and FA are moderately independent (the operational units for managing on lower level (Biomass district is under FA Gospić).

The biggest resource of cordwood are state owned stump forests and produced biomass is raw material for fire wood, pellet and chips (cogeneration and heating plants) in Lika –Senj County.

There is unique production chain in Lika –Senj County for biomass produced in state owned forests, no matter whether biomass is used for production of fire wood, pellets or chips (for cogenerations and heating plants). It is based on business policy of Croatian woods Ltd, which is unique on national level with organized public bidding for distribution of biomass for various products (for biomass for cogenerations is organised separated public bidding). Therefore chapter 3.8. embraced area of Lika –Senj County not only of potential Biomass district.

Croatian Forests Ltd. Has for all forests FSC certificate (since 2002.) and it is the reason that other subjects could have (FSC COC)[5]. Such subjects in Croatia are 341 (in Lika –Senj County).

FSC certificate and it monitoring by third independent body assure sustainable forest management (on FSC principles) which directly contribute do preserve biodiversity of species and habitats on protected area (NP Velebit) but also on all areas under state forests.

Forests are the most important natural resource in Lika –Senj County and is unreplaceable source of income for local communities. Croatian Forests Ltd. policy has exceptional socio-economic influence on welfare of local communities which in the end should be in focus of Croatian Forests Ltd and all subjects which manage protected areas in Lika –Senj County (NP Velebit, NP North Velebit, NP Plitivice lakes and NP Paklenica te Public institution for nature protection areas in Lika-Senj County).

On the other side is system of forest managing i private forests where we could say that there is no regulated management in protected area just as well in all Lika –Senj County. There is no organised associations of private forest owners, number of registered forest owners in Register of forests owners (register of Ministry of agriculture) is moderate and their production of

[4] This nuber do not include settlements of Town Senj which is not a part of Biomass district.
[5] FSC COC – FSC Chain of Custody

biomass is insignificant (only 73 private owners is in Register in all Lika –Senj County with 154,86 ha of forests, while in Biomass district is 62 forest owners who manage 123 ha of forest, May 2019.), forest ownership is disputable, all private forests do not have forest management programs and is questionable how they are implemented when all private forests are not visible on site and some are inapproachable (there is a lack of forest infrastructure). Average private forest owner (on national level) is a man older than 60, with or without preliminary or high school education)[6], they do not have forestry mechanisation (usually they use agricultural mechanisation for forest pertains). Also, there is no forest private owners with FSC or PEFC certificate and there are today no conditions to obtain such certificates.

Private and state forest are not separated but private forests are incorporated in vast state forests or they are nearby rural settlements.

Private forest owners because of their age and lack of financial resources without organised public help cannot improve present situation in private forest management. There is PRD RC 2014-2020 Measure 8 which could be used by private forest owners, their associations, and small producers but ON County level there is no some great interest because of unregulated ownership, no associations in County to purchase forest mechanisations for their members and put in order forest infrastructure.

Republic of Croatia assured all mechanisms on local/regional level which can contribute to improvement of present situation in private forests thru Management plans of protected areas and through Programs for improvement of managing private forests on County or municipality level (with respect of all legislative regulations), financed or coffined from regional or municipalities budgets. The best solution is to have one Program on county level which can be financed from several sources (budgets of County, municipalities, public agencies who govern protected areas, eventually private forest owners). Present state in private forest is also reflection of lack of financial resources of private forest owners of members of their families. For such integral approach must be identified political interest on national. Regional and local level.

Dual approach to all forests (on one side is regulated and centralised policy for state forests, and on the other side is unregulated and uncoordinated forest management in private forests) has negative consequences for local community. There is minimal influence of local community on forest policy and there is modest economic welfare for local communities gained from exploitation of state forests (key local resource) and it will be hard to maintain and improve forest management in private forests.

Market demand for biomass if higher than the offer (includes existing capacities for fire wood, pellets and chips for production of electric and heating energy). Also is determined (chapter 3.7. and 3.8., previously project deliverables) that demand for biomass will be even higher after all planned cogenerations are built. In that case demand for biomass on local level will not be met if the production in state forest remain on the same level.

In heating seasons 2017/2018 and 2018/2019 there were the lack of fire wood and pellets for local consumers (while heating seasons lasts 6 months) and prices were increased on county

[6] There is no such data on County or Municipality level but this data reflect well structure ofprivate forest owners in Lika –Senj County

level (in 2019. on local market retail price for pellet was 1,6 kn/kg, price of fire wood is 350-400 kn/m^3, while in 2017. retail price for pellet was 1,38 kn/kg, price of fire wood is 280-310 kn/m^3). It could be expected in such circumstances escalation of illegal forest exploitation in private and in state forests where FSC/PEFC certificate will have no significance and only importance will be profit on black market of cordwood (in informal interweaves is determined that part of illegal cordwood is delivered in north Dalmatia an there is no interest for its origin; consumers are citizens and small entrepreneurs which purchase fire wood and charcoal which also is illegally produced in county, but in insignificant quantity).

Consequences are negative: lack of paid taxes, illegal beneficiations, endangered biodiversity, species and habitats in protested areas and in other valuable forests. Also, it could be expected increasing danger of open fires in unregulated private forest or it could be a way to cover illegal exploitation. In time of climate change open fires could have great impact.

There is recommendation to implement mechanism for reduction/prevention this possible state on local level in a way to determine infusing demand for biomass energy products (fire wood, pellets) on local level and to assure regular supplement for local consumers from state forests. Also, it is needed to increase biomass production in state forests and to create unique long-term Program of improvement forest management in private forests, no matter for their insignificant present economic value.

In that case is possible to make improvement of such formally acceptable situation (state forests has FSC certificate, forest management programs, plans of production, public bidding is regulated, there is public Register of private forest owners, there is formal financial support for private forests through public forest advisers of Ministry of agriculture, public applications for financial support through PRD RC 2014-2020) to the state of balance in obtained standard of forest management i private and state forests, balance of demand and offer in biomass market and biomass energy products with less changing of prices.

In that exploitation of forests in protected area (NP Velebit) and County will more significantly contribute to the welfare of local communities and in the same time the preservation of existing biodiversity in protected areas but in all valuable forests in Lika –Senj County will be increased.

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[7] Directive (EU) br. 166/2006

Forest Bioenergy in the Protected Mediterranean Areas

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FORBIOENERGY - Forest Bioenergy in the Protected Mediterranean Areas

Quality requirements for the biomass from the protected areas

Appendix 1 – study report Italy

Work package 3 - Testing

Activity A.3.9. - Quality requirements for the biomass from the protected areas

Methodology for the planning sustainability and quality requirements for biomass from protected areas

Partner in charge: Regone Siciliana

THE CASE STUDY IN THE MADONIE NATURAL PARK (ITALY)

1 The availability in possibility to use one of the forest certifications schemes

The two most widespread forest certifications schemes currently usable are the “Forest Stewardship Council” (FSC), and the “Program for Endorsement of Forest Certification Schemes” (PEFC). The adoption of the forest certification schemes is considered very important for favouring the establishment of a local forest-wood-energy supply chain, while ensuring the conservation of natural resources and the protection of biodiversity. Indeed, such possibility has been considered one of the most suitable tool to increase the economic value of wood products, so that the specific objective SO6 (set within the deliverable 3.6.1) was to “Fostering the use of local wood including certified wood products”. On the other hand, forest certification is increasingly regarded as a valuable way to promote the sustainable forest management. In order to promote the adoption of forest certification systems in the Madonie Natural Park, we suggested the organization of fair events with information stands and exhibition of certified forest products, thus encouraging the local forest enterprises to adopt one of the two forest certification systems (PEFC or FSC). Indeed, it should be kept in mind that no forest area in Sicily, and in the Madonie Natural Park as well, is currently framed within a certification system of forest management and traceability protocols. In effect, neither at an European and national level the adoption of forest certification schemes is so widespread. Considering the forest certification across 43 European states, only about 6% of the forest is certified under FSC scheme, while about 7% under PEFC scheme (Maesano et al. 2018). Much lower are the values regarding Italy, where only 0,5% and 7,7% of forest area is currently certified by FSC and PEFC, respectively (Maesano et al. 2018). Much higher values are found in Northern European countries, where certified forests usually exceed 50% of total forest area. Hence, it is not a simple step but it could represent a key driving factor because the forest certification may ensure, at the same time, that a sustainable management of forest resources is brought forward, and this is, of course, a crucial aspect in a natural protected area, specific traceability protocols are adopted and the work conditions and training of forest workers are respected and considered. Overall, an improvement of the conservation status of forests, together with important benefits for the socio-economic development of the local territory and the sustainability of the forest-wood supply chain is highly expected. Sustainability and sustainable

development in general have to be intended as a development which is balanced between the economic aspects, ecological sustainability and socio-cultural aspects. The forest certifications schemes are innovative and voluntary tools through which an independent body accredited to the company assesses whether forest management respects predetermined ecological, economic and social standards, and certifies the compliance with the principles of sustainability through a written document. The forest certifications currently usable are the "Forest Stewardship Council" (FSC), and the "Program for Endorsement of Forest Certification Schemes" (PEFC). Both schemes generally also allow the use of a product brand which could help to valorize the wood products. The higher price of such products derives from the changes in forest management practices that are necessary to meet certification standards. The major current limitation for the development and spreads of the forest certification schemes in the Madonie Natural Park is the total lack of forest planning tools, both at territorial and local level. Indeed, the existence of forest management plans in force within the forest area is a prerequisite for both certification schemes. Hence, the certification process could be started and completed only after that an effective forest management plan is implemented and put into operation in the protected area. In conclusion, as many times highlighted in the course of the Project, the implementation of the necessary tools of forest management and planning is the crucial step for the chance to develop an efficient and sustainable wood supply chain, providing multiple cascading benefits. Among them, the possibility to adopt a forest certification scheme is one of the most relevant.

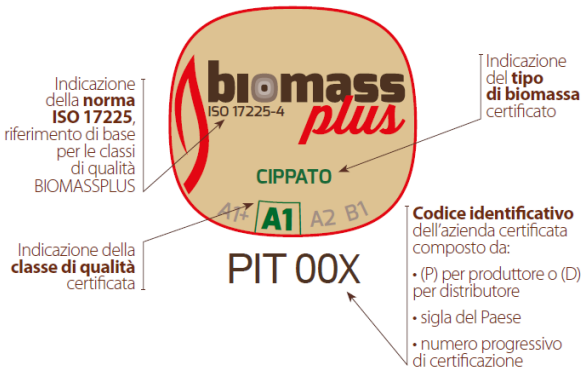
2 The chosen fuel type and the needed quality class based on the boiler requirements

The woody fuel used to feed the local forest-wood-energy supply chain comes from the forest interventions foreseen within the Forest Management Plan drafted for the Biomass District 4. The forest areas which should be subject to silvicultural interventions belong to the following forest category: beech stands, chestnut stands, downy oak and sessile oak stands, and reforestation. However, almost 60% of the overall area is represented by reforestation, followed by oak stands, beech stands, chestnut stands, downy oak and sessile oak stands, and reforestation. Furthermore, the coefficient of woody biomass utilization was notably higher in reforestation (generally higher than 30%), whilst it was generally less than 20% in the other forest categories. Moreover, most of the planned interventions are thinning on reforestation

aiming at conifers reduction and broadleaves increasing. The artificial stands are mountain conifer reforestations with *Pinus nigra*, *P. nigra* subsp. *laricio*, *Pseudotsuga menziesii*, *Cedrus* spp., and *Cupressus* spp. Ultimately, most of the wood deriving from the planned forest interventions comes from Mediterranean conifers, especially during the first period of validity of the FMP (5 years). In terms of calorific value, the differences among conifers and broadleaves appear not to be particularly large. According to the Slovenian Forestry Institute (http://wcm.gozdis.si/en/unit-converter), at 10% water content the wood of broadleaves (Beech, oak, birch and poplar) has a calorific value of 4,68 kWh/kg, compared to 4,73 kWh/kg in conifers (Larch, spruce and pine). At 20% of humidity the calorific value ranges from 3.8 to 4,1 kWh/kg in the main temperate forest tree species (www.biomasstradecentre2.eu). Finally, with the most common value of wood humidity, i.e. 30%, the average calorific value is 3,397 kWh/kg.

There can be no efficient and sustainable technology if it is not powered by sustainable biomass. The development prospective of the biomass energy sector cannot ignore the sustainability of biofuels and the emissions produced by the combustion process.

As for the forest biomass that will supply the local chain in the Madonie Park, producers could apply to the solid biofuel certification **BiomassPlus**, which works since 2015, thanks to a national agreement between AIEL (Italian Association of Agro-forestry Energy) and ENAMA (the one and only Italian Certification Body for the BiomassPlus Certification).



Nel marchio di certificazione BIOMASSPLUS, l'indicazione della norma ISO 17225 contiene anche l'informazione relativa alle parti specifiche per i diversi biocombustibili:
ISO 17225-**3** per le bricchette, ISO 17225-**4** per il cippato e ISO 17225-**5** per la legna da ardere.

The aim of the certification system is to provide high quality solid biofuels (like firewood, woodchips and briquettes) as energy source even for non-industrial use. The certification includes an inspection of the qualitative parameters and of the production plants with specific procedures that will produce over time high quality biofuels.

The BiomassPlus certification guarantees the quality of the product and of its production process, through a labelling system throughout the production chain, in terms of:

1. Traceability and legality

The biomass must have a documented and legal origin (as required by the EUTR Regulation 995/2010 - Timber Regulation) and must be documented throughout the supply chain with an identification code of the producer (PIT 00X) or certified distributor (DIT 00X) and with the product labeling.

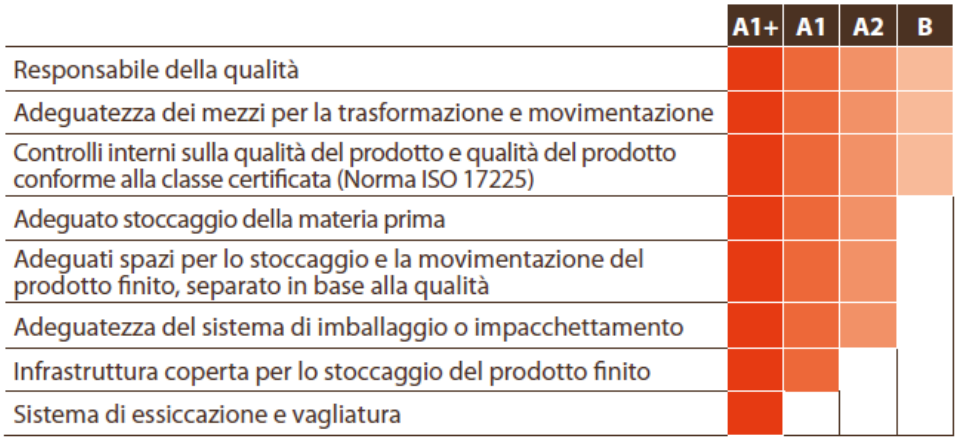
2. Environmental sustainability

   Each certified producer or distributor must guarantee to place/introduce on the market a woody biofuel obtained from a production cycle capable of generating a CO_2 emission saving equal to at least 70% compared to those produced by natural gas, with the same amount of energy production. This value is guaranteed by the monitoring and control of the operations necessary to obtaining the product.

3. Product and process quality

   Producers and distributors must respect the quality of the product certified in class A1 +, A1, A2 or B, in compliance with the ISO 17225 standard. The quality of the product and of the production process is checked through periodic checks by the certification body and through an internal quality control plan in the same company.

Requisiti generali delle aziende certificate BIOMASSPLUS per le diverse classi di qualità



The most important parameters affecting the quality of wood chips are: the average size, the water content, and the ash content, which determine the performance in combustion and the net calorific value (in kWh/kg), as well as the bulk density and the ash content. Other factor which could be taken into account are the identity of the tree species, the presence of rotting material, and the share of impurities such as plastic, rocks and similar. The use of low quality wood chips has two main negative consequences: the increase of maintenance and disposal costs of the ashes, and the possibility of access to incentives, for which quality class A1, A2 is required. The quality of biofuels is based on the European regulation ISO 17225, which defines the standards and quality classes for woody fuels, including wood pellets, wood chips and firewood.

Quality classes of woodchips

Caratteristiche qualitative del cippato distinte per classe di qualità – Norma ISO 17225-4

Classe di qualità	Unità di misura	A1+ A1+ cippatino	A1	A2	B1
Origine e provenienza ISO 17225-1		• Alberi interi senza radici • Tronchi • Residui delle utilizzazioni forestali • Residui di legno non trattato chimicamente	• Alberi interi senza radici • Tronchi • Residui delle utilizzazioni forestali • Residui di legno non trattato chimicamente	• Alberi interi senza radici • Tronchi • Residui delle utilizzazioni forestali • Residui di legno non trattato chimicamente	• Legno di foresta, di piantagione, e altro legno vergine • Residui di legno non trattato chimicamente
Pezzatura (P)		Specificare (vedi tabella sotto)			
Contenuto idrico (M)	% sul peso tal quale	M10 < 10	M25 < 25	M35 < 35	Deve essere dichiarato il valore massimo
Ceneri (A)	% sul peso secco	A1.0 < 1,0	A1.0 < 1,0	A1.5 < 1,5	A3.0 < 3,0
Potere calorifico netto (Q)	MJ/kg kWh/kg	Q > 16 Q > 4.5	Specificare	Specificare	Specificare
Densità apparente (BD)	kg/m³ tal quale	> 150	> 150	> 150	Specificare
Elementi chimici		Non prevista	Non prevista	Non prevista	Analisi chimica secondo norma ISO 17225-4

Classificazione della pezzatura delle diverse tipologie di cippato

Classe	Minimo 60% in peso della frazione principale (mm)	% in peso della frazione fine (< 3.15 mm)	% in peso della frazione grossolana (mm)	Lunghezza di tutte le particelle (mm)	Sezione massima delle particelle sovra-misura (cm^2)
A1+ cippatino	3.15≤P≤16	≤1%	≤5%>16	≤31.5	-
P16S	3.15≤P≤16	≤15%	≤6%>31,5	≤45	< 2
P16S (A1+)	3.15≤P≤16	≤6%	≤3%>31,5	≤45	< 2
P31.5S	3.15≤P≤31.5	≤10%	≤6%>45	≤150	< 4
P31.5S (A1+)	3.15≤P≤31.5	≤5%	≤3%>45	≤63	< 4
P45S	3.15≤P≤45	≤10%	≤10%>63	≤200	< 6
P45S (A1+)	3.15≤P≤45	≤5%	≤5%>63	≤63	< 6

Sulla base di questi parametri si definiscono le seguenti classi qualitative di cippato forestale:

Classi di qualità del cippato Norma ISO 17225-4	Contenuto idrico	Pezzatura	Ceneri sul secco	Potere calorifico	Valore economico
A1 	≤25%	P16-P31,5-P45	≤1%	da dichiarare ≥3,6 kWh/kg	100-120€/t
A2 	≤35%		≤1,5%	da dichiarare ≥3,1 kWh/kg	75-90€/t
B1 	da dichiarare	P45-P63	1,5-3%	da dichiarare	45-55€/t

Fig. 1-2 – Classi di qualità (immagine: AIEL)

Quality classes of firewood

Caratteristiche qualitative della legna da ardere distinte per classe di qualità – Norma ISO 17225-5

Classe di qualità	Unità di misura	A1+	A1	A2	B
Origine		• Fusti • Residui di legno non trattato chimicamente		• Piante intere senza radici • Fusti • Residui di utilizzazione • Residui di legno non trattati chimicamente	
Specie legnosa	Indicare la specie				
Diametro (D)	cm	D2, D5, D15, D15+	D2, D5, D15, D15+		D15, D15+
Lunghezza (L)	cm	L20, L25, L30, L33, L40, L50	L20, L25, L30, L33, L40, L50, L100		L30, L33, L40, L50, L100
Contenuto idrico (M)	% sul peso tal quale	M15 ≤ 15	M20 ≤ 20 M25 ≤ 25		M20 ≤ 20 M25 ≤ 25 M35 ≤ 35
Volume o peso	m^3 accatastato m^3 riversato kg tal quale	Indicare la tipologia di misurazione adottata nella commercializzazione (volume stero accatastato, volume stero riversato, peso)			
Proporzione tra pezzi spaccati e pezzi tondi	% dei pezzi	≥ 90	≥ 90	≥ 50	Non richiesto
Superficie di taglio		Regolare	Regolare	Non richiesto	Non richiesto
Presenza di carie o muffe	% dei pezzi	Non visibile	Non visibile	≤ 5	Dichiarare se >10%
Densità energetica o potere calorifico inferiore	kWh/kg-MJ/kg kWh/m^3-MJ/m^3	Va indicato			
Stagionatura o essiccazione		Va indicato se stagionata o essiccata			

Quality classes of briquette

Caratteristiche qualitative dei bricchetti distinte per classe di qualità – Norma ISO 17225-3				
Classe di qualità	**Unità di misura**	**A1**	**A2**	**B**
Origine		• Fusti • Residui di legno non trattato chimicamente	• Piante intere senza radici • Fusti • Residui di utilizzazione • Residui di legno non trattati chimicamente	• Legno di foresta, di piantagione, e altro legno vergine • Scarti non trattati chimicamente e residui dell'industria di lavorazione del legno • Legno non trattato chimicamente
Diametro (D)	mm	Va indicato		
Lunghezza (L)	mm	Va indicato		
Contenuto idrico (M)	% sul peso tal quale	< 12	< 15	< 15
Contenuto in cenere (A)	% sul peso secco	< 1	< 1.5	< 3.0
Densità (DE)	g/cm³	> 1	> 0.9	> 0.9
Additivi	w-%	< 2	< 2	< 2
Potere calorifico netto (Q)	MJ/kg kWh/kg	Q > 15,5 Q > 4,3	Q > 15,3 Q > 4,25	Q > 14,9 Q > 4,15
Elementi chimici		Analisi chimica secondo norma ISO 17225-3		

Whenever local producers and traders will decide to develop also the pellet market then they can apply for **ENplus®,** the main European and global/international certification scheme for pellet based on the fuel quality, quality of supply and sustainability. ENplus is a quality certification scheme that covers the entire supply chain of wood pellets: from the selection of the raw material, including production, storage and transport, to the delivery of the product to the end user.

The aim of the ENplus certification scheme for wood pellets is to secure the supply of wood pellets for heating and CHP in residential, commercial and public buildings with a clearly defined and constant quality. The quality classes ENplus A1, ENplus A2 and ENplus B fulfil and exceed the corresponding quality classes of the standard. ENplus A1 is best in class and is highly recommended for small boilers. ENplus A2 which shows slightly lower requirements than ENplus A1 (mainly ash content) are suitable for quality tolerant appliances. ENplus B quality should be suitable for larger boilers (> 100 kW), but its use must be approved by the boiler manufacturer. The ENplus product requirements exceed the ISO 17225-2 standard for some pellet properties. Each quality class will have a dedicated quality seal that shall be displayed on pellet bags.

The certification scheme covers the following essential points based on the reference standards in brackets:

- Requirements on raw materials and product properties (ISO 17225-2)
- Requirements on quality management in wood pellet production and handling (ISO 9001, EN 15234-2)
- Requirements on control, tracking and declaration, from the raw material to the end product delivered to the customer (EN 15234-2)

Table 1: Main properties of certified wood pellets

Property	Unit	ENplus A1	ENplus A2	ENplus B	Testing standard [11]
Diameter	mm	6 ± 1 or 8 ± 1			ISO 17829
Length	mm	3,15 < L ≤ 40 [4]			ISO 17829
Moisture	w-% [2]	≤ 10			ISO 18134
Ash	w-% [3]	≤ 0,7	≤ 1,2	≤ 2,0	ISO 18122
Mechanical Durability	w-% [2]	≥ 98,0 [5]	≥ 97,5 [5]		ISO 17831-1
Fines (< 3,15 mm)	w-% [2]	≤ 1,0 [6] (≤ 0,5 [7])			ISO 18846
Temperature of pellets	°C	≤ 40 [8]			
Net Calorific Value	kWh/kg [2]	≥ 4,6 [9]			ISO 18125
Bulk Density	kg/m³ [2]	600 ≤ BD ≤ 750			ISO 17828
Additives	w-% [2]	≤ 2 [10]			-
Nitrogen	w-% [3]	≤ 0,3	≤ 0,5	≤ 1,0	ISO 16948
Sulfur	w-% [3]	≤ 0,04	≤ 0,05		ISO 16994
Chlorine	w-% [3]	≤ 0,02		≤0,03	ISO 16994
Ash Deformation Temperature[1]	°C	≥ 1200	≥ 1100		CEN/TC 15370-1
Arsenic	mg/kg [3]	≤1			ISO 16968
Cadmium	mg/kg [3]	≤ 0,5			ISO 16968
Chromium	mg/kg [3]	≤10			ISO 16968
Copper	mg/kg [3]	≤10			ISO 16968
Lead	mg/kg [3]	≤10			ISO 16968
Mercury	mg/kg [3]	≤ 0,1			ISO 16968
Nickel	mg/kg [3]	≤10			ISO 16968
Zinc	mg/kg [3]	≤100			ISO 16968

[1] ash is produced at 815 °C
[2] as received
[3] dry basis
[4] a maximum of 1% of the pellets may be longer than 40mm, no pellets longer than 45mm are allowed.
[5] at the loading point of the transport unit (truck, vessel) at the production site
[6] at factory gate or when loading truck for deliveries to end-users (*Part Load Delivery* and *Full Load Delivery*)
[7] at factory gate, when filling pellet bags or sealed *Big Bags*.
[8] at the last loading point for truck deliveries to end-users (*Part Load Delivery* and *Full Load Delivery*)
[9] equal ≥ 16,5 MJ/kg as received
[10] the amount of additives in production shall be limited to 1,8 w-%, the amount of post-production additives (e.g. coating oils) shall be limited to 0,2 w-% of the pellets.
[11] As long as the mentioned ISO standards are not published, analyses shall be performed according to related CEN standards

In Italy ENAMA (https://www.enama.it) is the Certification Body – agreed upon AIEL (http://www.aielenergia.it) and recognized by EPC (European Pellet Council) – for the *ENplus Pellet Certification System*.

The ENplus® trademark is widely protected at an international level. This means that a non-licensed use of the trademark or parts thereof may constitute an infringement of the trademark owner's rights. Therefore, as established by the European Pellet Council (EPC), companies that improperly use the ENplus® trademark and do not implement the actions required will be listed in a "Black List "on the ENplus® international website.

2.1 The transportation and storage conditions

The transportation and storage of wood products for energy use are some of the most critical stages of the wood supply chain. Indeed, the way the wood is transported and stored has deep effects on the wood humidity, which is strongly linked to the quality of wood fuel, as well as on the decomposition and alteration processes by biotic and abiotic agents which may severely damage wood structures and basic components (cellulose, lignin, ecc.). Rotten, contaminated and moldy wood as well as demolition wood or shrubs with thin twigs is not suitable for producing high quality wood chips. Fresh wood contains about 45-55% of humidity, while stored wood chips could come down to 25-40% of humidity, which is the most commonly found range in the market. Then, after peculiar conditions and sufficient time, the wood chips is considered dried when the humidity is below 20%. From an economic point of view, it should be considered that humidity is one of the most important traits affecting the economic value of wood chips, as it can be seen in the quality classes according to ISO 17225-4 (Classes A1, A2 and B). The indoor storage is clearly to be preferred as wood is less subject to weather events and it is more controlled. Under controlled conditions, the parameters that most influence the drying process of the wood either as firewood and wood chips are: the available thermal power, the air temperature entered, the relative humidity of the air, the speed of the air flow and the physical characteristics of the wood material to be dried. However, the storage conditions are strongly dependent on the conditions of the forest subject to forest utilization (e.g. the road system), on the effective availability of sufficient free space for wood storage and the availability of dedicated platforms. The storage of the wood as it is can take place directly on the roadside, in the cases in which you have a sunny imposed and of adequate size, or, conversely, it is transported to a logistics platform where it is chipped and stored under cover.

When the storage takes place at a logistic-commercial platform, to speed up the water loss from the trunks, it is a recommended practice to cleave the larger trunks (diameter higher than 35-40 cm). Chipping on wood as it is should be preferable because, on the wood cut in winter, there is already a considerable water loss during the winter months. Then, if wood is left during the summer in a sunny and ventilated place outside the forest, at the end of summer it could have reached a water content lower than 30%, thus being particularly suitable for chipping. Furthermore, the 30% humidity value is defined as the storability life, a threshold below which the wood chips is classified as suitable for storage without problems of biological stability. In

conclusion, chipping should be preferentially carried out as the fuel becomes necessary, so that the storage time does not exceed 3-4 months.

For what concerns the quality of wood fuel in our case study in the Madonie Natural Park, we hypothesize that at least wood chips of class B and A2 could be produced in the production supply chain. Particularly, the wood chips coming from the chipping of small branches and twigs, which could be directly carried out in the forest, only wood chips of class B could be produced. The high quality wood chips requires, indeed, a more or less long period of indoor storage. Then, for A2 class the storage could be performed on dedicated trucks on squares. Conversely, the A1 wood chips class requires the storage and drying under cover and controlled conditions and following different consecutive steps. These latter situations are not common in the study area thus it is much more likely that only A2 wood chips could be produced and used to feed the boiler.

2.2 The boiler requirements and its compliance with the state regulations on emissions from the small or medium medium-sized combustion plants; usually a state decree on the emissions

The short wood-energy supply chain in the Italian case study (Madonie Natural Park - Biomass District No. 4) was planned to heat the swimming pool of the Municipality of Petralia Sottana. Until 2012 the thermal plant was constituted of n. 2 heating oil boilers with a thermal power of 581 kW. The heating system was designed for:

- heating the pool water;
- producing domestic hot water;
- heating the buildings of the swimming pool and of the tennis sport club.

In 2012, a new biomass (pellet) boiler with a total thermal capacity of 857 kW (Efficiency: 80%) was purchased by the Municipality. This boiler never came into operation as the building was closed for renovation.

Therefore, the objective of the project was to define the technical and economic conditions for the conversion of the boiler from pellets to self-produced wood chips, that is from the forest management of public property areas within 3 km from the pool building.

The pellet boiler of the swimming pool in the municipality of Petralia Sottana

In Italy the emission limit values to be respected in the thermal plants, both for civil and industrial use, are defined by the **Legislative Decree 152/2006**.

The **Decree n. 186/2017**, recently issued by the Ministry of the Environment, refers to the requirements of small or medium-sized combustion plants. This regulation defines the requirements, the procedures and the competences for the issue of the certification of the heat generators fuelled with biomass solid. The regulation governs the voluntary environmental certification system of heat generators for use in civil heating (fuelled with firewood, coal and biomass fuels). The regulation identifies the reference emission performance for the different quality classes, the relative testing methods and the monitoring procedures to be carried out for the issue of the environmental certification, as well as the specific obligations relating to the indications to be provided concerning the correct methods for the installation and management of the heat generators that have obtained the environmental certification.

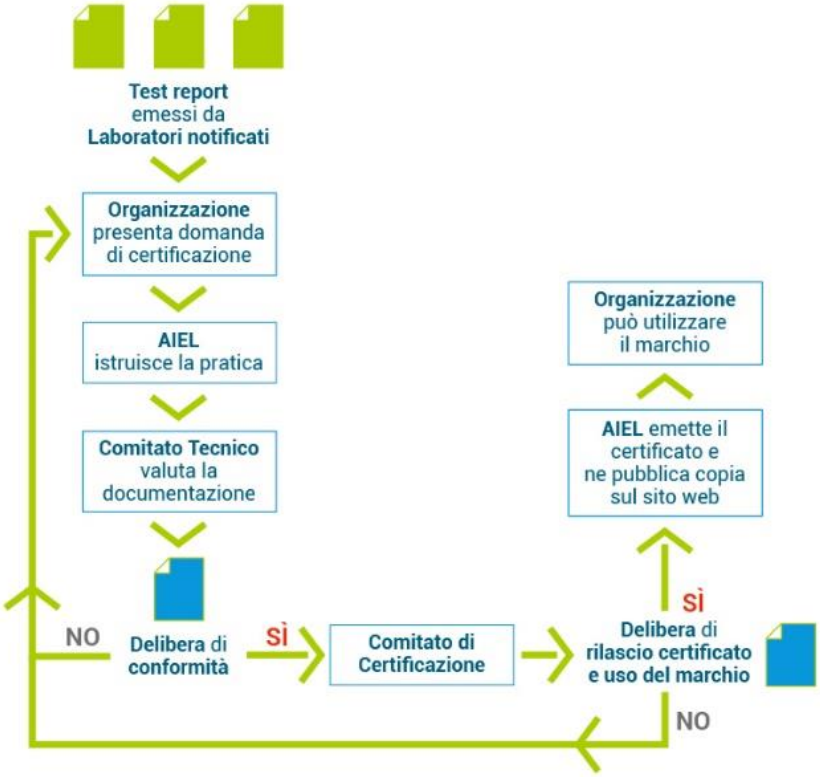
The certification of heat generators is issued on the basis of specific emission performances defined with reference to dust emissions, total organic carbon, nitrogen oxides and carbon monoxide. The regulation applies to the following categories of heat generators fueled with firewood, charcoal and biomass (identified in Legislative Decree 152/2006): boilers with a nominal thermal power up to 500 kW (UNI EN 303-5 boilers for solid fuels, with manual or automatic feeding), closed chimneys, open fireplaces, wood burning stoves, storage heaters, wood-fired kitchens, pellet-fired kitchens.

Classes of heat generatots					
Type of heat generator	PP (mg/Nm^3)	TOC (mg/Nm^3)	NOx (mg/Nm^3)	CO (mg/Nm^3)	ŋ (%)
5 stars class					
Wood chip or pellet boilers	10	5	120	25	92
4 stars class					
Wood chip or pellet boilers	15	10	130	100	91
3 stars class					
Wood chip or pellet boilers	20	15	145	250	90
2 stars class					
Wood chip or pellet boilers	40	20	200	300	90
1 stars class					
Wood chip or pellet boilers	products with lower performance than those envisaged for the 2 star class are classified with the 1 star class				

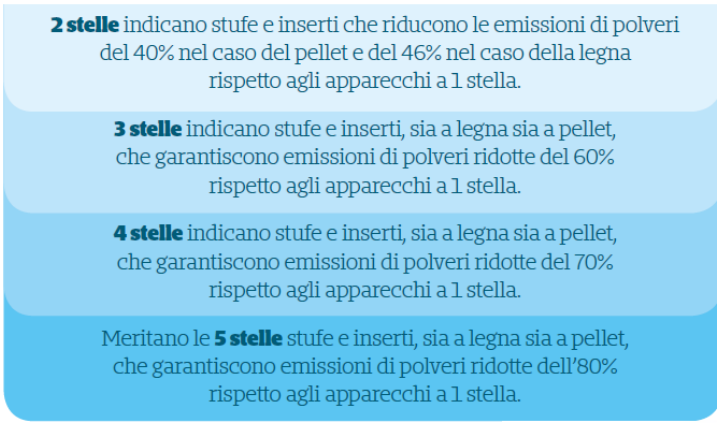
Following the entry into force of the decree, the air quality plans, in order to achieve an improvement in air quality values, may impose limits and prohibitions on the use of heat generators that are not certified or certified with a lower quality class.
State and regional funding programmes aimed at encouraging the installation of heat generators with reduced environmental impact ensure priority to those certified with a higher quality class.

As for italian certfication schemes, ***AriaPulita*** (CleanAir) is a product certification system established and promoted by AIEL (Italian Association of Agro-forestry Energy) which certifies the suitability of wood biomass heating systems to ensure specific performances, expressed in terms of efficiency and emissions (dust, nitrogen oxides, carbon monoxide, organic compounds). This system applies to fireplaces, wood and pellet stoves and biomass boilers below 35 kW.
The *AriaPulita* project is the first Italian experience that defines a quality standard that allows for the measurement, evaluation and communication of the environmental performance of domestic heating appliances that utilize biomass. It is an important and transparent tool, that benefits consumers, the general public and operators. Aria Pulita started from the experience of AIEL, the leading national organization for the agroforestry biomass sector, with the technical-scientific support of Etifor and the participation of many partners such as ENAMA, ENEA and Legambiente. There are over thirty brands of manufacturers and distributors of stoves, fireplaces and inserts that have joined the initiative.

AriaPulita certification process



AriaPulita allows to attribute to each certified heat generator a quality class consistent with the quality levels ensured, in terms of effeciency and emissions. The different quality classes are identified by an increasing number of "stars", variable from 2 to 5, depending on increasing levels of environmental performance in terms of productivity (efficiency) and emissions of: Primary particulate (PP), Nitrogen oxides (Nox), Total organic compounds (COTs) and Carbon monoxide (CO). For promoting the continuous increase in the quality of the appliances, the system does not certify single-star products, even though they meet the requirements that permit it to be placed on the market.



N. of certification QR code

Every machinery will receive a number of stars. Only 1 star means just a device suitable to be sold, a kind of product that doesn't come under *AriaPulita* certification. 2 stars will be appointed to stoves and inserts with 40% powders' reduced emissions (for pellets) or 46% (for firewood) compared with the 1 star machineries. 3 stars will guarantee powder emission's drop equal to 60% compared with the 1 star group, while with the 4 stars' assignment reduction will reach 70%. 5 stars will be appointed to stoves and inserts with 80% powders' reduced emissions.

AriaPulita certification represents an innovation for consumers that, for the first time, will be able to quantitatively classify this kind of boilers not only for output tied efficiency, but also for pollutants inserted in the atmosphere with their operation. *AriaPulita* contributes to the transparency of the market, informing the consumer and providing guarantees during the purchase. Industries can join voluntarily, on the will to invest in increasingly performing appliances with less environmental impact.

In Italy, a very recent new **State Law (n. 58, 28 June 2019)** about economic development has made important innovations for the biomass sector. Indeed, the biomass has been included among the so-called "white certificates", i.e. sources of energy with zero emissions. This could represent a strong incentive mechanism for the use of biomass as renewable energy source for the production of thermal energy. The Decree recognizes incentives for the increase in the energy efficiency also for the replacement of fossil fuels for renewable thermals, including woody biomass, solar thermal, bioliquids and biogas. The new legislative framework could favor

the construction of biomass plants for the production of thermal energy, for which an incentive mechanism was lacking. Other key measures of the Decree are the funding for supporting energy efficiency, favoring technological turn-over and the progressive replacement of fossil fuels. From an environmental point of view it should also be considered that it will be favored the diffusion of extremely high-performance productive systems and technological advanced, with very low emission levels both of PM and NOx, with reduced negative impacts on air quality.

According to AIEL (http://www.e-gazette.it/sezione/efficienza-energetica/aiel-decreto-crescita-sblocca-finalmente-certificati-bianchi-biomasse) (Italian Agroforestry Energy Association), "*the mechanism could potentially activate 1,600 biomass plants in the next 5 years, investing over 1.5 billion euros in agro-industrial and industrial sectors, district heating, the hotel sector and the protected crops sector (greenhouses). We estimated a potential saving of about half a million tons of oil equivalent*".

3 A system of quality insurance for the fuel to meet the sustainability and habitat preservation criteria

Besides of the above quality requirements that the forest biomass and the plant of the local supply chain should meet, producers and traders could apply to process certification schemes (like ISO14001, EMAS, etc.) and to product certification schemes (like ecolabel, organic products, etc.).

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AriaPulita: http://www.certificazioneariapulita.it/

Forest Bioenergy in the Protected Mediterranean Areas

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FORBIOENERGY - Forest Bioenergy in the Protected Mediterranean Areas

Quality requirements for the biomass from the protected areas

Appendix 1 – study report Spain

Work package 3 - Testing

Activity A.3.9. - Quality requirements for the biomass from the protected areas

Methodology for the planning sustainability and quality requirements for biomass from protected areas

Partner in charge: Amufor

SPANISH CASE STUDY

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Summary

Within the framework of D.3.9.1 it is intended to make known the international and European quality requirements and standards for the bioenergy use of wood chips and pellets, as well as to highlight the potential of the Mediterranean forest, both in quantity and quality, to provide these biofuels that present an opportunity for mobilization, management and added value for our forests.

The lack of management and economic value of forest protected areas of Natura 2000 in the Region of Valencia, mainly dominated by pines (*Pinus halepensis* Mill. and *Pinus pinaster* Ait.), but also holm oak (*Quercus ilex* L.) as main broadleaved species in the region, together with a continuous growing of forests on marginal agricultural land have leaded to an increased bushfire risk and devaluation of natural resources during the last decades.

The use of solid biofuels as woodchips and pellets can reverse this situation. It is noted that there is an industrial need of knowledge of woodchip quality and an influence of raw material composition on pellet manufacturing quality for the main species.

In this technical report both woodchip quality from the most representative forest species as well as pellet quality variables such as contents of moisture, ash, fine particles, chlorine and sulphate, but also mechanical durability, bulk density and net calorific value have been analysed following EN standards.

The obtained results demonstrate that it is possible to obtain high quality biofuels, both woodchips and pellets, from barked and debarked logs as well as from residudual biomass (branches), especially from pines like *Pinus halepensis* and *Pinus pinaster.* This implies that the abundant forest biomass residues in the protected areas in the Region of Valencia can be transformed into high added value solid biofuels, opening new opportunities for the development of local forest-based bioenergy chains and active sustainable forest management preventing forest fires and adapting climate change.

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1 Introduction

Mediterranean pine forests (mainly *Pinus halepensis* Mill. and *Pinus pinaster* Ait.) as well as holm oak forests (*Quercus ilex* L.) occupy big forest covered extensions along the Region of Valencia and represent the main forest resources in extended protected areas of Natura 2000. In the Region of Valencia, both pines are the more abundant softwood species, as consequence of natural expansion of unmanaged forests with high fire risk, especially in large protected areas of Natura 2000. The valorisation of forest biomass as bioenergy represents an opportunity to mobilize the forest resources that, nowadays, have not market value at the regional and local levels.

The use of biomass for thermal and electrical energy purposes has a significant increase and, consequently, quality standards have been developed to ensure the commercialization of homogeneous products with verifiable quality. This fact has led to the creation of exclusive regulations for solid biofuels.

On the other side, the increasing boiler installations, as well as pellet production capacity installed in the region, will need more raw material supply in form of chipped material in near future. Despite there exist numerous scientific research about woodchip and pellet quality and influence of raw material, especially on Northern European softwood species with an extended industrial use such as *Pinus sylvestris* and *Picea abies*, there is a lack of knowledge concerning the chipped raw material quality requirements of the most important softwood species in the western Mediterranean area such as *Pinus halepensis* and *Pinus pinaster* and the main broadleaved species holm oak (*Quercus ilex*), their tree fractions (log, branches and bark) and the boundary mixes between these species for high quality pellet production.

2 Objectives

The general aim of this technical report has been to analyse the influence of the raw material composition on the quality of chipped raw material obtained from different assortments of Mediterranean pinewood species (*Pinus halepensis* and *Pinus pinaster*) and holm oak (*Quercus ilex*). Additionally, pellet quality of the two main pinewood species have been also tested in the laboratory.

To achieve this aim, the specific objectives of the research are:

a) to analyse the main quality parameters of chipped raw material from pinewood (*Pinus halepensis* and *Pinus pinaster*) and holm oak (*Quercus ilex*)
b) to manufacture pellets from different pinewood assortments: debarked stem logs, non-debarked stem logs and branches,
c) to analyse the quality of the obtained pellets and the relationship between quality requirements and their possible interdependence,
d) to study the maximum tolerated bark content for each pellet assortment to accomplish with the maximum tolerated ash content according to European quality standards.

3 Forest certification schemes

AENOR (Spanish Association for Standardization and Certification - *Asociación Española de Normalización y Certificación*) is the competent Spanish organization dedicated to standardization and certification and part of the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN).

Compliance with regulations and classification within established standards improves the competitiveness of companies and fosters technological innovation.

Within the ISO/UNE standards, it is the UNE-EN ISO 17225 that, internationally, 8 standards affect the most commonly used solid biofuels such as pellets, chips and firewood:

Part 1: General requirements. (ISO 17225-1: 2014).

Part 2: Kinds of wood pellets. (ISO 17225-2: 2014).

Part 3: Classes of wood briquettes. (ISO 17225-3: 2014).

Part 4: Classes of wood chips (ISO 17225-4: 2014).

Part 5: Wood firewood classes. (ISO 17225-5: 2014).

Part 6: Classes of pellets of non-woody origin. (ISO 17225-6: 2014).

Part 7: Graded non-woody briquettes

Part 8: Graded thermally treated and densified biomass fuels

As certifications:

ENplus® certification

It is a private certification system based on the international standard ISO 17225-2, and refers exclusively to wood pellets for non-industrial uses.

The rights of the ENplus® brand are held by the European Pellet Council, with AVEBIOM being the national licensee responsible for the management of the system in Spain**.**

BIOmasud® certification

It is a certification system for Mediterranean Biofuels: Wood Pellets, Olive Bone, Wood Chips and Nutshells.

For wood pellets and woodchips, the system is based on international standards ISO 17225-2 for wood pellets and 17225-4 for chips, while for the rest of biofuels it is based on pre-standards developed in the project.

Apart from the quality, the system also has sustainability requirements such as the Carbon Footprint or the Energy spent to produce the Biofuel.

The rights of the BIOmasud® brand in Spain are held by AVEBIOM and CIEMAT.

Standards related to woodchip quality: UNE-EN ISO 17225-4

In the document, it is determined the fuel quality classes and the specifications of classified wood chips.

Specifications - regulations (UNE-EN ISO)

- Origin and source of the material: 17225-1:2014
- Particle size: 17827-2:2016
- Humidity: 18134: 2017
- Ashes: 18122: 2016
- Heating power: 18125: 2018

Quality classes of chips, from highest to lowest quality, A1, A2, B1 and B2

The main defining parameters of one quality or another are the amount of humidity of the chips, their ash content and calorific value.

Standards related to the quality of pellets:

Regarding the quality of pellets, the fuel quality classes and the specifications of wood pellets produced from the following raw material are included in the UNE-EN ISO regulation. Concretely, following the specifications and regulations related to:

- Origin and source: 17225-1:2014
- Dimensions: 17829:2016
- Humidity: 18134: 2017
- Ashes: 18122:2016
- Heating power: 18125: 2018
- Bulk density: 17828:2016
- Mechanical durability: 17831-2:2016
- Amount of fines: 17827-2:2016
- Chlorine and sulphur: 16994:2015

The main defining parameters of one quality or another are the content of nitrogen and/or chlorine, ash and calorific value.

The quality classes, from highest to lowest quality are, A1, A2 and B

A1: virgin wood pellets and wood residues not chemically treated, with low ash, nitrogen and chlorine content.

A2: fuels with a slightly higher content of ash, nitrogen and/or chlorine).

B: pellets in whose production it has also been possible to use recycled wood and industrial residues. Also included are values for the content of heavy metals.

4 Analysis of the solid biofuel's quality

4.1 Woodchips and pellets of pinewood

4.1. Materials

After a statistical analysis based on GIS on the Natura 2000 forest protected areas of the Region of Valencia over more than 5.000 km^2, the most representative forest types are the mature forests of *Pinus halepensis* and *Pinus pinaster* in single or mixed stands. In order to allow the repeatability of the analysis in terms of materials, harvesting operations and chain of custody, quantitative geographical parameters (altitude, slope, orientation, distance to main road) as well as forestry structural parameters (age, basal area, stock density, species mixture, accessibility) were established as selection criteria and indicators to select the most representative experimental stands. As result of the preliminary study of statistical representativity, the material was taken from a 63-year-old afforested stand of *Pinus halepensis* and *Pinus pinaster* in the forest district V074 "Navalón" in the municipality of Enguera, province of Valencia (Spain), as shown in figures 1 and 2.

Figure 1. Selected logs for chipping and pelletizing of Pinus halepensis with diameters at breast height (DBH) of more than 20 cm (DBH20). Own source.

Figure 2. Selected material for chipping and pelletizing of Pinus pinaster with diameters at breast height (DBH) of 15-20 cm (DBH15). Own source.

4.1.2. Experimental design

With the selected representative raw material, the aim of the experimental design has been to analyse any possible influence of key material variables on woodchips and pellet quality requirments. To allow testing repeatability, the variables under study were tree species (*Pinus halepensis* and *Pinus pinaster*), bark presence (yes or no) and wood fraction (chipped material from logs with diameters at breast height of 15-20 cm (DBH15), from logs with diameters at breast height (DBH) of more than 20 cm (DBH20) and from branches of the tree crowns. 30 selected trees of each class were harvested and 15 of them were debarked. All logs were chipped directly with a mobile forest chipper STARK SH 4585. The obtained chipped material was classified and stored on forest road. Thus, woodchips were classified for each pine species according to the fraction from with they proceeded (DBH15, DBH20 and branches) and according to the bark presence, i.e. barked or debarked logs. Figure 3 shows an example of the classified material for *P. halepensis* DBH20 at the chipping station on the forest road.

Figure 3. Woodchips of sampled material of Pinus halepensis DBH20 at forest road (chipping station). Own source.

On the left: stem material without bark
On the middle: branches material
On the right: stem material with bark

In order to assure the traceability of the chain of custody of the chipped material from the forest to the laboratories, woodchip assortments of 10 kg each one were obtained from each woodchip pile for the manufacturing of wood pellets in the pilot plant.

In parallel to this, mixes of non-debarked and debarked woodchip material within the same species were elaborated in defined fractions. Pellets were produced from this material in order to determine the quantity of non-debarked material that a debarked woodchip assortment can contain to still comply with A1 standard quality following EN 14961-2.

4.1.3. Chemical characterization of woodchips

The elemental chemical analysis was carried out and some other inorganic microcomponents present in a secondary analysis were identified.

According to EN 14918, the elements H, O, N are mainly used for calculating the net calorific value (Q). Even when C and S are not required in this formula, they were determined due to the combinations that can occur in different forms, mainly with H, O and other substances that may or may not participate in combustion.

It was important to determine the content of heavy metals that were incorporated into the wood, e.g. through contaminated soils. For this, the following chemical elements that are monitored in the production of pellets for domestic use were determined following EN 14961-2:

- Determination of metallic elements and sulfur, using in this study the ICP (Inductively Coupled Plasma) method
- Determination of arsenic by fluorescence
- Determination of mercury by atomic absorption spectroscopy by automatic analyser

Once the results were obtained, the concentration levels of these chemical elements were established, determining if their values were within the limits established by the standards.

4.1.4. Energy characterization of woodchips

In the energetic characterization of the woodchips, the net calorific value (Q) and the ash percentage have been evaluated, following the following technical standards:

- EN 14918 Solid biofuels. Determination of the calorific value.
- EN 14961 Solid biofuels. Specifications and fuel classes.
- EN 15234 Solid biofuels. Assurance of fuel quality.
- EN 14775 Solid Biofuels. Determination of ash content.

4.1.5. Pellet manufacturing

From the 10 kg woodchip samples, a minimum of 5 kg of pellets per each woodchip assortment were manufactured used for the qualitative analysis in the lab. Woodchips were

received from the forest 5 days after chipping with a moisture mass fraction between 40% and 60%. They were stored in ventilated plastic containers for their natural drying. After three weeks and to ensure a sufficient and homogenous moisture content in all samples, woodchips were disposed in a climatic chamber ACS50 (UC50 model, 20 kW) at 20 ºC and 90% of air humidity until 15% moisture mass fraction.

After this, woodchips were grinded to 5 mm sawdust with a hammer mill (OLIGOTECHNOLOGY) in order to obtain homogeneous and comparable particles from all samples. A second reduction of material size was done by a refining mill (MECAFA) to obtain sawdust of 3 mm required as input by the pellet machine. A KAHL press with plane matrix of 50 kg h^{-1} capacity with 3 mm circular openings for particle screening was utilized for pelletizing, working at a temperature comprised between 90-105 ºC. Pellets of 6mm diameter and 40 mm length were produced without using any additive, as shown in figure 4. Pellets were air cooled in uncovered plastic trays in normal climatic conditions of 20 ºC and 50% air humidity.

Figure 4. Sample of experimental pellets manufactured with KAHL press with plane matrix of 50 kg/h capacity. Own source.

4.1.6. Pellet analysis

After pellet production, wood pellets were analysed according to the standards for non-industrial pellet quality classification (EN 14961-2). Following quality parameters were analysed:

a) Origin, source and dimensions

The main parameters of the raw material composition of the biomass obtained from the harvesting of *Pinus halepensis* and *Pinus pinaster* have been studied following the appropriate standards (EN 14961-1 and EN 16127). Moreover, percentage of bark content has been measured in non-debarked log samples.

b) Moisture content

The moisture content has been measured with a CARBOLITE stove model AAF1100 following EN 14774-1.

c) Ash content

The ash content has been analysed with the same stove following EN 14775. The ash content in pellets is very relevant for the correct performance of stoves and boilers in which pellets are combusted due to slags and residue depositions. On the other hand, a high ash content can indicate the presence of external materials in raw material for pellet production such as additives, dirty, non-wood residues etc. Moreover, a high ash content reduces net calorific value (Q) and implies sinterization risk affecting negatively to mill equipment and pellet presses in the industrial manufacturing processes.

d) Fine particle content

Fine particles or sawdust has been analysed with a CISA mechanical vibration equipment (model RO200N, 0.45 kW) following EN 15149-2. The fine particle content is a result of the production, packaging and transport processes. This is a key quality requirement as a limiting factor for pellet movement during boilers feeding. High fine particle content contributes to an inefficient feeding with a more heterogeneous material, which derives in a poor combustion quality. An excessive fine particle presence may also cause fire hazards in storage silos and healthy risk for the respiratory tract of the factory operators.

e) Mechanical durability

The mechanical durability has been tested with a pellet durability tester Bioenergy TUMBLER Series following EN 15210-1, as shown in figure 5. This is a key quality requirement for the pellet consumers and the main physical metrical parameter considered by industry. A high pellet durability is very important to reduce fine particle presence and to maintain a good pellet quality during storage and transport. Mechanical durability is determined, among other factors, by lignin and water content as well as with compression pressure during pellet pressing and an appropriate cooling process.

Figure 5. Test of mechanical durability with Bioenergy TUMBLER Series following EN 15210-1. Own source.

f) Bulk density

Bulk density has been measured following the actual standard EN 15103. Bulk density depends on raw material and pellet manufacturing conditions such as press pressure, particle moisture content during the pressing, etc. Bulk density is also an important quality requirement for transport efficiency.

g) Net calorific value (Q)

Net calorific value (Q) has been tested with calorimetric bomb PARR model 1351 following standard EN 14918.

h) Chlorine and sulphur content

The chlorine and sulphur content has been determined also with the calorimetric bomb following standard EN 15289.

4.2 Woodchips of holm oak

4.2.1. Materials

The analysis was developed in the Natural Park of Tinença de Benifassá, in the north of the Region of Valencia, Province of Castellón, District of Els Ports (Morella). The presence of holm oak (*Quercus ilex*) in pure and mixed forests in our region is shown in figure 6. More than 70% of the pure populations are found in the northern part of the region, in the province of Castellón, on the upper level, with a gradient altitude between 800 to 1,200 m oversee level.

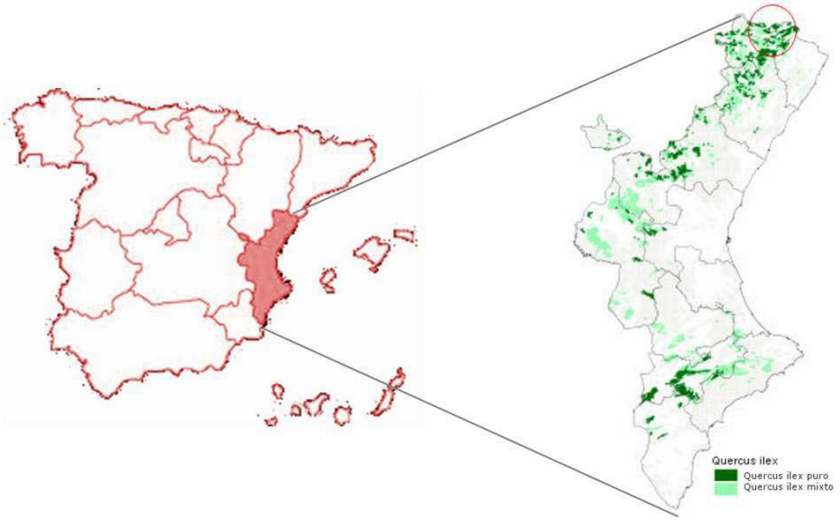

Figure 6. Location of sampled stands of Quercus ilex in Natural Park Tinença de Benifassá. Own source.

An important part of this forest stands are natural regenerations of pure holm oak, after large and devastating forest fires about 20-30 years ago (figure 7). It should be noted that all selected holm oaks were identified in the Forestry Unit of the Polytechnic University of Valencia as *Quercus ilex L. subsp. ballota* (Desf.) Samp.

Figure 7 Sampled stands of Quercus ilex in Natural Park Tinença de Benifassá. Own source.

4.2.2. Experimental design

After the identification of the most representative forest areas mainly through the GIS, the sampling was carried out at an average altitude of 1,100 m.o.s.l. in regular forest stands of approximately 30 years of age. The following parameters were documented in the field for each forest stand: stock density (trees ha-1), average altitude (m), slope (%), exposure, average DBH (cm) and distribution of DBH classes (%) (see figure 8). Mean values and standard deviation were calculated for each stand, selecting five representative plots of a minimum plot size of 0.25 ha. A total of 75 representative trees were selected for clearing and chipping.

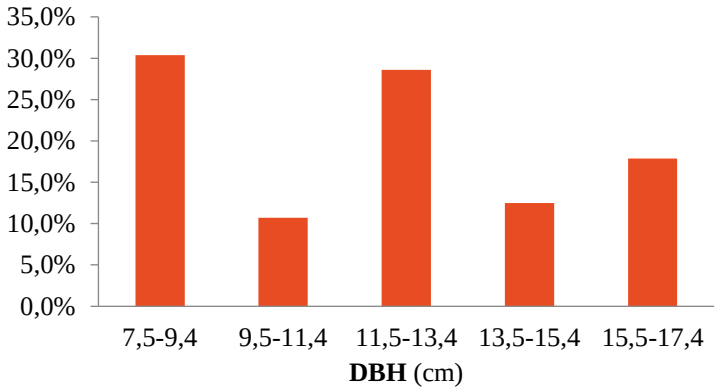

Figure 8. DBH distribution in the selected stands of Quercus ilex.

4.2.3. Chemical and energetic characterization of woodchips

The quality parameters of the obtained woodchips of *Quercus ilex* were analised as explained in chapters 3.1.3. and 3.1.4.

4.3 Results

Woodchips quality properties of pinewood and oakwood

Table 1 shows the main results for the chemical tests for concentration of the main elements in the woodchips of the pine and oak species.

Table 8. Results of chemical analysis of concentration of the main elements in tested woodchips

Element	*Pinus halepensis*	*Pinus pinaster*	*Quercus ilex*
C	48,3%	49,0%	51,1%
H	6,6%	6,4%	6,2%
O	44,9%	44,4%	42,4%
N	0,1%	0,1%	0,2%
S	0,01%	0,01%	0,02%

Furthermore, table 2 shows the main results for the chemical tests for concentration of secondary components in the woodchips of the pine and oak species.

Table 9. Results of chemical analysis of concentration of secondary components found in tested woodchips

Element	*Pinus halepensis*	*Pinus pinaster*	*Quercus ilex*
As	0,03 mg/Kg	0,02 mg/Kg	0,03 mg/Kg
Cr	0,06 mg/Kg	0,06 mg/Kg	0,05 mg/Kg
Pb	0,07 mg/Kg	0,09 mg/Kg	0,1 mg/Kg
Hg	0,3 mg/Kg	0,2 mg/Kg	2,7 mg/Kg
Ni	0,1 mg/Kg	0,1 mg/Kg	0,3 mg/Kg
Zn	6,2 mg/Kg	4,8 mg/Kg	3,8 mg/Kg

Moreover, table 3 shows the main results for the energetic tests in the woodchips of the pine and oak species.

Table 10. Results of energetic values and ash contents in tested woodchips

Properties	*Pinus halepensis*	*Pinus pinaster*	*Quercus ilex*
Q	18,02 MJ/Kg	17,89 MJ/Kg	17,09 MJ/Kg
Ash content	1,0%	0,8%	2,7%

Finally, the next table shows a summary of the woodchips compliance technical quality requirements for pellet production according to actual standards for all wood species analysed.

Table 11. Summary of the woodchips compliance technical requirements for pellet production according to actual standards

properties	unit	technical limits	*Pinus halepensis*	*Pinus pinaster*	*Quercus ilex*

ashes	%	<1,5	✔	✔	✘
Q	MJ/Kg	16,3<x<19,0	✔	✔	✔
N	%	<0,5	✔	✔	✔
S	%	<0,03	✔	✔	✔
As	mg/Kg	<1,0	✔	✔	✔
Cr	mg/Kg	<10,0	✔	✔	✔
Pb	mg/Kg	<10,0	✔	✔	✔
Hg	mg/Kg	<0,1	✔	✔	✔
Ni	mg/Kg	<10,0	✔	✔	✔
Zn	mg/Kg	<10,0	✔	✔	✔

All woodchips obtained compliance with the quality requirements for pellet manufacturing following the actual standards. Only the chipped material of *Quercus ilex* shows a higher ash content than allowed. As content is a key quality parameter for solid biofuels, so only pinewood chipped material has been considered for experimental pellet manufacturing and analysis.

Pellets quality properties of pinewood

4.2.5.5. *Quality properties of pellets of Pinus halepensis and Pinus pinaster*

All woodchips assortments were pelletized under the same laboratory conditions. Table 5 shows the average results for quality properties of each woodchip assortment and Table 6 the statistical result of the influence of raw material variables over the quality properties.

Table 12. Pellet quality properties

Sample	BC(%)	M (%)	A (%)	DU (%)	F(%)	BD (Kg/m^3)	Q (MJ/Kg)	Cl(%)	S (%)
PH B 15	4,60	5,50	0,83	96,61	0,70	652	17,39	0,02	0,01
PH DB 15	-	4,83	0,62	99,11	-	618	17,38	0,02	0,01
PH B 20	12,92	5,50	0,94	99,80	0,21	590	17,84	0,02	0,01
PH DB 20	-	4,67	0,55	92,79	0,29	593	17,85	0,01	0,01
PP B 15	9,34	6,33	0,41	97,70	0,38	638	17,32	0,01	0,01
PP DB 15	-	5,17	0,25	99,25	0,17	650	17,41	0,01	0,01
PP B 20	13,53	5,83	0,46	99,60	0,21	629	17,77	0,02	0,02
PP DB 20	-	3,83	0,20	97,61	0,63	600	18,65	0,02	0,02
PH BR	-	3,33	0,85	82,31	0,76	563	18,36	0,02	0,02
PP BR	-	5,83	0,94	96,55	0,71	640	17,69	0,01	0,01

PH= *Pinus halepensis*, PP= *Pinus pinaster*, B= Barked log, DB= Debarked log, 15= DBH 15 cm, 20= DBH 20cm, BR= Branches BC=bark content, M=moisture, A=ash, DU= durability, F= fine particles, BD= bulk density, Q= net calorific value, Cl= Chlorine, S= sulphur

a) Bark content in pellets

The obtained results show a higher bark percentage in *Pinus pinaster* (11,43%) than in *Pinus halepensis* (8,76%). Moreover, at the same tree age, a higher diametric class is related with higher bark percentage for both species. The statistical analysis shows no significant influence of the tree fraction on the bark content in the samples performed and studied.

b) Moisture content of pellets

The highest moisture content is found for the samples of *Pinus pinaster* barked DBH 20 (6,33%) and the lowest for the samples of *Pinus halepensis* branches (3,33%). Table X shows a significant higher moisture content in pellet samples with bark presence at the same diametric class. So, at a diametric class of 20 cm, *Pinus halepensis* debarked samples are drier (4,67%) than samples with bark (5,50%) and *Pinus pinaster* debarked samples are also drier (3,83%) than samples with bark (5,83%).

Table 13. Influence of raw material variables on pellet properties

P-value	BC(%)	M (%)	A (%)	DU (%)	F(%)	BD (kg/m^3)	Q (MJ/kg)	Cl(%)	S (%)
Species	(n.s.)	(n.s.)	0,0004	0,0492	(n.s.)	0,0310	(n.s.)	(n.s.)	(n.s.)
Tree fraction	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)
Bark presence	-	0,0308	0,0023	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)

BC=bark content, M=moisture, A=ash, DU= durability, F= fine particles, BD= bulk density, Q= net calorific value, Cl= Chlorine, S= sulphur, n.s. indicates that the coefficient is not significant.

c) Ash content of pellets

The obtained results show a significantly higher ash content in *Pinus halepensis* pellets (in average 0,75%) than in *Pinus pinaster* pellets (0,45%). Additionally, pellets from raw material with bark presence show higher ash percentage (in average 0,60%) than pellets from debarked raw material (0,45%). Moreover, the ash content of pellet samples manufactured from branches is higher (in average 0,90%) than the content observed in pellets from logs (0,53%). Thus, according to the statistical analysis, the ash content is significantly influenced by the bark content for both species.

d) Fine particle content

Pinus halepensis samples show an average fine particle content of 0,5%. This value is very similar to the fine particle content of *Pinus pinaster* samples (0,4%). The statistical analysis shows no significant differences in the fine particle content of the samples studied.

e) Mechanical durability

The results obtained show slight differences for the mechanical durability between *Pinus halepensis* pellets (in average 94,4%) and *Pinus pinaster* pellets (95,9%). Nevertheless, the statistical analysis demonstrates that this difference is significant. Slight differences in lignin content between tree species can determine wood viscoelastic properties and therefore can

influence on mechanical behaviour of pellets. Mechanical durability, but also bulk density and ash content, highly depend on the pelletized tree species.

f) Bulk density

The small differences observed between the bulk density of *Pinus halepensis* pellets (603 kg m^{-3}) and *Pinus pinaster* pellets (632 kg m^{-3}) can be considered as significant after the statistical analysis. On the other side, neither the tree fraction (log or branches) nor the bark presence have significant influence on the bulk density. Therefore, bulk density depends also mainly on the wood species.

g) Net calorific value (Q)

The net calorific value (Q) in dry basis at a constant pressure is very similar for both species, being 17,80 MJ kg^{-1} in average (17,84 MJ kg^{-1} for *Pinus halepensis* diameter class 20 cm with bark and 17,77 MJ kg^{-1} for *Pinus pinaster* diameter class 20 cm with bark). The statistical analysis shows no significant differences between species. It should be taken into account, that Q is very similar among softwood species in Europe.

h) Chlorine and sulphur content

The results obtained for chlorine (in average 0,02%) and sulphur (in average 0,01%) mass fraction show no significant differences between the two pine species analysed.

4.2.5.5. *Pellet quality evaluation*

According to the pellet analysis results showed in Table 7, most of the pellets manufactured with woodchips from different freactions of *Pinus halepensis* and *Pinus pinaster* comply with A1 quality requirements, following EN 14961-2. Exceptions are the pellets manufactured with small dimensions of *Pinus halepensis* with bark (PH B 15 and PH B 20) as well as the pellets manufactured with branch material from both species (PH B and PP B), which have a high ash concentration (>0,7%) reaching only A2 quality.

Table 14. Pellet quality evaluation according to EN 14961-2

Sample	M (%)	A (%)	F(%)	BD (kg/m3)	Q (MJ/kg)	Cl(%)	S (%)	Pellet quality
PH B 15	5,50	**0,83**	0,70	652	17,39	0,02	0,01	**A2**
PH DB 15	4,83	0,62	-	618	17,38	0,02	0,01	A1
PH B 20	5,50	**0,94**	0,21	590	17,84	0,02	0,01	**A2**
PH DB 20	4,67	0,55	0,29	593	17,85	0,01	0,01	A1
PP B 15	6,33	0,41	0,38	638	17,32	0,01	0,01	A1
PP DB 15	5,17	0,25	0,17	650	17,41	0,01	0,01	A1
PP B 20	5,83	0,46	0,21	629	17,77	0,02	0,02	A1
PP DB 20	3,83	0,20	0,63	600	18,65	0,02	0,02	A1
PH BR	3,33	**0,85**	0,76	563	18,36	0,02	0,02	**A2**
PP BR	5,83	**0,94**	0,71	640	17,69	0,01	0,01	**A2**

PH= *Pinus halepensis*, PP= *Pinus pinaster*, B= Barked log, DB= Debarked log, 15= DBH15 cm, 20= DBH 20cm, BR= Branches

M=moisture, A=ash, DU= durability, F= fines, BD= bulk density, Q= net calorific value, Cl= chlorine, S= sulphur

4.2.5.5. *Interdependence between pellet quality factors*

The summary of regression coefficients given in Table 8 and the interdependence diagnosis show that there exists a highly significant inverse linear correlation between bark percentage present in raw material and fine particle content in the manufactured pellets (R^2=0,981 for *Pinus halepensis*), as shown in Figure 9.

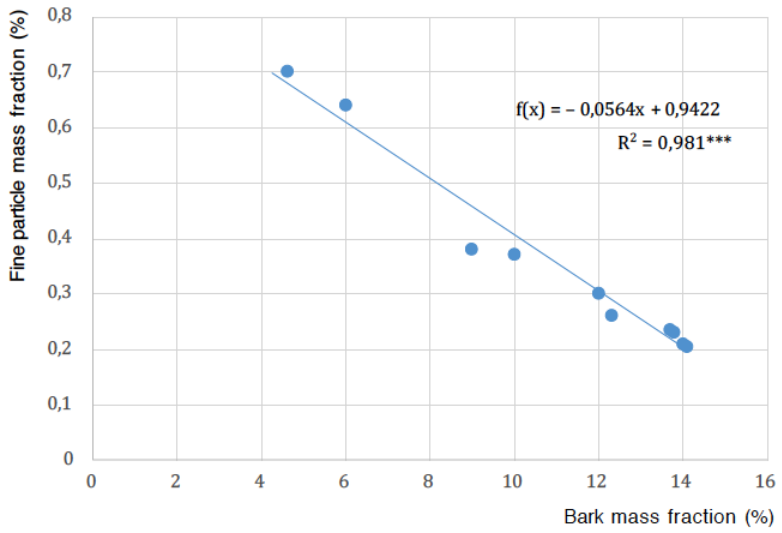

Figure 9. Regression analysis between bark percentage present in raw material and fine particle content of manufactured pellets of Pinus halepensis

A direct correlation can be observed between bark and ash content, but the significant dependence of ash content on the tree species and the lack of enough bark content data per species made no possible to determine a significant regression coefficient.

Furthermore, a highly significant positive non-linear correlation can be observed between bark content and mechanical durability (R^2=0,955), as shown in Figure 10. This confirms that an increase of bark content increases also mechanical durability. This can be explained due to that higher lignin and extractives concentration, as occurs in bark in comparison with wood, having a positive effect on cohesion mechanism during pellet manufacturing.

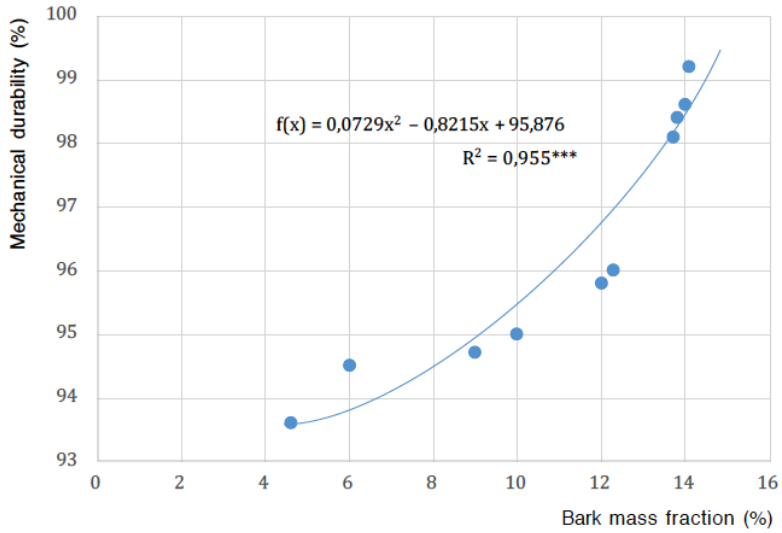

Figure 10. Regression analysis between correlation bark content and mechanical durability of manufactured pellets

Finally, an inverse correlation can be observed between mechanical durability and fine particle content when it is studied separately per pelletized tree species, being higher for *Pinus halepensis* (R^2=0,980) than for *Pinus pinaster* (R^2=0.914). The interdependence among the rest of pellet properties show no significant correlation values (R^2≤0,8).

Table 15. Summary of regression coefficients for interdependence of properties studied

R^2	BC(%)	F(%)	A (%)
BC (%)	-	0,981	*
DU (%)	0,955	0,980 (PH) 0,914 (PP)	-

PH= *Pinus halepensis*, PP= *Pinus pinaster*, A=ash, BC=bark content, DU= durability, F= fines

* only for *Pinus pinaster*

4.3.2.4. Maximum tolerated bark content

One practical result of this analysis is the possibility to add non-debarked forest material (from non-debarked small-sized logs or even biomass residues such as branches) to woodchips obtained from debarked logs in order to still reach high quality pellets with allowable ash mass fractions (≤0,7%), which is the more restrictive quality parameter.

In this sense, Table 9 shows that depending on the tree species, it is possible to add a considerable amount of low value woodchips from branches or non-debarked small-size logs to high qualitative woodchips from debarked logs. So, for example for *Pinus halepensis* up to 50% of low valued chips from branches could be mixed with 50% of high valued chips from debarked logs with a minimum diameter of 20 cm in order to obtain high quality pellets.

Table 16. Summary of possible sample mixtures of barked raw material that produce A1 quality pellets (ash content ≤0,7%)

Specie	Sample mix	%DB	%B

PH	DB 15 – B 15	65	35
	DB 20 - B 20	65	35
	DB 15 - BR	70	30
	DB 20 - BR	50	50
PP	DB 15 - BR	35	65
	DB 20 - BR	35	65
	B 15 -BR	55	45
	B 20 -BR	50	50

PH= *Pinus halepensis*, PP= *Pinus pinaster*, B= Barked log, DB= Debarked log, 15= DBH15 cm, 20= DBH 20cm, BR= Branches

On the other side, for *Pinus pinaster* up to 65% of low valued chips from branches could be mixed with 50% of high valued chips from debarked logs with a minimum diameter of 20 cm in order to obtain also high quality pellets.

The rest of quality parameters (bulk density, moisture content and mechanical durability) are not considered critical for obtaining high quality wood pellets because, despite some of them depend on the raw material composition, they can be highly improved with the improvement of adequate pellet manufacturing processes.

5 Transportation and storage conditions

In the Valencian Community, there are some problems derived from logistics and transport in the rural areas due mainly to:

- Difficult mechanization of works due to difficult access (poor condition of forest tracks, low road density, etc.).
- Lack of logistics infrastructure and storage space and qualitative and/or dimensional classification.
- High cost of production, mainly due to the dispersion of the resource and the high costs of transformation and transport.

In the case of integrated uses of biomass and wood, at least the following harvesting systems should be studied and developed (steps of the shelterwood method).

The storage, transfer and transport are also important factors for the final quality of solid wood biofuels. The quality deficiencies of solid fuels can be almost completely avoided with careful storage, transfer and transportation with the products.

Thus, according to EN 15234-1, it is important to consider the following factors:

- Meteorology and climatic conditions (for example, humidity).
- The size, design and conditions of the storage areas.

- Possible infections (fungi).
- The adequacy and cleanliness of tools, devices and equipment.
- The influence of transport on fuels (mechanical resistance…)
- The training and experience of responsible personnel

Woodchip

In any chosen system, costs have to be calculated and experimented in order to achieve optimization in three main actions "harvesting, chipping and transportation".

1. Harvesting: implementation of silvicultural operations.
2. Chipping: good quality raw material.
3. Transportation to the plant.

Pellet

Pellets are distributed in:

1. Bags of 15 kg: Pellets of the highest quality in 15 Kg bags, usually made by paper. The most practical and convenient way to store and use them at all times.
2. Big-bags: large bags with approximately 1,000 Kg. For larger consumers with storage possibility. Lowest price.
3. In bulk: For large consumers with the possibility of storage in hoppers or large tanks. Direct loading and unloading in the truck. Simpler and more economical

6 Boiler requirements

All the information about boiler requirements is included in "Real Decreto 1042/2017, de 22 de diciembre, sobre la limitación de las emisiones a la atmósfera de determinados agentes contaminantes procedentes de las instalaciones de combustión medianas y por el que se actualiza el anexo IV de la Ley 34/2007, de 15 de noviembre, de calidad del aire y protección de la atmósfera". https://www.boe.es/buscar/doc.php?id=BOE-A-2017-15368

Valores límite de emisión para las instalaciones de combustión medianas existentes

Cuadro 1

Valores límite de emisión (mg/Nm³) para las instalaciones de combustión medianas existentes con una potencia térmica nominal igual o superior a 1 MW e inferior o igual a 5 MW, que no sean motores ni turbinas de gas

Contaminante	Biomasa sólida	Otros combustibles sólidos	Gasóleo	Combustibles líquidos distintos del gasóleo	Gas natural	Combustibles gaseosos distintos del gas natural
SO2	200(1)(2)	1.100	–	1.250	–	200(3)
NOx	650	650	200	650	250	250
Partículas	50	50	–	50	–	–

(1) El valor no se aplica en el caso de instalaciones que quemen exclusivamente biomasa sólida leñosa.
(2) 300 mg/Nm³ en el caso de instalaciones que quemen paja.
(3) 400 mg/Nm³ en el caso de gases de bajo poder calorífico procedentes de hornos de coque (industria siderúrgica).

Figure 11. Emission values for existing medium combustion plants. Source: Real Decreto 1042/2017, de 22 de diciembre.

On the other hand, there is a technical guide about the "Instalaciones de biomasa térmica en edificios (Installation of thermal biomass in buidlings" (IDEA 2009) that has to be considered in biomass installations: https://www.idae.es/sites/default/files/documentos/publicaciones_idae/documentos_10920_Instalaciones_Biomasa_Term_edificios_2009_b6fe691f.pdf

7 Sustainability of the biofuel and habitat preservation criteria

Bioenergy is an essential tool for the sustainable development in rural areas in the Mediterranean basin, as it is a market instrument that can enhance the sustainable management of forest resources on public and private lands, as well as actively contribute to the prevention of bushfires. Therefore, forest biomass is a competitive resource in the renewable energy market.

There are multiple positive effects regarding the valorisation of biomass: the forest management leads to improve the forest conditions, reducing the risk of forest fires, diversifying energy sources, decreasing external energy dependence, improving stability in the economy, reducing GHG emissions and generating employment.

The sustainable forest management favours the environmental services that motivated the declaration of protected spaces. Therefore, there is compatibility between "management-conservation".

8 Conclusions

The extracted forest raw material in silvicultural treatments of forest stands of the main tree species in the protected areas of Natura 2000 in the Region of Valencia (*Pinus halepensis*, *Pinus pinaster* and *Quercus ilex*) can be chipped on road to obtain high qualitative woodchips. Only *Quercus ilex* has shown a slight high ash content percentage that can influence negatively in combustion or pelletization processes and final quality of final biofuels derived.

Furthermore, for the representative mature stands of *Pinus halepensis* and *Pinus pinaster* analysed in the representative protected areas of Natura 2000 in the Region of Valencia, a careful management of the feedstock assortments will produce high grade pellets and allow useful harvest of forestry resources in the Mediterranean region that are currently not being utilised and generating an important fire hazard.

The selection of the pine tree species and the percentage of bark content are the main raw material variables that affect pellet quality. The tree species mainly affects bulk density and mechanical durability, while bark presence mainly influences moisture and ash content.

Even pellets manufactured from logging residues of *Pinus halepensis* and *Pinus pinaster* (small-sized logs and crown material such as branches) are able to reach high pellet qualities, if the ash content is duly controlled. This enables the possibility to include full-tree harvested and chipped material for direct pellet manufacturing, opening the possibility to reduce production costs by eliminating debarking processes.

It is noted that it is possible to obtain woodchips with sufficient quality from the studied harvesting systems. In addition, the province of Valencia, in which these species are predominant, has abundant biomass resources that can be transformed into energy products with high added value.

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Forest Bioenergy in the Protected Mediterranean Areas

Municipality of Petralia Sottana

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Disclaimer

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FORBIOENERGY - Forest Bioenergy in the Protected Mediterranean Areas

Quality requirements for the biomass from the protected areas

Work package 3 - Testing

Activity A.3.9. - Quality requirements for the biomass from the protected areas

Methodology for the planning sustainability and quality requirements for biomass from protected areas

Partner in charge: PP4 Regional development agency Green Karst ltd.

Programme Cofinanced by the European Regional Development Fund
Programme Cofinancé par le Fonds Européen de Développement Régional

1 Introduction

Slovenia is the third most forested country in Europe since forests cover more than half of the country (58 %). In addition to extensive forest coverage, there is a lot of wood available from the non-forest categorised land, primarily from abandoned farmland (e.g. meadows and pastures), overgrown by the forest and bush vegetation. According to a recent SFS study, the potential of wood biomass for energy purposes grown outside the forest amounts to approximately 300.000 m3 per year.

In the Pivka intermittent lakes landscape parc, vast forests cover large part of the protected area, there are 9.659,32 ha of forests. 44% are public forests and 56 % are privately owned. A very small part, 0,05 % is community owned. Private forest estates are small, with an average area of only 3 ha, and even these are further fragmented into several separate plots. For the great majority of the owners these estates are not of economic interest. On the other hand, larger and undivided forest estates of state-owned forests enable good professional management.

Approximately a quarter of round-wood from forests in Slovenia is used for energy purposes, mostly for heating. Most of the fuel wood is currently used by households for heating purposes, and covers approximately one third of the national energy demand. In general, the most commonly used wood fuel type in Slovenia is firewood, but the use of wood chips and pellets increases. The data from SFI (Slovenian Forestry Institute) for 2016 shows that more than half of the households in Slovenia use wood biomass for heating (57 %). Slovenia is one of the countries with the greatest biodiversity in Europe and has a long tradition of nature conservation. Close-to-nature forestry management ensures both; exploitation of forests as well as nature conservation. There are two Natura 2000 sites present within the protected area, the Javorniki – Snežnik, accepted under the Habitats Directive (CD 92/43/EEC) and Snežnik – Pivka, accepted under the Birds Directive (2009/147/EC).

The following forest types are present in the park area: Illyrian beech forests with common beech (Fagus sylvatica) cover large part of the protected area and represent main habitat type. The gorges and gravel slopes are coverd by Large-leaved Lime (Tilia platyphyllos), maple trees (Acer sp.), common ash (Fraxinus excelsior), and elm (Ulmus sp.). On the warm sunny hill slopes thermofilic oak forests (Quercus sp.) can be found where also mixed deciduous forests are present (Cernatič Gregorič A., 2013).

In the Pivka river basin or valley, where meadows, pastures and fields prevailed in the past, river willow forests (Salix sp.) are present. The overgrowth is mainly consisted of different fast growing and spreading bush species such as hawthorn, rock cherry, common hazel, wild privet and similar. These are the species which are primarily interesting for the biomass withdrawal and pellet production.

2 Objectives

An existing system in the Pivka town, described in the activity A.3.8. – Planning sustainable forest – wood – energy supply chain was be chosen and its specifics taken into account in setting criteria and demands on quality assurance and quality check.

A system planned under A.3.8 is described and the main critical points, influencing quality of fuel reaching the end user are further described in detail. Also, demands according to national legislation on emission of substances are described. The legislation defines criteria for the scale of the burning device, the type of fuels which can be used, limit values for different emissions.

3 Forest certification schemes

In Slovenia, both Chain of custody and sustainable forest management certification schemes are present and under operation. Bureau Veritas, d.o.o. is an international company which undertakes certification under FSC or PEFC schemes since 2008. In both schemes, they have awarded many individual certificates in Slovenia. From the Ljubljana office, the FSC or PEFC certification is carried out in all countries of the former Yugoslavia.

Also, the Institute for Forest Certification, operating under the Slovenian Chamber of Agriculture and Forestry offers the PEFC certification. The PEFC system is best suited for small forest owners and is adapted to the Slovenian situation. Owners of smaller forests can apply for group forest certification through the Chamber of Agriculture and Forestry of Slovenia. Thus, the costs are greatly reduced.

EUTR Regulation no. 995/2010 (EU Timber Regulation) lays down the obligations of operators who place timber and timber products on the European Union market for the first time. The regulation applies to all natural and legal entities which have obtained timber directly from EU forests or imported timber or timber products from non-EU countries. The regulation aims to stop the trade in illegally harvested timber in the EU. The regulation requires economic operators to set up an appropriate due diligence system to enable the traceability of timber from its origin. In Slovenia the Bureau Veritas has developed a unique and comprehensive BV **DDS due diligence system** that is fully compliant with the requirements of EUTR. Bureau Veritas is an authorized monitoring organization by the European Commission. This is offered as the third possibility on the wood market regarding certification possibilities.

In Slovenia, the **FSC certificate** was acquired by the Agricultural Land and Forest Fund for all state forests. Some Slovenian companies obtained also the Chain of Custody certificate. This means that also all the state-owned forest in the protected area of Pivka intermittent lakes landscape park is managed according to this scheme. The share of state-owned forest in the pilot area is 44%, which amount to 4.250,1ha certified under FSC certificate.

The **PEFC certificate** has been obtained through the Slovenian Chamber of Agriculture and Forestry by one private forest owner who owns 10,6 ha of forest are covered by it.

4 Solid biofuels' standards

The Slovenian Institute for Standardization (SIST) is recognized as the national standards' body in the Republic of Slovenia. SIST develops, adopts and maintains Slovenian standards, and participates in the work of international (ISO, IEC, ITU-T) and European Standardisation Organisations (CEN, CENELEC, ETSI) where its experts represent national interests.

In Slovenia the following standard on solid biofuels are available and in used by the producers and consumers side:

According to the **international standard EN ISO 17225-5: 2014**, the firewood is divided into two main groups:

- group A: firewood higher quality: water content below 25 %, higher share of chopped wood, share of rotten wood must be below 5%. This wood is suitable for use in fireplaces and furnaces. The group is further divided into A1 and A2 groups. In A1 the share of split wood exceeds 90 %, and no rotten wood is allowed.
- group B wood is suitable for use in central heating boilers since the water share can reach 35% and there is no condition regarding split or rotten wood share.

Table 17: quality grades for firewood, according to EN ISO 17225-5: 2014 standard.

QUALITY CLASSES	A1	A2	B
Biomass source	Timber wood, unpolluted wood residues	Whole trees, timber wood, wood processing residues	Whole trees, timber wood, wood processing residues
Diameter (cm)	≤ 2 do > 15		> 5 do > 15
Length (cm)	≤ 20 do ≤ 100		≤ 20 do ≤ 100
Water content (%)	≤ 20 do ≤ 25		≤ 20 do ≤ 35
Share of split wood (%)	≥ 90	≥ 50	No demand
Share of rotten wood (%)	0	≤ 5	If rotten wood share is ≥ 10% the info has to be given

Standard EN ISO 17225-4 classifies chips into two groups:

- chips for domestic (individual) use: are classified into quality classes A (A1 and A2) and B (B1 and B2). Chips classified in class B can be made from not chemically contaminated wood waste and used wood.

– chips for industrial use

Table 18: quality grades for woodchips, according to EN ISO 17225-4 standard.

QUALITY CLASSES	A1	A2	B1	B2
Particle size (mm)	According to Table 4			
Water content (%)	< 10 < 25	< 35	Has to be determined	
Ash share (%)	< 1,0	< 1,5	< 3,0	
Bulk density (kg/m^3)	> 150 > 200 > 250	> 150 > 200 > 250 > 300	Minimal value has to be determined	
Key chemical elements with limit values determined			N, S, Cl, As, Cd, Cr, Cu, Pb, Ni, Zn	

And standard **EN ISO 17225-2 quality standard** classifies the pellets into two groups:

- pellets for domestic (individual) and
- pellets for industrial use.

Pellets for home use are classified into quality classes A1, A2 in B.

Table 19: Pellets for home use are classified into quality classes A1, A2 in B (Source: Kocjan D. et al. (2018). Ogrevanje z lesnimi gorivi – Peleti).

QUALITY CLASSES FOR HOME USE	A1	A2	B
Diameter (mm)	6 ± 1 8 ± 1		
Length (mm)	3,15 - 40		
Water content (%)	≤ 10		
Mechanical stability (%)	≥ 97,5		≥ 96,5
Bulk density (kg/m^3)	≥ 600		
Fine particles share (%)	≤ 1		
Ash content (%)	≤0,7	≤ 1,2	≤ 2

Pellets for industrial use are divided into quality classes I1, I2 in I3**.**

Table 20: Pellets for industrial use, divided into quality classes I1, I2 in I3 (Source: Specifications of biomass products traded on the Graceful Globe Biomass Exchange).

QUALITY CLASSES FOR INDUSTRIAL USE	I1	I2	I3
Diameter (mm)	6 ± 1		
Length (mm)	3,15 - 40		
Water content (%)	≤ 10		
Mechanical stability (%)	97,5 ≤ 99,0	97 ≤ 99,0	96,5 ≤ 99,0
Bulk density (kg/m^3)	≥ 600		
Fine particles share (%)	≤ 4	≤ 5	≤ 6
Ash content (%)	≤1,0	≤ 1,5	≤ 3

Some pellet producers in Slovenia underwent the certification procedure also for another available standard, namely the **ENplus® standard** for non-industrial use pellets. ENplus has a wide scope, encompassing the entire wood pellet supply chain. From the early stages of production to the delivery process, all actors must have detailed guidelines, efficient monitoring procedures, and dedicated training at their disposal to ensure high and consistent quality levels.

In some countries, ENplus® is managed by national pellet associations, called the National Licensers. In Slovenia there is no national licence body, therefore the producers and traders have to contact organisations, active at an international level to submit to the certification procedure and obtain the certificate.

Another certification possibility is offered by a **BIOmasud® certification scheme**. In some Mediterranean countries there is also a biomass market with production of solid biomass fuels from olive stones, almond shells and pine nut shells, olive tree pruning and similar, that aren't used in other European regions. Biomasud developed a certification system which covers many of the solid biofuels traded in the Mediterranean region. This label defines quality requirements but also includes minimal sustainability criteria along the whole value chain, and a traceability system that allows resource management from a global perspective.

In Slovenia a biomasud certification body is the above mentioned Bureau Veritas d.o.o.. For the wood pellets and the wood chips, the system is based on international standards - ISO 17225-2 for wood pellets and ISO 17225-4 for wood chips, while for other biofuels it is based on the pre-standards developed in the frame of the project.

5 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC) SYSTEMS

A simplified QA/QC system is proposed to be adopted by the single stages in the established wood biomass energy production chain, in order to follow and assure the implementation of the sustainability, operation standards, storage and compliance with the end users quality requirements. Commitment of producers, suppliers and end-users is essential in order to assure the requirements are known, respected and the end product is in compliance with the installation and end-user quality requirements.

A simplified version of the standard procedure, according to the Standard EN 15234-1:2011 - Solid biofuels - Fuel quality assurance is proposed to be adopted by each wood energy supply chain. This Standard defines the procedures to fulfil the quality requirements (quality control) and describes measures to ensure adequate confidence that the biofuel specification is fulfilled (quality assurance). It covers the whole chain, from supply of raw materials to point of delivery to the end-user. It includes solid Wood fuels origin from the following sources: agriculture and forestry, vegetable waste from agriculture and forestry, vegetable waste from the food processing industry, wood waste, with the exception of wood waste which may contain halogenated organic compounds or heavy metal, fibrous vegetable waste from virgin pulp production and from the production of paper from pulp, if it is co-incinerated at the place of production and heat generated is recovered, cork waste.

The following areas should be defined to fulfil the QA/QC requirements:

- Traceability of raw material
- Production requirements
- Transportation, handling and storage after production
- Final fuel specification

6 FUEL VS. HEAT ACQUISITION

In Pivka the District heating system is actually not owned by the municipality. The contract with the owner was signed and the contract states the price of the heat that is used and payed by the public users in the municipality. So, the whole responsibility on the quality of fuel and furnace and all other maintenance costs are invested by the owner and subject to his responsibility to fulfil the requirements of the Slovene law.

7 The district heating system in Pivka and its requirements

From 2013, on force is the Decree on the emission of substances into the atmosphere from small and medium combustion plants (Uradni list RS, št. 24/13) which was amended in 2015. It defines:

- Criteria for classifying combustion plants;
- Fuel that may be used in combustion plants;
- Evaluation of the emission of substances in the flue gases;
- Limits emissions from combustion plants;
- Measures relating to reducing emissions into the air;
- Operational monitoring of emissions into the air.

Combustion plant is small if the thermal input is less than 1 MW in the use of solid fuel. If the thermal input is more than 1 MW and less than 50 MW, the combustion plant is medium. Allowed solid fuels are: natural wood (firewood, sawdust, cuts, shavings, bark, and cones), wood briquettes and pellets from natural wood and coal, briquettes and coke from coal. Limit values for combustion plants are prescribed by the Decree on the emission of substances into the atmosphere from small and medium combustion plants limit values are set for the CO [g/m^3] and total dust [g/m^3] emissions.

Source: http://www.artim.si/reference_web/pivka_reference.html

Source: http://www.artim.si/reference_web/pivka_reference.html

Quality requirements

The furnace is in the range of small devices and is as such subject to technical defects if the quality of fuel is not as requested. The owner reported that the moisture content has to be below 30% and very little or no earth, small sand od gravel particles are to be present in the fuel. In case the lower quality fuel is used, the yield decreases and there are defects are very frequent.

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European Standards:

- EN 14961 series of standards

EN 14961-1:2010 Solid biofuels – Fuel specification and classes – Part 1: General requirements
EN 14961-2:2011 Solid biofuels – Fuel specification and classes – Part 2: Wood pellets for non-industrial use
EN 14961-4:2011 Solid biofuels – Fuel specification and classes – Part 4: Wood chips for non-industrial use
EN 14961-5:2011 Solid biofuels – Fuel specification and classes – Part 5: Firewood for non-industrial use

- EN 15234-1:2011 - Solid biofuels - Fuel quality assurance

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