sucellog

Triggering the creation of biomass logistic centres by the agro-industry

Guide on technical, commercial, legal and sustainability issues for the assessment of feasibility when creating new agro-industry logistic centres in agro-food industries

Co-funded by the Intelligent Energy Europe Programme of the European Union

Authors: CIRCE, Research Centre for Energy Resources and Consumption

Editors: SUCELLOG Consortium

Contact: CIRCE, Research Centre for Energy Resources and Consumption
sucellog@fcirce.es
Tel.: +34 876 555 511
www.fcirce.es

Website: www.sucellog.eu

circe
CENTRO DE INVESTIGACIÓN
DE RECURSOS
Y CONSUMOS ENERGÉTICOS

Co-funded by the Intelligent Energy Europe
Programme of the European Union

Table of contents

List of Tables

List of Figures

Acknowledgements

This document was elaborated in the framework of SUCELLOG project (IEE/13/638/SI2.675535), supported by the European Commission through the Intelligent Energy Programme (IEE). The authors would like to thank the European Commission for the support of the SUCELLOG project as well as the Co-authors and SUCELLOG partners for their contribution to this Handbook.

SUCELLOG Project

The SUCELLOG project - Triggering the creation of biomass logistic centres by the agro-industry - aims to widespread the participation of the agrarian sector in the sustainable supply of solid biomass in Europe. SUCELLOG action focuses in an almost unexploited logistic concept: the implementation of agro-industry logistic centres in the agro-industry as a complement to their usual activity evidencing the large synergy existing between the agro-economy and the bio-economy. Further information about the project and the partners involved are available under www.sucellog.eu.

SUCELLOG Consortium:

CIRCE: Research Centre for Energy Resources and Consumption, Project coordination
Eva López - Daniel García –Fernando Sebastián: sucellog@fcirce.es

WIP: WIP - Renewable Energies
Dr. Ilze Dzene: Ilze.Dzene@wip-munich.de
Cosette Khawaja: cosette.khawaja@wip-munich.de
Dr. Rainer Janssen: rainer.janssen@wip-munich.de

RAGT: RAGT Energie SAS
Vincent Naudy: vnaudy@ragt.fr
Matthieu Campargue: mcampargue@ragt.fr
Jérémie Tamalet: JTamalet@ragt.fr

SPANISH COOPERATIVES: Agri-food Cooperatives of Spain
Juan Sagarna: sagarna@agro-alimentarias.coop
Susana Rivera: rivera@agro-alimentarias.coop
Irene Cerezo: cerezo@agro-alimentarias.coop

SCDF: Services Coop de France
Camille Poutrin: camille.poutrin@servicescoopdefrance.coop

DREAM: Dimensione Ricerca Ecologia Ambiente
Enrico Pietrantonio: pietrantonio@dream-italia.net
Dr. Fiamma Rocchi: rocchi@dream-italia.it
Chiara Chiostrini chiostrini@dream-italia.net

Lk Stmk: Styrian Chamber of Agriculture and Forestry
Dr. Alfred Kindler: alfred.kindler@lk-stmk.at
Tanja Solar: tanja.solar@lk-stmk.at
Klaus Engelmann : klaus.engelmann@lk-stmk.at
Thomas Loibnegger: thomas.loibnegger@lk-stmk.at

Introduction

SUCELLOG project aims to trigger the involvement of the agrarian sector in the sustainable supply of new solid biomass, focusing on the opportunities that agro-industries have to become biomass logistic centres. In that sense, the project promotes that agro-industries diversify their regular activity and take advantage of two facts:

- Some agro-industries have equipment compatible with the production of solid biomass (driers, pelletisers, chippers, storage silos, etc.)
- Agro-industries are used to deal with agrarian products and to fulfil consumers' quality requirements.

For that purpose, SUCELLOG supports some agro-industries with an evaluation of their opportunities to become logistic centres of biomass through different type of activities. The agrarian associations members of SUCELLOG Consortium, trained within the project, are the ones developing these tasks with direct assistance and recommendations from SUCELLOG experts. The issues assessed by the project for the agro-industries are:

- Biomass resources availability and possible logistic chains to ensure the supply of raw material.
- Segment of consumers from the solid biomass market to be targeted depending on their demand.
- Evaluation of the existing facility and of the compatibility to process the biomass raw material.
- Technical and economic feasibility as well as environmental sustainability of the new activity.

This document contents a series of templates, tables, check-lists, guidelines, etc., that have been demanded by them when carry out the work regarding the above-mentioned issues. It is considered that it can be useful also for stakeholders when considering a similar new business line. Some of this information has been included in the high quality handbooks elaborated within the project (Handbook on basic demand of information and Handbook on how to carry out a feasibility study on how to become a logistic centre). The present guidelines complement this knowledge transfer to the agrarian sector, highlighting in bold the most important considerations that the project has faced when supporting the agro-industries assessment. More concretely this document includes:

Regarding biomass assessment:

- European projects with GIS tools or maps providing resource quantities,
- seasonality of main agrarian residues,
- template for interviewing local suppliers of biomass in terms of quantities, quality and prices,
- possible logistic chains to ensure the supply.

Regarding solid biomass market:

- Quality issues to bear in mind when producing solid biomass,
- template for interviewing local potential consumers in terms of quantities, quality and prices,
- list of combustion equipment designed to work with agro-fuels,
- legal aspects related to contracts with solid biomass consumers.

Regarding the production facility:

- List of prices for different equipment,
- guidelines on production and maintenance costs,
- check-list to evaluate soundness of working environment and avoidance of fire-risks.

Regarding environmental sustainability issues:

- Tools to evaluate the environmental sustainability of the new business line,
- emission limits for biomass combustion equipment in Europe.

1. Biomass resources availability

When a new business on solid biomass production is started, two main issues have to be solved in order to avoid risks: the supply of the raw materials have to be ensured along the time and there has to be a market demanding a quality that the new business is able to produce.

Regarding the first, **the fact that biomass resources are existing in the territory does not ensure that they are available for the new business activity. Prices, seasonality, competing uses and the existence of logistics chains that collects the raw material have to be carefully evaluated.**

As a first stage, an estimation on quantity of residues around should be perfomed taking into consideration numerous studies and statistical data found in bibliography that are available in most European countries. The results should be further contrasted with possible suppliers (farmers or logistic operators) in the area who would provide also data on prices, quality and contract conditions complementing the local framework study.

The details on the steps when assessing the boundary conditions in terms of resources are described in Handbook on how to carry out a feasibility study on how to become a logistic centre. This section presents some hints complementing this information. It provides the stakeholder with a summary on some available tools that can complement theoretical data on resource assessment, it gathers the seasonality of the agrarian resources, a template to get information from local resources providers and finally, some information about the logistics chain of permanent crop prunings.

1.1. Data offered by European projects complementing national databases on biomass resource assessment

GIS databases as well as national/regional inventories or Eurostat can be used to obtain a first estimation of the quantity, localisation and surfaces. Several European projects provide data on biomass assessment that can be consulted to complement it. In the next sub-sections, some examples of tools are provided and explained mainly in a visual way.

1.1.1. Bioraise project

- Web: http://bioraise.ciemat.es/Bioraise/
- Countries covered: Spain, Portugal and France

This project has created a GIS tool for biomass resources assessment in Southern Europe. This web is a map-interactive resource that enable the user to easily identify what are the biomass resources (herbaceous, wood prunings and shrubs) in an area, there quantities and where exactly are they placed.

It also provides data about industrial by-products, mapping their producers and several type of stakeholders that can be of interest when starting a business in this line (see Table 1). As a GIS tool, it can be visualized on a Google-like map, as Figure 1 illustrates.

Table 1: Producers and Stakeholders considered in Bioraise project.

Producers	Resources	Stakeholders
Wood industry Olive oil press industry Nut hulling industry Distilleries	Bark, chips, sawdust, other wood by-products Olive pits and pomace Almond, pine nut and hazelnut shell Grape pomace and grape seeds	Industrial equipment and machines Installation and services Biofuel manufacturing / biomass valorisation Biofuel distribution Research centres Big biofuel consumers

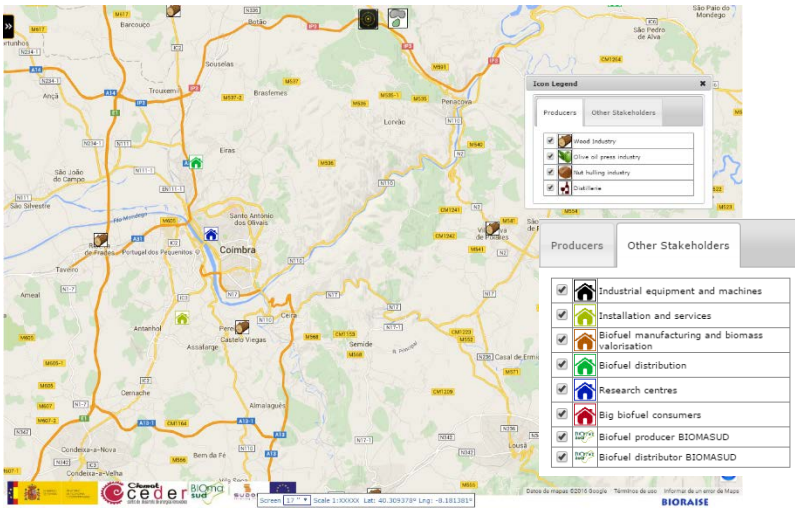


Figure 1. Visual aspect at regional scale, with the complete legend of symbols (e.g: Coimbra surroundings), (Bioraise project)

The producers and stakeholders are displayed or grouped in proximate zones (Figure 2). This web provides a tool to calculate resources in a circle defined by its radius. Once the area is fixed, then several options, both for field products or industrial by-products, can be calculated: amount of resources, collection costs and quality characteristics of these resources (ash and energetic contents) (see **¡Error! No se encuentra el origen de la referencia.** and Table 3).

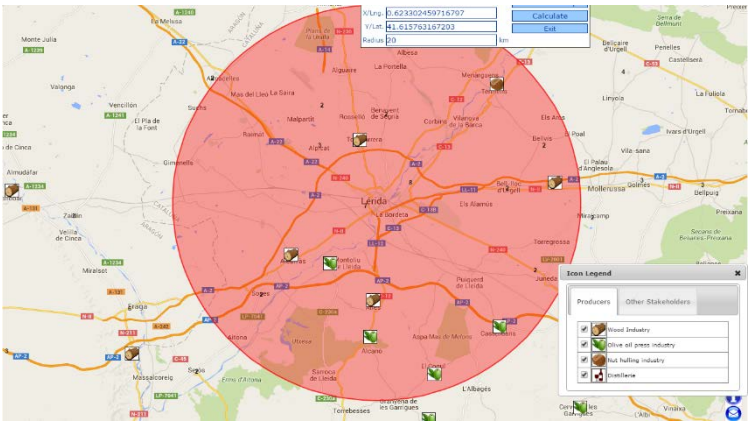


Figure 2. A defined radius (20km) selecting a particular city (e.g: Lérida) (Bioraise project)

Table 2. Example of the options and the calculations that Bioraise tool can provide for field products

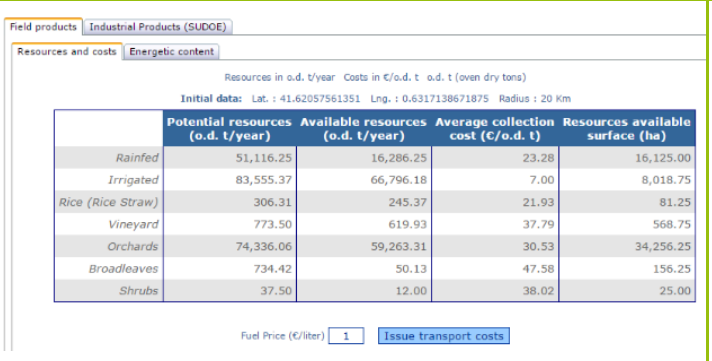
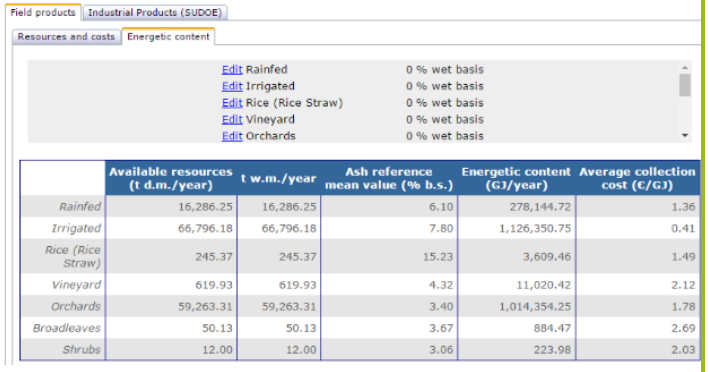
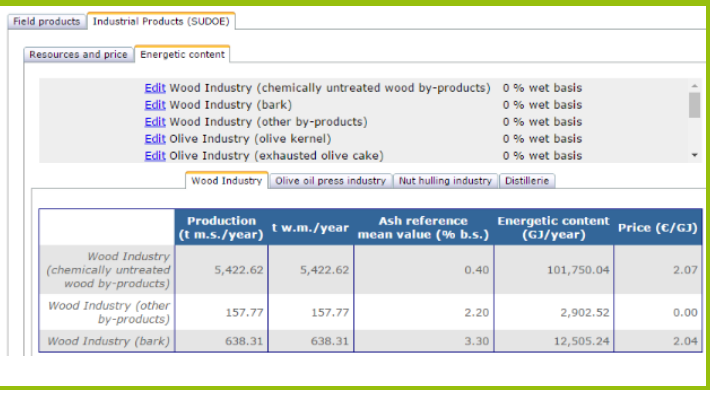
	Resources and Costs	Energetic content
Field products		

Table 3. Example of the options and the calculations that Bioraise tool can provide for industrial products

	Resources and Costs	Energetic content
Industrial products		

1.1.2. Basis Bioenergy

- Web: http://www.basisbioenergy.eu/
- Countries: Belgium, Austria, Denmark, Germany, France, Spain, Italy, Sweden

The project web contains a very powerful GIS tool (see Figure 3) centred on the wood chip biomass resource, mapping the location of biomass production plants, generation plants, forestry coverage and distribution harbours among others.

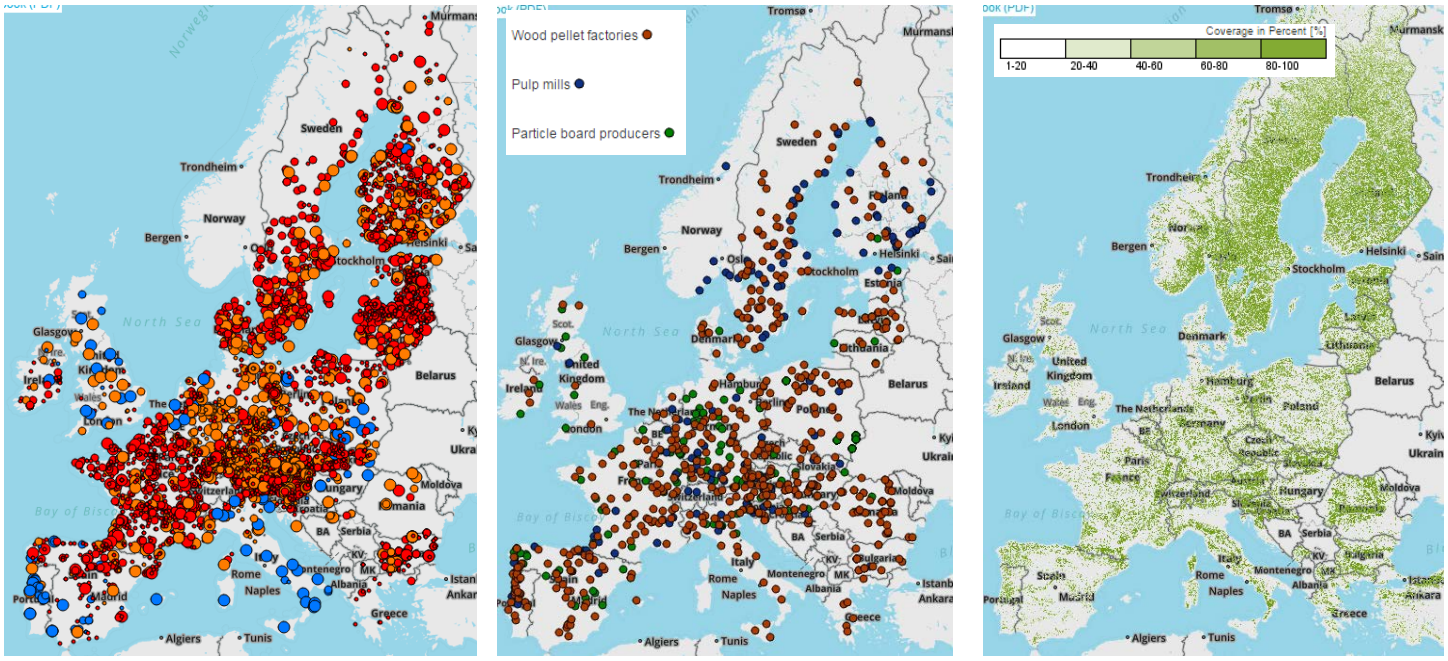


Figure 3. LEFT: Bioenergy plants. CENTRE: Other wood chip stakeholders. RIGHT: Forest coverage (BasisBioenergy project)

The web also offers a GIS based maps where indicators on how well a market can be implemented in determined regions (state level or province level for high potential areas), see Figure 4. The information can be assessed based on which type of market is required: biogas, bio-methane, small-scale heat, district heating, CHP, biodiesel and bioethanol.

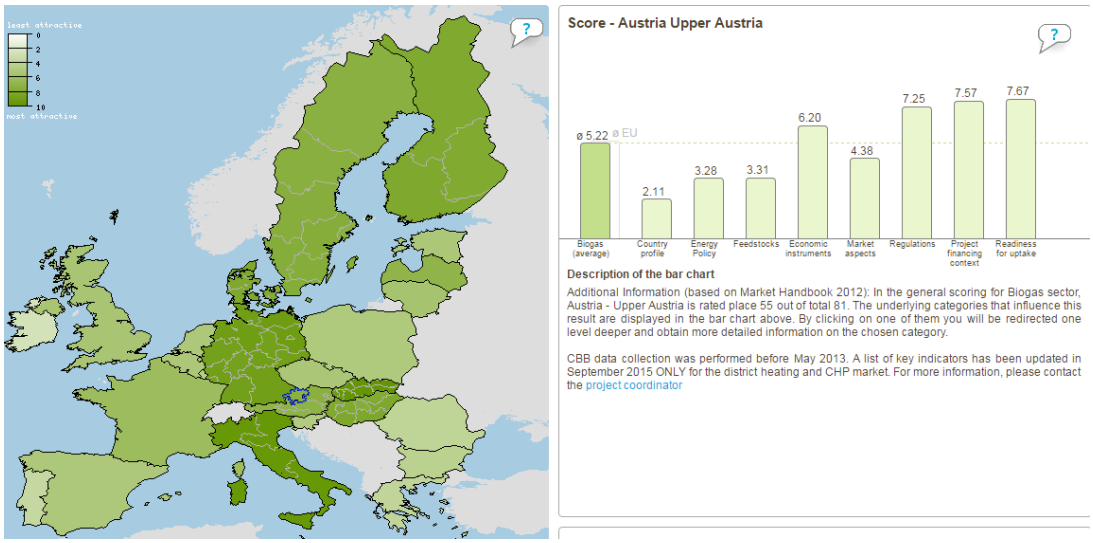


Figure 4. Exploring the market development for biogas in a region of Austria (BasisBioenergy project)

1.1.3. SUCELLOG Project

The SUCELLOG Project made a regional estimation of the available agrarian resources in order to build tables and maps for stakeholders interested in this type of resources. All the information, as well as the methods for calculation, can be found in project reports D3.2 and in the website. The project is focused in some regions of the countries participating in the project (see Figure 5).

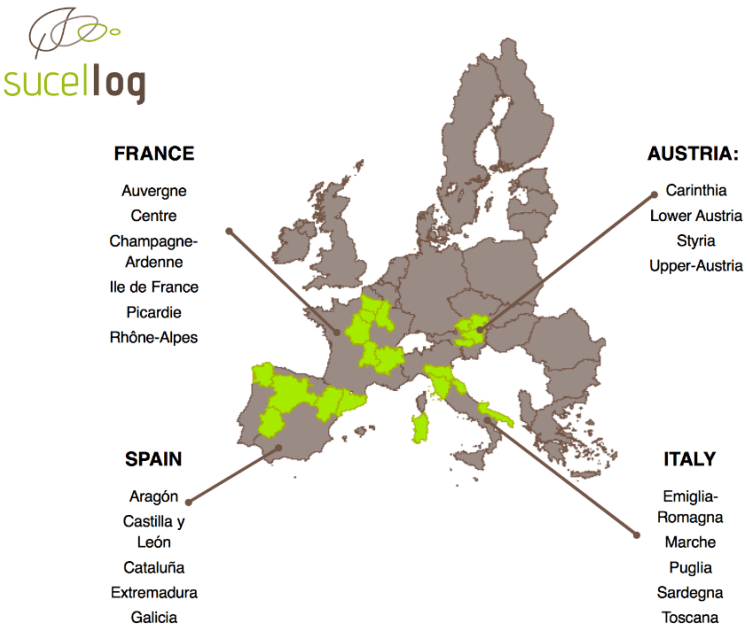


Figure 5. Regions assessed in SUCELLOG project

The information provided by this project has the peculiarity that the quantities of biomass are tons of dry matter already available to become solid biomass. For this purpose, a percentage representing the current alternative uses (including the use of these resources as soil amendment) defined by the agrarian associations participating in the project and with a wide knowledge of the territory, has been extracted from the initial amount of resources resulting in available biomass.

The type of tables and maps that can be found are shown in Figure 6 and Figure 7. The maps also include the location of agro-industries which have been selected by the project as the most interesting ones to develop a logistic centre in their facilities because of the already existing equipment and/or the residues produced.

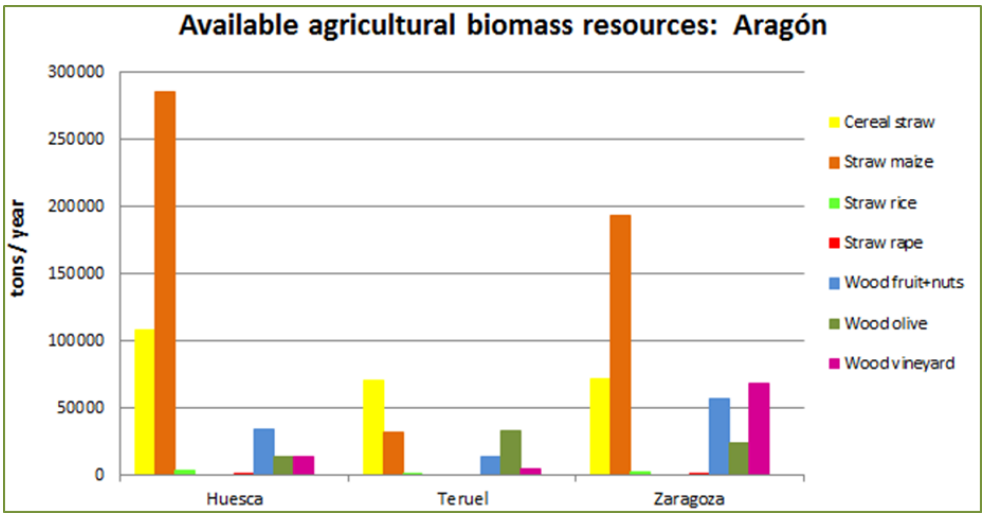


Figure 6. Biomass available residues, Aragón region

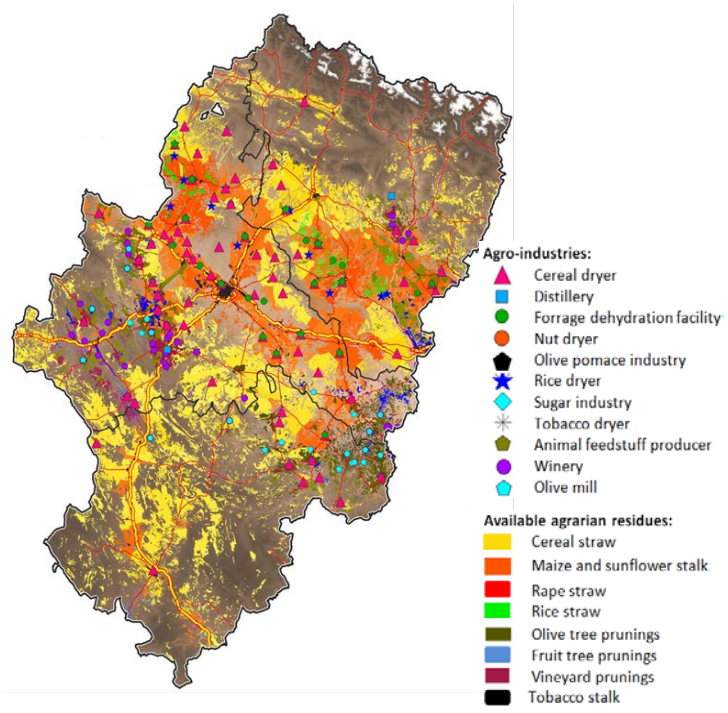


Figure 7. Location of available biomass and agro-industries in Aragón region

1.2. Seasonality of agrarian biomass resources

Unlike what happens with wood sources, agrarian resources are seasonal. Table 4 shows the summary of the seasonality of the resources evaluated within SUCELLOG project, covering the situation in Spain, France, Italy and Austria.

Table 4. Crop availability periods, monthly

CROPS AVAILABILITY	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Feedstuff residues	■	■	■	■	■	■	■	■	■	■	■	■
Cereal straw						■	■	■				
Soya Straw										■	■	
Rape stalks							■	■				
Corn stalks									■	■	■	▨
Corn cobs									■	■	■	▨
Husks/silo dust from cereal driers						■	■	■	■	■	■	■
Rice husks	■	■	■	■	■	■	■	■	■	■	■	■
Husks/residues from oil seeds	■	■	■	■	■	■	■	■	■	■	■	■
Tobacco residues							■	■	■	■		
Distillery residues	■	■	■	■						■	■	■
Beet pulp								■	■	■	■	■
Vineyard prunings	■	■	■							▨	▨	■
Olive prunings		■	■	■								
Seed fruit pruning	■	■	■	▨	▨				▨	■	■	■
Stone fruit pruning	■	■	▨								▨	■
Dry fruit pruning	■	■	▨							▨	■	■
Citrus pruning		■	■	■	■							
Grapevine oilseed cake									■	■	■	
Grape marc and stems								■	■	■	■	■
Grape pits	■	■	■									
Olive pits	■	■	■	■	■					■	■	■
Olive oil pomace	■	■	■	■	■					■	■	■
Nut shells	■	■	■	■	■				■	■	■	■

■ *Periods when the biomass is produced by harvest or processing activities*

▨ *Differences between countries are represented in striped box*

1.3. Assessing biomass availability at a local scale: interviews with stakeholders

As it has been explained in the introduction of this section, theoretical data on biomass resources should be screened through the consultation to local stakeholders (like farmers or logistic operators). **Interviews with them are essential to reach information about real availability or competing uses, prices and the technical possibility to collect these resources. Since answers can be varied, SUCELLOG strongly recommends to interview several stakeholders in order to reach a representative overview of the local framework.**

Within SUCELLOG, two different survey templates have been elaborated: one focused on the farmer and the other one for the logistic operator and are shown in Figure 8 and Figure 9, respectively.

Template for the interview - version FARMER

What type of residue do you produce in your cultivation practices? _____

How much do you produce (t/ha)? _____

How many hectares do you have (ha)? _____

Do you normally change the type of cultivation from one year to another?

Which months of the year you are producing this residue? _____

Do you sell this residue in the market? _____

To which kind of consumer (animal feeding, bedding, ...)? _____

Do you sell all your residue? _____

At which price (€/t)? _____

Is it a stable market? _____

If you do not sell the residue, please explain the reason _____

If you leave the residue on the soil as organic amendment, please explain if part of the residue could be extracted without creating negative consequences on the soil _____

Which is the distance from your field to the potential consumers of your resources (km)? _____

Would you be able to harvest the residue with your machinery? _____

Would you be able to transport the residue? _____

At which price will you sell the product (€/t)? _____

Transport is included? _____

If transport is not included, how much will be the transport cost to XXX ? _____

Figure 8. Template for resource assessment - interview to a farmer

Template for the interview - version LOGISTIC OPERATOR

What type of residue do you collect? _____

How much is it normally produced in the area (t/ha)? _____

Does the farmer receive anything for the residue? How much (€/t)? _____

To which type of market do you sell this residue? _____

Do you sell all of it or you normally store from one year to another due to possible scarce demand?

At which price is this residue sold (€/t)? _____

Is it a stable market or there is a high fluctuation of prices? _____

How much can you say that is available in this area every year that is not used for other markets or left on the soil as amendment? _____

Which is the price of the residue itself + harvesting costs (€/t)? _____

Which will be the price for the transport to XXXXX (€/t)? _____

Can your machinery collect different type of resources? _____

In that case, which is the difference in consumption or in the final price? _____

If finally an agreement is done for the supply to XXXx, do you have any special requirement concerning the type of contract to be made in terms of time? _____

If a base price is fixed and add increments according to CPI (consumers price index), would be interested in making contracts of 1 year duration? _____

Maximum contract duration you are interested in? _____

Figure 9. Template for resource assessment - interview to a logistic operator

1.4. Logistics chain on biomass resources

In order to ensure the supply of raw material to the solid biomass production centre, a logistics chain that collects the resources should exist or should be created. Herbaceous resources like straw do have a well-developed logistics chain since the straw has a market from long time ago (animal feeding, bedding, …). Residues produced in the agro-industries do not have logistics problems either.

On the contrary, wood prunings present logistic challenges which make them an unexploited resource that is mainly burnt or mulched and left on the soil. Although sometimes the mulching is performed for the incorporation of an organic amendment into the soil, in most cases this practice is done to avoid the disposal cost of the residue. However, European stakeholders should start considering this resource as a bioenergy

product since the collection imply savings for the farmers in terms of time and money (avoiding mulching) as well as fire risks.

EuroPruning project (http://www.europruning.eu/) has detected that there are still social barriers to be overcome. The stakeholders are still reluctant to consider prunings as an energy source due to their scarcity since it is though that the collection costs make the business unprofitable. However, in the last years, **new machinery has been developed for harvesting pruning branches in an efficient way and experiences working with this type of resources are growing in Europe**. The following sub-sections provide information about them coming from.

1.4.1. Existing technologies for harvesting wood prunings

Within the EuroPruning project, more than 70 technologies available in the market for the collection of prunings have been identified. They are summarised in Table 5. As it can be observed, 55 of them consist in adaptations from conventional mulchers, with different degrees of innovations and integration for improving the pruning biomass harvesting. Chippers are still lacking for sufficient development and penetration in the sector, however this type of machinery is required whenever the product is aimed to be compatible with consumers of regular woodchips, though in general, is possible to find consumers for shredded material. Commercial prunings balers are also available in the market as well as machinery that integrates the pruning and harvesting in one step.

A total of 35 companies offering this type of machinery in the market have been detected, sited in Spain (4), France (2), Italy (19), Germany (3), The Netherlands (2), Poland (3) and Canada (1). Table 6 provides their names. **Since machinery performance depends very much on field characteristics, SUCELLOG strongly recommends to contact with the local manufacturer in order to make some previous tests under the particular conditions to be exploited.**

Table 5. Summary of existing technologies in Europe (EuroPruning project)

Techn.	Figure	Code	Nr observed	
Shredders and mulchers		[M1]	3	55
		[M2]	12	
		[M3]	37	
		[M4]	2	
		[M5]	1	
		[M6]	1	
		[M7]	0	
CHIPPERS		[CH1]	1	5
		[CH2]	3	
		[CH3]	1	
		[CH4]	1*	

Techn.	Figure	Code	Nr observed	
		[CH5]	0	
BALERS		[BL1]	1	9
		[BL2]	4	
		[BL3]	4	
Integrated pruning and harvest		[PP1]	0	1
		[PP2]	1	
		TOTAL	71	

Table 6. Summary of harvesting machineries available in Europe (and Canada), numbers of models (EuroPruning project)

Machine constructor	Country	Mulchers	Chippers	Balers	Integ. pre-prunners
Anderson	Canada			1	
Belafer	Spain	2			
Berti	Italy	4			
Caeb	Italy			1	
Concept Machines Bernhardt (CMB)	France	1			
Costruzioni Nazzareno	Italy		2		
Facma	Italy	1			
Falc	Italy	3			
Favoretto Paolo	Italy				1
Forest Technology Centre	Poland	1			
Inventor	Poland	1			
Jonues i fills	France	12			
Jordan	Germany		1		
Kuhn	Germany	2			
Lely	The Netherlands			1	
Lerda	Italy			2	
Nobili	Italy	2			
Omarv	Italy	2			
Omat	Italy	1			
ONG	Italy		1		
Oonyx	France	1			
Orsi	Italy	1			
Perfect (Van Wamel B.V.)	The Nederland	1			
Peruzzo	Italy	2	1		
Picursa	Spain	11			
Pimr	Poland			1	
Promagri	Spain	2			
Rinieri	Italy	2			
Seppi	Italy	2			
Serrat	Spain	7		1	
Sgarbi	Italy				
Sousliskoff	France	2			
Stoll	Germany	1			
Tierre	Italy	2			
Tigieffe	Italy			1	

Machine constructor	Country	Mulchers	Chippers	Balers	Integ. pre-prunners
Wolagri	Italy			1	

1.4.2. Experiences working with prunings

Around 10 Mha are dedicated to plantations of vineyards, olive and fruit tree in Europe according to Eurostat (October 2014). EuroPruning has quantified that, due to these practices, 25 Mt of wood is produced every year coming from prunings and plantation removal of those crops.

Although their use is currently scarce, some experiences are working with this type of resource showing the economic and technical feasibility of prunings as an energy source. The advantage of using a local resource, which in turn implies a cost of disposal, has been the catalyst for these initiatives. Two different cases at different scale are shown below. **It is important to highlight the different types of logistics chain** that they present**,** meaning that **there are several alternatives and the one that fits better into the business model of the different stakeholders should be found.**

Serra Council Hall

This village with 3000 inhabitant is located in a very mountainous area of Valencia Region (Spain). The initiative, promoted by the town hall, grew up with the goal of avoiding the fire risks that were frequently caused by the burning of pruning residues. Municipal wastes disposal and the pruning from 8 farmers (60 tons) are being used to heat municipal buildings and reducing the energetic bill up to 19 000 € per year.

The logistic chain followed in this case and that is part of the success of Serra's initiative is presented in Figure 10. The Figure 11 and Figure 12 show some pictures from parts of the chain.

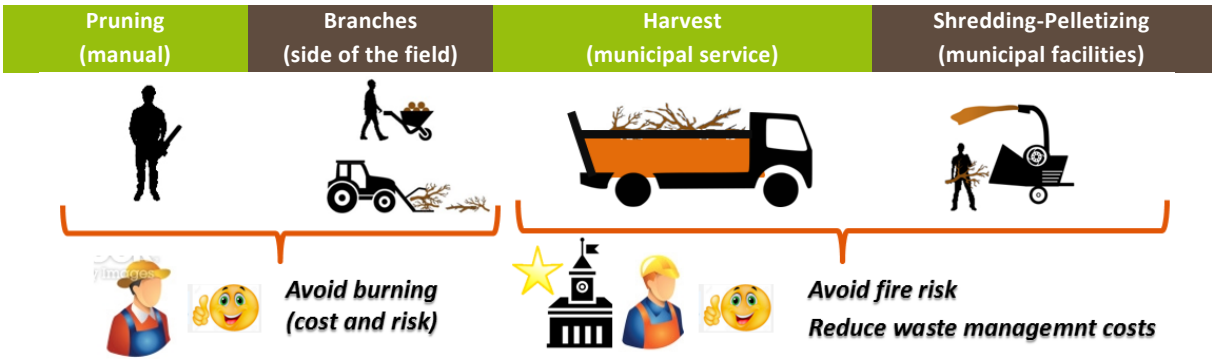


Figure 10. Scheme of the logistic chain of Serra case

Figure 11. Serra example. (Left) Shredder of pruning (Right) Material storage

Figure 12. Serra example. (Left) Pelletizing (Right) Biomass boiler

Pellets de La Mancha

This initiative is running from 2011 and is the unique example in Spain, producing 20000 tons of pellets per year from vineyard prunings. The different logistics chains operating for gathering the resources are presented in Figure 13. Figure 14 shows some pictures from the pelletizing facility.

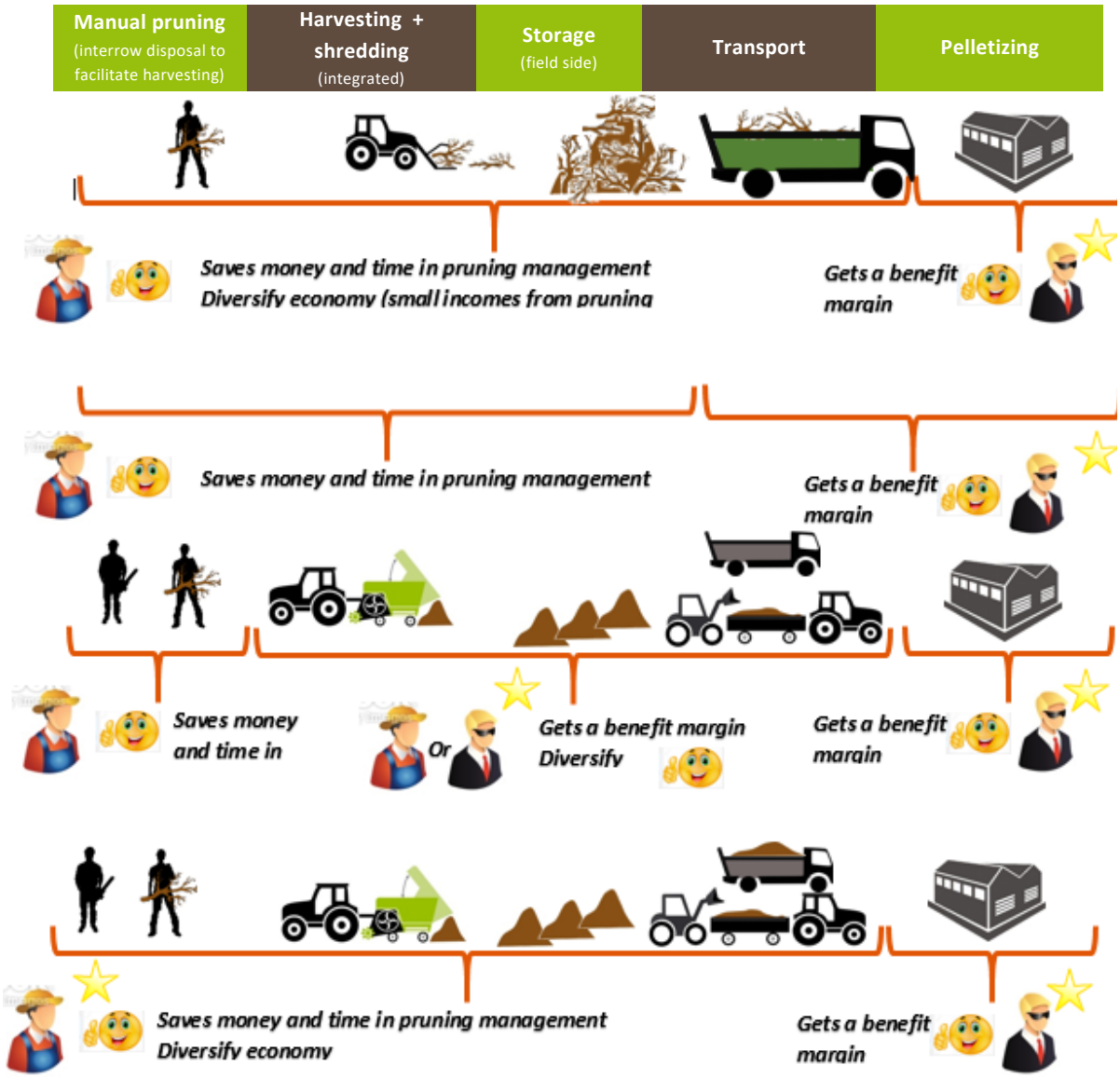


Figure 13. Scheme of the different logistics chains working in the case of Pellet de la Mancha

Figure 14. (Up) Pruning storage (Left down) Transport to the plant (Right down) 15 kg bag filling facility

2. Solid biomass market

As mentioned in section 1, **the existence of a solid biomass market demanding the quantities, qualities and prices that the new business line is willing to produce is essential to ensure the feasibility of the project.**

All aspects to bear in mind when performing a market study are detailed in Handbook on how to carry out a feasibility study on how to become a logistic centre. Complementary information for stakeholders can be found in this section.

Regarding the quality of the final product, it depends on the quality characteristics of the raw materials used and on the pre-treatments carried out in the logistic centre. In the following section 2.1 the most important quality issues to be taken into consideration when producing solid biomass are included.

Additionally, it should be taken into account that when evaluating the suitability of the project, the customer segment to be targeted should be carefully selected. Section 1.1 provides a template that can be useful when interviewing local current consumers of biomass in order to assess their potentiality to be engaged as customer for the new logistic centre. It can also serve to evaluate the type of product offered by the competitors.

Finally, this section offers a list of existing combustion equipment available in the market able to operate with agrarian solid biomass together with some guidelines for underwriting a supply contract with a consumer.

2.1. Quality issues

The main properties which influence quality (moisture content; ash content; content in Nitrogen, Chlorine and Sulphur; net calorific value; ash softening temperature; particle size distribution; bulk density) are explained inside SUCELLOG Handbook on basic demand of information.

The following sub-sections present average quality values of some biomass raw materials, the most common solid biomass formats, recommendations of quality values for solid biomass included in international standards and the most common quality certificate systems in Europe.

2.1.1. Typical properties of biomass resources:

Here below are shown **some of the average quality properties according to ISO 17225 (International Standard for solid Biofuels) and MixBioPells* (IEE project dealing with non-woody pellets)**. The values are provided in dry basis (db).

It should be noted that these are theoretical values, which cannot be similar in all local conditions, especially in terms of ash content which depends on the amount of exogenous mater collected along the logistics chain. **For this reason, these values should be taken only as reference values, chemical analysis to be determine the real values of the raw material planned should be performed to have more realistic data.**

Table 7. Net calorific value and ash content of different biomass resources.

Raw material	Net calorific value (kWh/kg db)	Ash content (w-% db)
Wood from coniferous	5,1 – 5,5	0,1 – 1,0
Wood from broadleaves	5,1 – 5,3	0,2 – 1,0
Straw from wheat, ray, barley	4,4 – 5,3	2 - 10
Straw from rape	4,4 – 5,3	2 - 10
Olive pits	4,8 – 5,4	1,2 – 4,4
Olive pomace	3,9 – 5,3	3,4 – 11,3
Rice husks	4,0 – 4,5	13,0- 23,0
Sunflower husks	4,7 – 6,1	1,9 – 7,6
Cherry/Apricot pits	5,4 - 6,4	0,2 – 1,0
Almond/ hazelnut shells	4,9 – 5,3	0,95 – 3,0
Corn cob*	4,6	1 - 3
Corn stalk*	4,6 – 4,9	11 - 17

Whereas ash content values are normally provided in dry basis, it is not the case for the net calorific value (Q). To translate the value in dry basis included in the table, into a net calorific value on wet basis (kWh/kg ar), for a certain moisture content (M, w-% ar), the following equation should be used:

$$Q\ (kWh/kg\ ar) = [Q\ (kWh/kg\ db) * (1-0{,}01*M)] - [24{,}43 * M * (1/3600)]$$

2.1.2. Solid biomass format

The solid biofuel can be produced in the different formats. The most common ones are shown below. I**t should be noted that not all formats fit in all combustion equipment and this should be taken into consideration when evaluating the market. E.g. there are some equipment that is specific for pellets and cannot work with chips. The manufacturer of the equipment should be consulted in that case.**

Pellets / Briquettes

Source: http://www.briquetas.org/

Fruit biomass: pits or shells

Chips / Hog fuel

Cobs

Bales

2.1.3. Quality properties to be fulfilled by the solid biomass products

The following tables present some of the main properties that international standards and some quality labels recommend as the proper ones for non-industrial use. The values of moisture content and net calorific value are provided in wet basis (ar) whereas ash and chlorine content are given in dry basis (db). **To have more detail of all the quality limits, the user is encouraged to acquire the complete standards here.**

SUCELLOG reminds that it is not compulsory to fulfil quality requirements stated in the standards and, for this reason, it is recommended to interview the potential consumers in order to understand their quality demands.

Table 8. Properties of woody pellets according to ISO 17225-2 and ENplus quality label

Property	Class A1	Class A2	Class B
Moisture content (w-% ar)	≤ 10	≤ 10	≤ 10
Ash content (w-% db)	≤ 0,7	≤ 1,2	≤ 2,0
Net calorific value (kWh/kg ar)	≥ 4,6	≥ 4,6	≥ 4,6
Cl (w-% db)	≤ 0,02	≤ 0,02	≤ 0,03

Table 9. Properties of non-woody pellets (mixed pellets included) according to ISO 17225-6

Property	Class A	Class B
Moisture content (w-% ar)	≤ 12	≤ 15
Ash content (w-% db)	≤ 6	≤ 10
Net calorific value (kWh/kg ar)	≥ 4,0	≥ 4,0
Cl (w-% db)	≤ 0,10	≤ 0,30

Table 10. Properties of wood chips according to ISO 17225-4

Property	Class A	Class B
Moisture content (w-% ar)	≤ 35	Maximum value to be declared
Ash content (w-% db)	≤ 1,5	≤ 3,0
Net calorific value (kWh/kg ar)	Minimum value to be declared	Minimum value to be declared
Cl (w-% db)	-	≤ 0,05

Table 11. Properties of olive pits according to BiomaSud quality label

Property	Class A	Class B
Moisture content (w-% ar)	≤ 12	≤ 16
Ash content (w-% db)	≤ 1,3	≤ 2,6
Net calorific value (kWh/kg ar)	≥ 4,4	≥ 4,2
Cl (w-% db)	≤ 0,04	≤ 0,08

Table 12. Properties of almond and hazelnut shell according to BiomaSud quality label

Property	Class A	Class B
Moisture content (w-% ar)	≤ 12	≤ 16
Ash content (w-% db)	≤ 1,6	≤ 3,2
Net calorific value (kWh/kg ar)	≥ 4,2	≥ 3,9
Cl (w-% db)	≤ 0,03	≤ 0,06

2.1.4. Labelling of agrarian solid biomass

European consumers demand more and more certified products. Solid biomass labelled provide confidence to the customers since their quality has been certified by accredited institutions. Not only the manufactured products are certified, but also the processes that are necessary for their production and logistics.

The most common labels in the market and the type of products that are certified are:

- ENplus label: wood pellets.
- DINplus label: wood pellets and briquettes.
- BiomaSud label: wood pellets, wood chips, olive stones, pine nut shells, almond shells, chopped pine cone, hazelnut shells and blends of the cited biomasses (producer must specify the %).

No certification systems has been developed yet for mixed pellets or briquettes produced partly by herbaceous resources considered in the international standard ISO 17225-6 "Solid biofuels – Fuel specifications and classes – Part 6: non-woody pellets" and ISO 17225-7 "Solid biofuels – Fuel specifications and classes – Part 6: non-woody briquettes".

Initiatives like the certification ENagro was born some years ago but it is still not in the market. The aspect of the proposed label is shown in Figure 15. **SUCELLOG strongly thinks that this type of certification systems can help to boost the integration of agrarian resources in the biomass market.**

Figure 15. (left) general certification label, (centre) certification label for specific biomass, (right) certification label for A/B classes

2.2. Recommendations when introducing a new fuel in the market

When new products want to be launched in the local market, a detailed study of their properties as fuels should be carried out. This is especially important when dealing with a non-usual product as biomass from agriculture resources is.

For this reason, SUCELLOG recommends two type of actions:

- Characterization from the thermochemical and physical point of view and comparison with limits recommended by International standards (EN ISO 17 225, see some in section 2.1.3). The measured parameters should be moisture and ash content, heating value, ash fusibility, elementary and major elements and physical properties (bulk density and durability for pellets) Characterization analysis offer therefore a "forecast" on how the fuel would behave and the results are normally provided to the possible customer as usual marketing procedure.
- Combustion tests in commercial boilers under controlled conditions in order to provide counsel to the agro-industry when looking for a potential consumer and to the consumer when feeding their system with the produced fuels. The aim of the combustion tests is to characterize the different biomass fuels under study in real combustion conditions.
  For these tests, it is highly recommended that the company who has installed the boiler or who is managing their performance (like an ESCO) is contacted to monitor the following parameters during the tests:

  - Energy delivered: heating output, combustion efficiency, ignition time
  - Atmospheric emissions: O_2, CO, C_xH_y, SO_2, NO_x, air excess and gas temperature. This point is highly important since emissions should be in compliance with national legislation.
  - Ash-related phenomena: slagging formation, ash-tray blocking and fouling in the heat exchanger.

It is important to take into account that atmospheric emissions and ash related phenomena such as slagging formation are highly dependent on the quality of the fuel, but also on the combustion technology (fixed, moving or underfed grate) and even on the boiler particular settings and regulation parameters. For this reason, it is essential to carry out adjustments on the settings (when possible) in order to improve the combustion performance.

During SUCELLOG project, and as part of the support carried out to the agro-industries willing to become logistic centres, some fuels produced from agriculture residues have been characterized and tested in combustion equipment. Comparison with forest-wood fuels (DIN+ and industrial wood pellets) have been carried out. Results on fuel characterisation are shown in **Table 13**. Main recommendations are shown in **Table 14** as some guideline on what can be expected of these fuels. However, it is important to highlight that the results obtained should not be directly extrapolated since factors like soil characteristics, harvesting procedure, etc. can influence fuel characteristics and, therefore, combustion behaviour. In the same way, as said before combustion recommendations cannot be taken as a rule but only as a guideline.

FUELS PRODUCED AND TESTED within SUCELLOG project

CORN COBS PELLETS

STRAW/WOOD PELLETS (60/40 %)

OLIVE TREE PRUNING CHIPS

CORN COBS GRITS

STRAW PELLETS

VINEYARD PRUNING CHIPS

Table 13. Fuel characterization-main parameters

FUEL	Element	Ash content [A]	LHV [Q]	Nitrogen [N]	Sulfur [S]	Chlorine [Cl]
	Method	EN 14775	EN 14918	EN 15104	EN 15289	EN 15289
	Unit	w-% db[1]	$MJ.kg^{-1}$ db	w-% db	w-% db	w-% db
CORN COB PELLETS		4,46	17,00	1,16	0,110	**0,160**
CORN COB GRITS		2,04	17,37	-	-	-
STRAW/WOOD PELLETS 60/40		3,16	17,86	0,35	0,032	0,072
STRAW PELLETS		4,78	17,53	0,40	0,067	0,120
OLIVE TREE PRUNING CHIPS		1,59	17,88	0,55	0,022	0,042
VINEYARD PRUNING CHIPS		3,53	17,11	0,88	0,040	0,044
INDUSTRIAL WOOD PELLETS		2,66	-	0,19	0,033	0,024
HIGH QUALITY WOOD PELLETS (DIN+)		0,24	-	< 0,1	< 0,010	< 0,010
WOOD CHIPS (ISO 17225-4 type B)		3,00	-	≤ 1,0	≤ 0,1	≤ 0,05

[1] w-% db : mass percentage of the material on dry Basis

Table 14. Recommendations on combustion performance

Fuel	Corn cob pellets	Corn cob grits	Straw/wood pellets	Straw pellets	Olive tree prunings	Vineyard prunings
O2 in flue gases Excess of Air (λ) (Wood pellets 11% - λ 1,9)	6% λ 1,6	11% λ 1,9	6% λ 1,6	6% λ 1,6	11% λ 1,9	11% λ 1,9
Boiler technology	Moving grate highly recommended to decrease considerable slagging formation			Moving grates (Fix bed boiler possible)		
Optimal distribution of secondary (SA) and primary air (PA)	80% PA 20% SA	90% PA 10% SA	80% PA 20% SA	80% PA 20% SA	70% PA 30% SA	70% PA 30% SA
Movement of the grate	1,8 cm/min				1,2 cm/min	
Maintenance recommendations	Daily cleaning in case of fix bed boiler 2 times higher compare to Wood pellets (Heat exchanger cleaning)				2 times higher compare to Wood pellets (Heat exchanger cleaning)	
Start-up process	50% Increasing of the start-up process				Same as wood pellets	
Compliance with NOx national limits	YES (on the limit) **(NOx : 750 mg/Nm^3)**	YES **(NOx : 750 mg/Nm^3)**	YES **(NOx : 525 mg/Nm3)**	YES **(NOx : 525 mg/Nm3)**	YES **(NOx : 500 mg/Nm3)**	NO **(NOx : 500 mg/Nm3)**
Compliance with CO national limits	YES **(CO : 450 mg/Nm^3)**	NO **(CO : 450 mg/Nm^3)**	NO **(CO : 250 mg/Nm3)**	NO **(CO : 250 mg/Nm3)**	NO **(CO : 350 mg/Nm3)**	NO **(CO : 350 mg/Nm3)**

2.3. Template for interviewing potential consumers on the quality requirements and demand

INTERVIEW TO POTENTIAL CONSUMERS

Describe the consumer demand (heat/electricity for municipality/farm/household…) _____

Situation of the consumer (distance to the logistic centre) _____

The energy consumption (thermal kWh or MWh) _____

Hours of consumption per year _____

When do you need the solid biomass (seasonality of the consumption)? _____

Is there a variation of the consumption during the day / the week ? _____

Type of boiler (grate, fluidized bed, etc) and output power (kW) _____

Which quantity of biomass do you consume (tons) per year _____

Which type of biomass (format and origin); example: 5000 tons/year of forest wood pellets? _____

Can your boiler accept other type of solid biomass? _____

Did you already did some tests with these other types of biomass? _____

Where do you buy the biomass? Do you have a regular provider? _____

Do they bring it to your facility by truck? _____

How much are you paying currently (€/t, €/MWh)? _____

Which price is the maximum you could pay (€/t, €/MWh)? _____

Which type of contract do you have with your biomass supplier? _____

Months/Year of duration? _____

Which is the main characteristic you ask for in the biofuel you buy (not to have a lot of ashes, not to have chlorine, be able to work at high temperatures, etc.) _____

Do you ask for any quality label when you buy the (example: "I only buy ENplus products") _____

Which quality do you need for your boiler?

- Maximum ash content (%) _____
- Maximum moisture content (% wet base) _____
- Particle size in case of chips _____
- Others: _____

How often do you open and clean your boiler? Do you have an automatic discharge of ashes? _____

What are you doing with the ash? Do you need specific quality to use it? _____

Do you have a specific person managing the boiler inside the company? _____

Somebody outside the company? _____

Do you have any experience with agro-fuels? Please describe the fuel, the price and possible problems if any

_____

Are you likely to consume agrofuel products? _____

Under which conditions? _____

Would you install a special boiler for agro-fuels in case the fuel price is much reduced compared to your regular fuel? _____

Figure 16. Template for the evaluation of the market- interview to a solid biomass consumer

2.4. List of combustion equipment for agrarian solid biomass

Here below, some of the equipment available in the market for combustion of solid biomass coming from agricultural resources are listed, in alphabetic order. The tables present the quality characteristics of the solid biofuel that the manufacturer demands (moisture content expressed in wet basis, w-% ar; ash content expressed in dry basis, w-% bd) as to ensure a correct performance of the equipment. The use of fuels with different properties can cause the loss of guarantee.

Nevertheless**, whenever a potential consumer is interested in acquiring a combustion system, SUCELLOG highly recommends the consumer to contact the manufacturer in order to test the exact type of solid fuel to be used in long tests (1 week minimum) in order to evaluate possible problems in the performance**.

Binder		www.binder-gmbh.at					
	Heat exchanger:	Hot water; Saturated steam; Air-to-air Heat exchanger					
	Combustion systems:	Max. moist. content	Max. ash content	Pellet	Chips	Bales	Availability
	Underfed Hearth RRF	30 %	1,5 %	✔	✔	X	100-5.000 kW
	Moving grate PSRF	15 %	7 %	✔	X	X	>150 kW
	Moving grate TSRF	30 %	7 %	✔	✔	X	>150 kW
	Moving grate SRF	60 %	7 %	✔	✔	X	>150 kW

COMPTE.R		www.compte-r.com					
	Heat exchanger:	Hot water; Saturated steam; Air-to-air Heat exchanger; Thermal fluid					
	Combustion systems:	Max. moist. content	Max. ash content	Pellet	Chips	Bales	Availability
	GRANUL'ECO	-	-	✔	X	X	600-1.000 kW
	Pelletech	35 %	-	✔	X	X	150-500 kW
	Customised design	-	-	✔	✔	✔	-

GUNTAMATIC		www.guntamatic.com					
	Boiler:	Hot water					
	Combustion systems:	Max. moist. content	Max. ash content	Pellet	Chips	Bales	Availability
	POWERCORN; Industrial plant	20 %	-	✔	✔	X	20-1000 kW

HARGASSNER		www.hargassner.at					
	Boiler:	Hot water					
	Combustion systems:	Max. moist. content	Max. ash content	Pellet	Chips	Bales	Availability
	AgroFire	-	-	✔	✔	X	25-40 kW

KBW	www.kwb.at					
	Boiler:	Hot water				
	Combustion systems:	Max. moist. content	Max. ash content	Pellet	Chips	Bales	Availability
	Multifire Pelletfire Plus	40 %	-	✔	✔	X	20-120 kW

LIN-KA	www.linka.dk					
	Boiler:	Hot water; steam				
	Combustion systems:	Max. moist. content	Max. ash content	Pellet	Chips	Bales	Availability
	Shredded straw boiler	15 %	5 %	X	X	✔	200-1500 kW

REKA	www.reka.com					
	Boiler:	Hot water				
	Combustion systems:	Max. moist. content	Max. ash content	Pellet	Chips	Bales	Availability
	Moving grate HKRST	30 %	-	✔	✔	X	20-3500 kW
	Refractor grate HKRSV	50 %	-	✔	✔	X	20-3500 kW
	Manual boiler HK	-	-	X	X	✔	22-125 kW

TWIN HEAT	www.twinheatuk.com					
	Boiler:	Hot water				
	Combustion systems:	Max. moist. content	Max. ash content	Pellet	Chips	Bales	Availability
	Water-cooled burner CS	15 %	-	✔	✔	X	90 kW

2.5. Guidelines for contracting solid biomass supply

This section presents a concise guide for consumers interested in underwriting a contract with a supplier of solid biomass products. The recommendations could be also useful for agreements between the raw material supplier and the solid biomass production plant.

The present guidelines includes some essential terms and contractual clauses for a valid definition of the agreement; besides it identifies other appropriate elements, whose inclusion can be useful for a more detailed definition and regulation of the relationship. The Guidelines aim to specify the clauses to be provided in the

agreement, in order that not only the relationship between the parties is valid and in force, but the mutual obligations of the parties are certain.

In fact, a clear identification of the rights and the duties of the parties can be very useful to prevent disputes between them or, at least, to reach a rapid settlement of the possible disputes. In particular:

- the first part of the Guidelines contains the essential elements and clauses of the agreements; and
- the second part contains the clauses which may be included or not in the agreement, depending on the specific requirements.

ESSENTIAL ELEMENTS AND CLAUSES

Written form

Even when it is not specifically required from the law, it is strongly recommended to adopt the written form of the agreement in order to give certainty to the relationship.

Individuation of the signatory parties

In the first part of the agreement the detailed identification of the parties, buyer and supplier, has to be correctly indicated; if the party is a company, the following information must be indicated:

- Company's name;
- VAT/tax identification number or other identification code;
- name of Registrar's office where the company is enrolled;
- registered office;
- legal representative.

Determination of the object

It is very important to correctly define the object of the agreement, i.e. to individuate the required services in a detailed form.

Consequently, the agreement will indicate the required product, the quantity and the quality of the supply, or, for some characteristic of the product, the range of values agreed by the parties (in this case, please note that the agreement will usually provide a variable price).

If the agreement provides the supplier's obligation to supply the products "on demand" of the buyer (without any buyer's obligation to purchase a minimum quantity of products), it can be advisable to consider the right of the buyer to be preferred (i.e. to consider that his orders have the priority upon orders of other buyers), in order to guarantee the respect of the delivery's deadline.

The determination of the technical specifications/product quality

The contract must also indicate the specific technical characteristics and the quality of the products and bind the supplier to strictly comply with them. Moreover, the agreement will ensure the obligation for the supplier to respect the current regulations, keeping in particular consideration the origin of the products and the production chain.

The determination of the mode of delivery

The agreement should define terms and conditions of the delivery. It is important to specify:

- the manner to make purchase orders. It is strongly recommended to provide purchase orders in writing and a written confirmation of their receipt;
- if the delivery is a supplier's responsibility;
- delivery location of the product, frequencies and times.

The determination of product's quality and procedures for quantity and quality check

In order to check the quality of the product, it is important to define how to verify the compliance of the product with the agreed quality specifications; moreover, systems for weighting or otherwise gauging the amount of product delivered will also need to be agreed.

Finally, the agreement will define the ways to solve disputes in case of failures in quality or quantity of the product supplied.

The determination of the obligations of the Parties

The agreement should list in detail the obligations of the parties.

The main obligation of the supplier will be to supply products with the quantities and the quality specified in the agreement, according to the manner and the timing agreed. It should be specified the quality requirements: moisture content and/or calorific value, particle size distribution and ash content.

The main obligation of the buyer will be to send the orders according to the procedures agreed and to pay for the supply according to the agreed schedule.

Pricing and price adjustment method

The determination of the price of the supply is an essential element of the agreement. The agreement can contain the exact determination of the price or set out the criteria for the exact determination of the price.

In long-term contracts, the parts usually agreed on a price adjustment mechanism (e.g. based on an existing index).

Mode and scheduling of invoicing and payment

The agreement should specify the tax documents related to the supplies that the supplier has to deliver to the buyer. It also should define the mode and scheduling of invoicing and payment of the supplies.

The determination of agreement duration

This clause is very important, because it sets when the agreement becomes effective and its duration and, therefore, shall determine the period of time at which the parties are bound by the contractual obligations.

Termination of the agreement

It is advisable the agreement provides the circumstances - such as serious breaches of the contract - which allow each of the parties to cause the early termination of the agreement.

Signing of the agreement

Finally, remember that it is always necessary that the agreement is signed below and initialled on each page and in any attachment.

OTHER CLAUSES

Exclusive rights

The agreement can set that the supply relationship is exclusive. The exclusive rights can be unilateral, in case the agreement binds one of the parties, or mutual, in case the agreement binds both parties.

Usually the exclusive rights guarantee results, delivery times and lower prices on the supply of the product; in this case the agreement will usually provide for a minimum quantity purchase. The geographical area where the exclusive rights are applied should be well located, considering the presence of possible, present or future, competitors.

The breach of the exclusive rights is usually a cause for the earlier termination of the contract.

The penalty clause

With the introduction of this clause, the parties want to strengthen the compliance of the main obligations of the agreement - such as the obligation to respect the exclusive rights, to deliver the products in time, to supply products with the agreed quality - and to regulate the consequences of the breach, agreeing a preventive and conventional assessment of damages.

It is necessary that the penalty is not excessive, considering the value of the agreement and the caused damages. In any case, it is advisable to preserve the opportunity to claim compensation for additional damages.

Force majeure

With this clause the parties regulate the consequences of the occurrence of force majeure events (e.g. major natural events, strikes, wars, etc.) that prevent, entirely or partially, to fulfil the obligations agreed.

The clause is intended to limit the damaging effects of the occurrence of such events, committing both parties to find a solution to avoid or minimize loss, or giving the opportunity to the damaged party to cease the agreement or to reduce its own obligations.

Prohibition of agreement assignment

This clause intends to prevent that one of the parties, without the prior approval of the other party, may assign the agreement to a third party. This provision is particularly important when there is a relationship of confidence between the parties (“intuitus personae”).

Resolution of disputes

The agreement should include a dispute resolution process, which should cover all aspects of the agreement performance, setting out what actions are deemed as a “breach of contact” and the termination process.

The agreement may also regulate the modality of resolution of disputes. It can provide, for example, an attempt at amicable settlement before resorting to the judicial authorities. Moreover, the agreement can identify a competent court to decide on disputes or provide for a resolution of disputes by an arbitration board.

Early withdrawal

This clause is intended to regulate the right of either party to terminate the agreement before the natural termination. This clause is certainly necessary in case of open-ended agreement and may be advisable for the long-term agreements.

The clause should indicate the modality in which it can be exercised withdrawal (usually with a written advance notice).

General clauses

The agreement may provide general clauses that are intended to regulate different aspects of the relationship, such as:

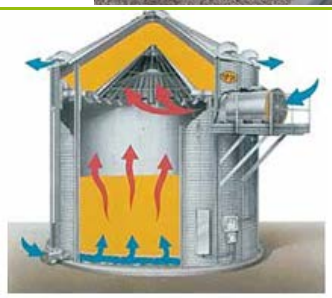
- how to modify the agreement. It is appropriate to provide that any change is made in writing and must be agreed between the parties.
- how to make communications concerning the supply relationship. It is appropriate to provide means of communication that guarantee both certainty and speed.

3. Assessment of the production facility

This section has been especially designed for agro-industries willing to become logistics centres. SUCELLOG assess in the first part of the project the agro-industries present in Spain, France, Italy and Austria in order to evaluate the compatibility of the equipment to be used in the production of solid biomass.

Although more detailed information can be found in Handbook on how to carry out a feasibility study on how to become a logistic centre, according to the study carried out in SUCELLOG project, **the most sensitive parts of the facility when feeding a different raw material are the drier and the pelletiser.** The Table 15 presents the compatibility of the most common marketed driers with different formats of the raw material. Concerning the pelletiser, the production can be highly affected by a different raw material, requiring the change of dies and adaptation of the operation.

Table 15. Basic drier types commercially available and compatibility with resource format

		Granulated (pits/shells)	Chips	Herbaceous
Horizontal – Rotary		✔	✔	✔
Horizontal – Belt		✔	✔	X
Vertical – Silo	  http://www.scolarisrl.com	✔	To be tested	X

This section presents firstly a list of prices for equipment in case investment is needed. Secondly, some values for the estimation of production and maintenance costs coming from other European projects are gathered. The section ends with a check-list to evaluate the biomass production facility in terms of possible fire and environmental risks.

3.1. Equipment prices

Table 16 provides prices related to the main components of a facility producing solid biomass. They should be taken only as a reference. **SUCELLOG encourages to contact local machinery manufacturers in order to gather more detailed information**. Prices only correspond to the product and do not include indirect costs (like automation, electricity and mounting).

Table 16. Equipment prices

Equipment	Capacity	€ (no TAX included)
Pelletising line (including drier, mill, pelletiser and cooler)	Between 0,3 t/h to 1 t/h	400.000 €
	From 3t/h to 5 t/h	900.000 €
Rotatory drier	0,1 t evaporated water capacity . . . . . (=300 kg/h dry raw material) (burner not included)	100.000 €
	1,3 t evaporated water capacity . . . . . (=5 t/h dry raw material) (burner not included)	300.000 €
Belt drier	1,3 t evaporated water capacity . . . . . (=5 t/h dry raw material) (burner not included)	470.000 €
Mixer	Capacity : 0,3 m^3 – 1 t/h of blend	20.000 €
	Capacity : 1 m^3 – 5 t/h of blend	50.000 €
Mill + Pelletiser	0,3 t/h	
	Pelletiser	50.000 €
	Mill	20.000 €
	5 t/h	
	Pelletiser	150.000 €
	Mill	60.000 €
Cooler	1 t/h of pellets	20.000 €
	5 t/h of pellets	40.000 €
Tube grinder	6 t/h	117.000 €
Burner for the drier	Hot air burner for rotatory drier : 2 MW	150.000 €
	Hot water boiler for belt drier : 2 MW	270.000 €

3.2. Guidelines on production and maintenance costs

The solid biomass production costs depends on the type of facility processing the raw material and of the type of raw material, e.g. the cost of generating a wood pellet is not the same as the one from the straw pellet. The same happen for the maintenance costs. **The producer of biomass should, therefore, assess carefully the own related costs.**

The European project MixBioPels (https://www.dbfz.de/index.php?id=872&L=0) evaluated the production costs in €/MWh for different agrarian solid biomass in pellet or briquette format. The results can be observed

in Figure 17. **Fuel costs including costs of pelletizing and briquetting in €/MWh as well as fluctuations of wood and fossil fuel prices**They include the cost of purchasing the raw material and the costs for harvesting, transport (up to 50 km), drying and pelletizing/briquetting. Costs vary from 18 to 56 €/MWh, depending on the used raw material and the processing plant.

According to the study carried out by MixBioPells, **the costs for pelletizing and briquetting can represent 11-32 % of the total fuel costs**. **The project highlights that the optimal operation of the production plant, especially with regard to the production of mixed raw material pellets, is a large cost advantage.**

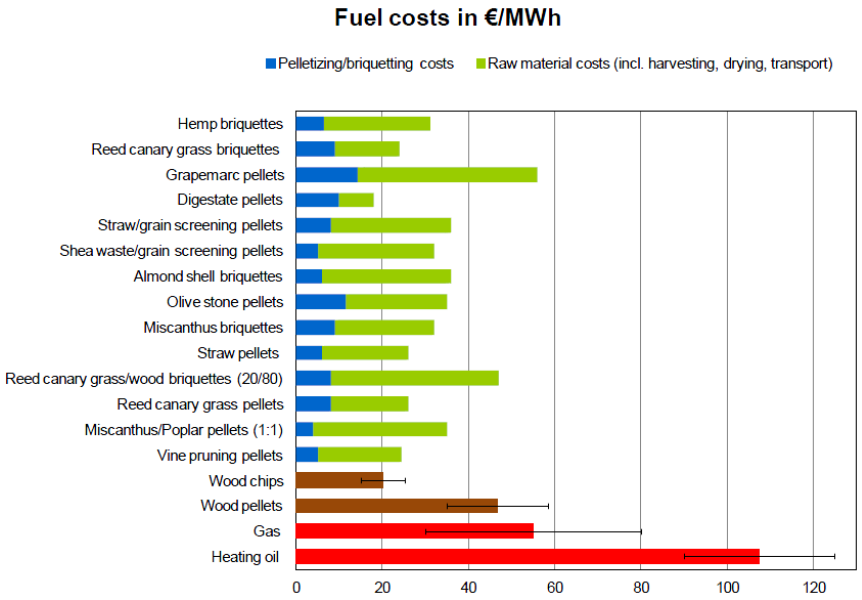


Figure 17. Fuel costs including costs of pelletizing and briquetting in €/MWh as well as fluctuations of wood and fossil fuel prices (MixBioPells project)

Regarding maintenance costs, the Biomass Trade Centres project (http://www.biomasstradecentre2.eu/) web page offers the user a Financial calculation excel sheet with useful values proposed in the VDI 2067 German normative. The maintenance percentages on the investment costs from this project are shown in Table 17.

Table 17. Maintenance percentages, VDI 2067 (Biomass Trade Centres project)

Concept	Maintenance percentage of investment
Storage building	1,0 %
Paved storage area	1,0 %
Office container	1,0 %
External facilities	1,0 %
Site development costs	1,0 %
Weighbridge	2,0%
Fuel feeding systems	3,0 %
Drying fans	3,0 %
Screening unit	3,0 %
Wood splitter	1,0 %
Vehicles	3,0 %

Additionally, the S2Biom project (http://s2biom.alterra.wur.nl/) contains a complete list of logistic components at every stage of biomass production chain. It offers a wide range of description and data for every entry (Table 18).

Table 18. Biomass chain data on operation and maintenance (O&M) costs of the different logistical components (S2Biom project)

Main Stage	Specific Activity	O&M cost [€/t]
Harvesting	Baling	2,90 - 14,50
	Field hauling	3,00 – 3,50
Feedstock handling	Telehandler	0,68 - 0,93
	Crane	7,20 – 8,00
	Front loader	1,80 -2,00
Drying	Belt drier	1
	Heater	1
	Rotary drum	1
Pelletizing	Large (4.5 ton/h)	50
	Medium (1.4 ton/h)	57
	Small (0.4 ton/h)	68
Size reduction	Drum chipper	7,75 - 15,16 [€/m^3]
	Disk chipper	6,72 - 13,48 [€/m^3]
	Screw chipper	13,44 [€/m^3]
	Chunking	1,95 [€/m^3]

3.3. Check list for the assessment of risks when producing solid biomass

Transforming an agro-industry into a seasonal agro-industry biomass logistic centre involves the use of new organic bulk materials in their facilities. The handling and storage of biomass generates two main risks for work security: fire risk and environment soundness.

This section provides a general overview of risk prevention, paying special attention to the biomass storage. Table 19 has been elaborated as a check-list to be used by the responsible of risks in the facility when assessing the risks. It is based on European regulation and it does not constitute an internal audit or regulatory overview. Local and national regulations should be consulted to comply with them.

The main fire cause on a biomass storage place is the introduction of an exogenous ignition source in the form of:

- Flame (hot work);
- Hot element (lighting falling, cigarettes);
- Incandescence particles from an handling equipment;
- Electric shock (lightning, static electricity).

The main environmental impacts caused by biomass storage place in normal conditions are:

- Sound of processing equipment ;
- Contamination of pluvial water on the water collection network by exogenous contaminants ;
- Dust emission from biomass (diffuse, channelled release)

The main social impacts caused by biomass storage place in normal conditions are:

- Workplace accident (fall, handling) ;
- Fire risk ;
- Professional injury or disease ;

In order to reduce the occurrence risk of such an event, the preventive and protective measures, presented in the table below, must be implement at the storage facilities level, including related handling facilities.

Table 19. Preventive and protection measures check-list

FIRE RISK		
Preventive measures	**Compliant/ Noncompliant**	**Comments**
Storage biomass building's structure		
Implementation of a technical study attesting that a local damage / fire (wall, roof, beams, poles) does not cause a global damage chain in the entire building structure.		
Storage places buildings presented reaction and fire resistance features. Minimal ones are : - External walls must be made with adapted components - The entire structure has to have a minimum fire resistance of 15 min - Separating walls between to storage cells and between a storage cell and a technical room has a minimum fire resistance of 2 hours.		
Periodic check and equipment maintenance		
Maintenance of electric installation for storage place building : - Metallic equipment with bare bonding conductor Protection against shock, against flame spread, for electric cables and other pipelines - At least one exit equipped with a central power switch, clearly signalled, able to cut the building general power supply.		
Safety and existing firefighting devices maintenance (e.g. smoke evacuation facilities, detection and extinguishing systems, fire doors, dry risers).		
Site lighting study		
Exploitation		
Smoking ban on site		
Ban of outside burning on site		
Prohibition of bringing fire, in any form, near the storage place.		
Display of instructions and proceedings (emergency stop and equipment safety request, warning)		
Storage building monitoring, by guards or remote surveillance, for alert transmission to fire department and emergency services and their reception on site		
Works		
Specific care for hot working in the building		
Equipment checking 2 hours after works-end and before activity upturn		
Building cleanliness		
Regular cleaning of the building		
Risks-adjusted cleaning equipment		
Storage biomass residence-time limited		

Protective measures	Compliant/ Noncompliant	Comments
Existence of a smoke extraction system		
In the higher parts, the building is equipped with smokes and heat natural evacuation facilities.		
Manual control of these evacuation facilities is installed, at minimum, in two opposite points of the building, near the exits.		
Presence of a fire detection system		
At all time, automatic fire detection with transmission from the alarm to the operator is compulsory for cells, technical installations and offices placed near storage places.		
This detection activates an audible at any building's points alarm		
Measures of intervention	**Compliant/ Noncompliant**	**Comments**
Extinguished distributed on the entire site		
Fire hydrant supplying by private or public water network (minimum flow of 120 m^3/h during 2 hours), closer than 100 m from the storage place.		
Water reserves on site		
Presence of fire extinction water retention pound		
Evacuation plan		
SOCIAL AND ENVIRONMENTAL SOUNDNESS		
Environmental measures	**Compliant/ Noncompliant**	**Comments**
Dust emission		
Limitation of temporary outside storage		
Protective canopy for loading and unloading stage or central vacuum cleaner if needed (if needed)		
Dust removal systems		
Cleaning log		
Noise		
Noise study (if the site is place near housing estate)		
Water contamination		
Prevent waste water contamination on site due to truck traffic (sludge traps, oil separator for pluvial water network)		
Safety measures	**Compliant/ Noncompliant**	**Comments**
Communication and information panels (general safety instructions are stated and displayed)		
Employees are trained to fire-fighting equipment use		
Appropriate personal protection Equipment (PPE) available for each employee (work clothes, dust masks, protective gloves) especially when handling the material		
All gateways are equipped with guardrail		
Works-at-height are performed with a preventive plan		
Silos are equipped with adequate evacuation facilities (emergency pathways and exits)		

Employees are able to face emergency situation and warn the emergency services. Safety instructions are stated		

Specific European directives detailing the above recommendations should be consulted:

- DIRECTIVE 2012/18/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC
- DIRECTIVE 94/9/EC OF THE EUROPEAN PARLIAMENT AND THE COUNCIL of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres
- DIRECTIVE 2006/11/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community

4. Assessment of the environmental sustainability of the new project

The assessment of sustainable aspects of the project are as important as the techno-economic ones.

Although the Renewable Energy directive 2009/28/EC sets binding sustainability criteria for biofuels and bioliquids, but so far not sustainability criteria is compulsory for solid and gaseous biomass, the communication from the European Commission, COM/2010/11 (non-binding), highly recommends the following:

- Art.17, part 2. Minimum reduction of the greenhouse gases emissions will be 35 %.
- Art.17, part 1. Residues and wastes must fulfil only the minimum GHG emissions, but not the rest stablished criteria.
- Art.17, parts 3,4,5. Raw material from high-value biodiversity origins, from high-carbon reservoir lands or from non-drained peat fields is not recommended.
- Art.17, part 6. Raw agricultural material grown in the European Community must be processed in conformity of requirements and regulations on EU agricultural field.
- Art.18, part 1. It is compulsory to economic agents to demonstrate the fulfilments of the criteria and method used related to mass balance and custody chain.

The following sub-sections present, first, a tool to calculate the GHG emissions from the new business line and the savings compared to fossil fuels, and second the European emissions limits to be accomplished by combustion facilities working with biomass.

4.1. Evaluation of GHG emissions savings

Many tools are available on the web to evaluate the amount of GHG emissions savings due to the use of solid biomass. The European project Biograce II (http://www.biograce.net/) aims at harmonising the calculations methods for GHG emissions. The project has elaborated a tool, approved by the European Commission and available on the web with free downloadable Excel format.

Biograce II approach takes into account not only the conversion of the solid biomass when accounting for the savings but also the whole logistics chain of the raw material. Therefore, the tool considers harvesting and transport of the raw material, pre-treatment to reach the final product, transport of the product and final conversion. The list of the available solid biomass for the evaluation are displayed on Figure 18.

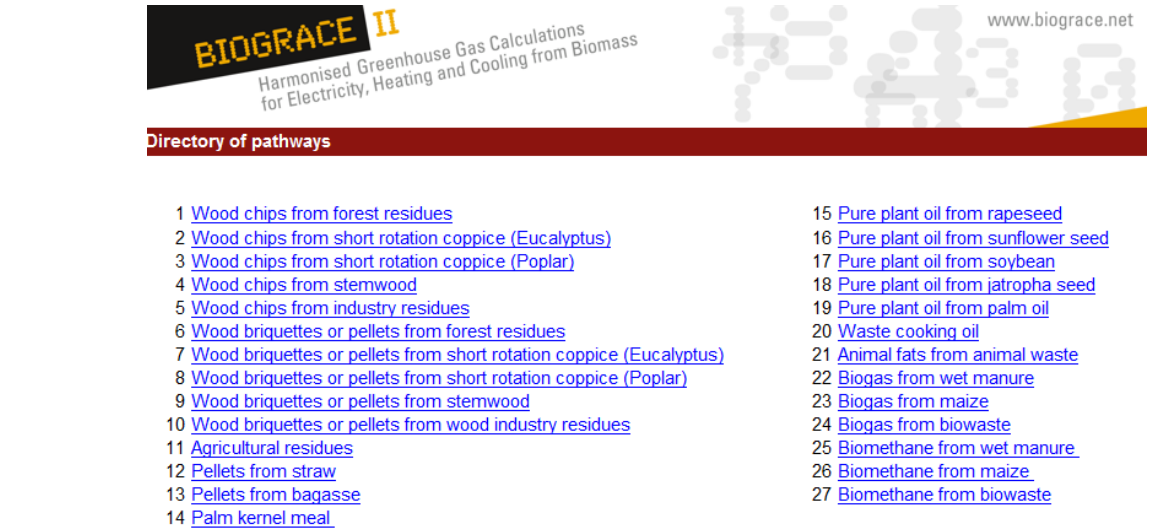


Figure 18. Directory of the solid biomass to be evaluated through the tool (Biograce II project)

Multiple settings must be indicated for each particular case (standard values are also available):

- General settings: main output (heat/power), conversion efficiencies and/or temperature of useful heat)
- Baling of herbaceous resources or harvesting for others: moisture, energy consumption during harvesting
- Transport of raw material: type of transport, distance
- Drying: energy consumption
- Pellet/chip production: moisture, energy consumption during pelletising/chipping
- Transport of pellets/bales/chips/others: moisture, transport chain and distances
- Final conversions: type of end of conversion (e.g. Boiler) and emissions
- CO_2 capture and storage options

Figure 19 shows the results obtained in a case where the use of straw pellets for heat and power generation was evaluated.

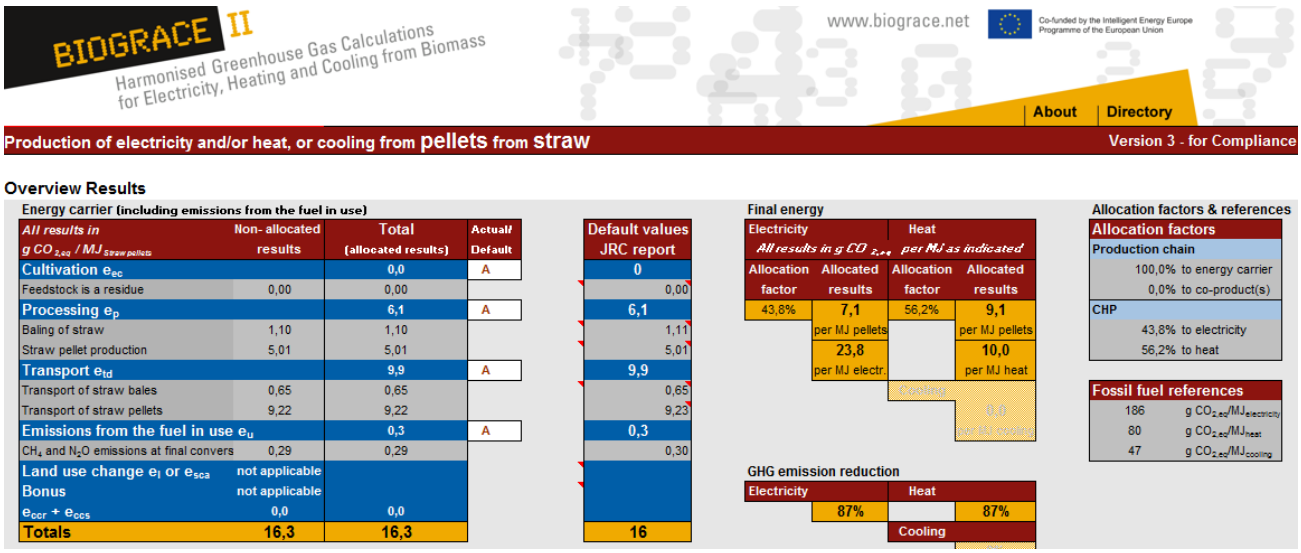


Figure 19. Results of an example for straw pellets:
87 % in GHG emissions reduction for both heating and power applications (Biograce II project)

4.2. Emissions limits for the combustion of solid biomass

The combustion of biomass produces apart from CO_2 emissions of Particulate Matter (PM), Sulphur Oxides (SOx), Nitrogen Oxides (NOx), Carbon Monoxide (CO) and Volatile Organic Compounds (VOC). The quantity and type of each emission depend on the type of fuel used as well as on the boiler configuration and its operation performance.

In order to regulate these emissions, the European Union has elaborated along the years a series of directives that has been transposed to national level. Countries or regions can additionally set more restrictive limits. The European regulations currently in force are:

- Directive 2010/75/EU for large scale facilities (> 50 MW_t), which sets the following emissions limits in already existing plants:

Table 20. Emissions limits for >50 $MW_{thermal}$ plants

Thermal output power (MW_t)	PM (mg/Nm^3)	SO_2 (mg/Nm^3)	NOx (mg/Nm^3)
50-100	30	200	300
100-300	20		250
> 300	20		200

- For facilities from 1 to 50 MW_t no limitations are currently in force at European level although countries can have their own restrictions. The Clean Air Policy Package sets for already existing plants emissions levels to be accomplished before 2030:

Table 21. Emissions limits for 1-50 $MW_{thermal}$ facilities

Thermal output power (MWt)	PM (mg/Nm3)	SO2 (mg/Nm^3)	NOx (mg/Nm^3)
1-5	50	200 300 (straw based)	650
5-20			
20-50	30		

- The Commission Regulation (EU) 2015/1185 for biomass stoves and the Commission Regulation (EU) 2015/1189 for biomass boilers will entry in force in 2020. They set the emissions limits for small power facilities (< 500 kW_t) working with woody biomass (either agrarian or forestry). Non-woody biomass boilers are exempted. The limits are:

Table 22. Emissions limits for < 500 $kW_{thermal}$ facilities

Feeding	Particles	CO	VOC	NOx
	mg/Nm^3 at 10 % O_2			
Manual	60	700	30	200
Automatic	40	500	20	