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

SUCELLOG: IEE/13/638/SI2.675535

D4.3c
Summary of the current situation of Società Cooperativa Le Rene and feasibility study

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About 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 biofuels 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.

Project coordinator

Project partners

About this document

This report corresponds to D4.3c of the SUCELLOG project - Summary of the current situation of Tschiggerl Agrar GmbH and feasibility study. It has been prepared by:

WIP-Renewable Energies
Sylvensteinstr. 2
Cosette Khawaja, Rainer Janssen
E-mail: cosette.khawaja@wip-munich.de, rainer.janssen@wip-munich.de
Tel: +49 89 720 12 740, +49 89 720 12 743

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1. Introduction

This report includes a description of the current situation of the agro-industrial cooperative Società Cooperativa Agricola Le Rene s.r.l. and an assessment of the techno-economic feasibility to become a logistic centre in addition to its usual activities. As part of other tasks (Task 4.2, 4.3, 4.4, 4.5) in the project, data has been gathered by the partner DREAM through interviews with the cooperative director and other stakeholders. This information constitutes the basis for this report. The aim of the feasibility study is to investigate whether the use of agricultural biomass residues in the region for bioenergy production in Le Rene - acting as a logistic centre - would be feasible and, most importantly, sustainable.

2. Cooperative description

Le Rene was founded in 1973 as a cooperative that gathers several farmers of the area between the cities of Pisa, Livorno and Lucca. The cooperative is located in the North of Tuscany in Italy, Via Palazzi 40 - 56121 Coltano Pisa (Figure 1).

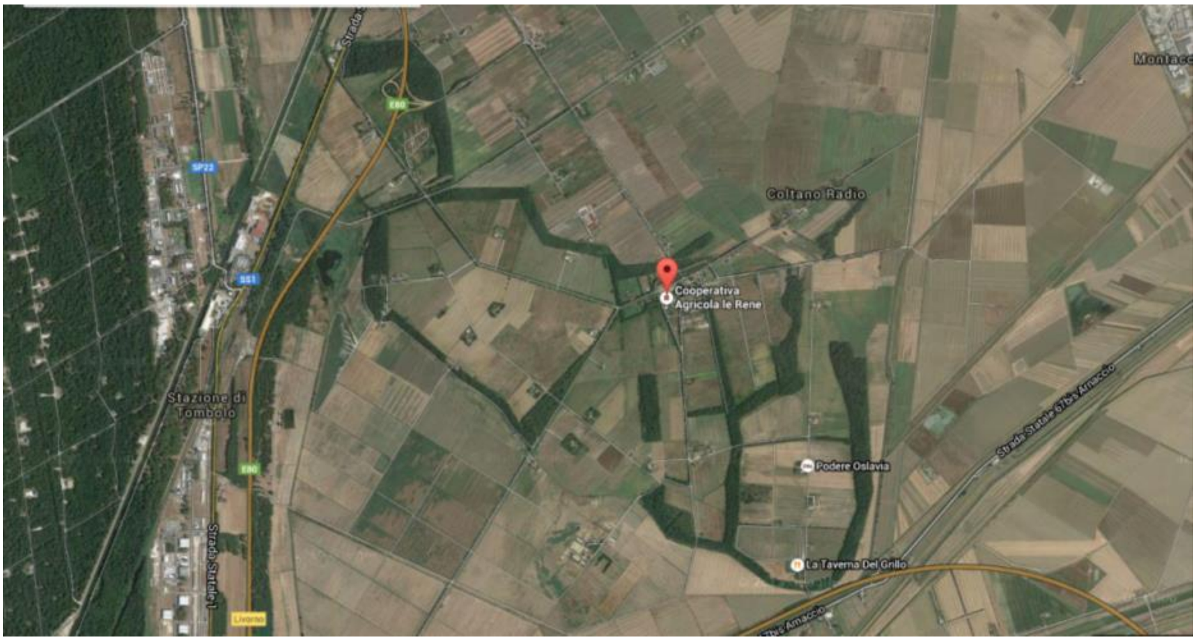


Figure 1: Location of Le Rene cooperative (Source: Google maps).

With time, the cooperative has increased its activities, building two different plants (Coltano and Caligi, 4.7 km from each other) and buying fields for cultivation.

The current main activities of the cooperative particularly in Caligi plant, where the new business line as logistic centre is planned to be developed, are the following:

a. Sunflower harvesting, treatment and trading.
b. Cereal drying (maize and rarely wheat)
c. Pine nuts production
d. Olive oil production

3. Development of a new business line as an agro-industry logistic centre

Le Rene cooperative is interested in starting an activity as a biomass logistic centre. For this new business line, the cooperative would like to explore the possible synergies between its plant and the agricultural raw materials in the area (industrial residues from its own activity, olive pomace, corn cobs and agro-prunings) with three main purposes:

- To become a consumer of their own biomass for the drying processes with the aim of increasing the added value of its maize or sunflower production.
- To produce good quality olive pits from the olive pomace supplied by the oil industries in the area.
- To produce corn cob grits to be sold in the area.
- To produce good quality "agro-chips" and/or hogfuel from prunings with a competitive price, since in the last years the cooperative received several requests in this sense from possible consumers.

4. Biomass resources availability

In task 4.2 of the SUCELLOG project, a biomass procurement and competitiveness assessment has been performed for an area of 30 km around the cooperative location. The assessment showed that a considerable amount of agricultural residues (with no market competition or sustainability requirements) are available for the production of solid biomass as shown in Figure 2.

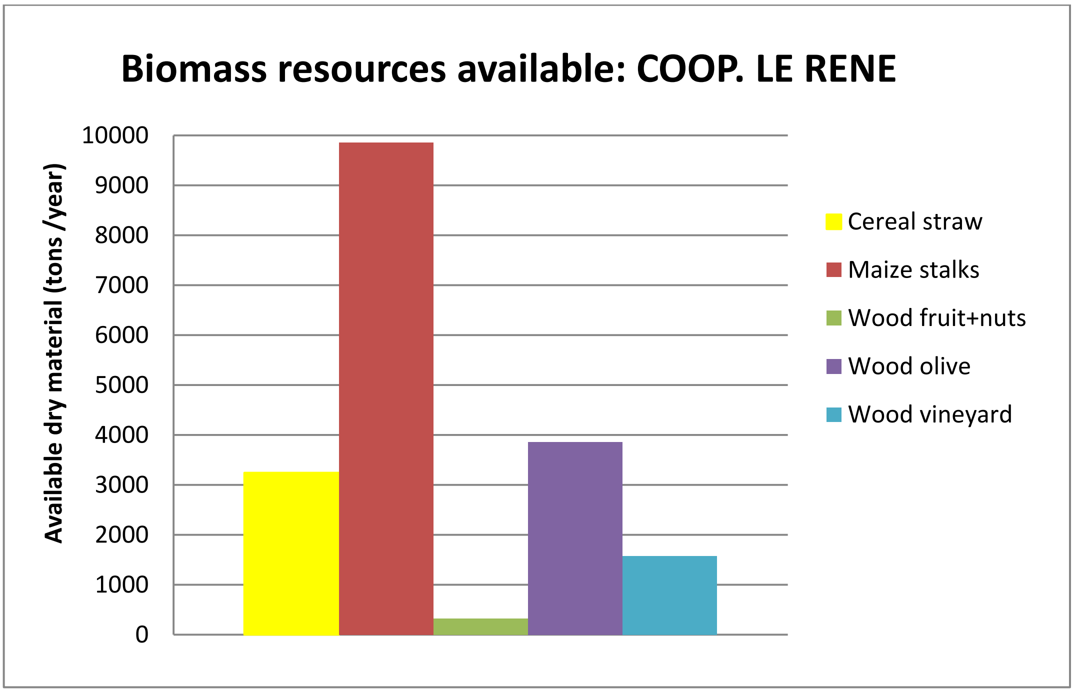


Figure 2: Amount and type of resources available in a 30 km radio.

From the analysis of the figure and the interviews held with the stakeholders, it can be concluded that:

- Maize stalk, which is abundant in the region, is considered an undesired raw material by La Rene and would not be taken into account for the production of solid biomass. The reason is the high amount of sand and stones that it contains, due to the fact that it is harvested in September-November during the rainy season.
  However, the cobs which are usually left on the soil together with the stalks, can be considered as raw material for the logistic centre. The amount in the area would be around 3,500 t/yr. In order to harvest the corn cobs, the regular machinery used for harvesting the corn grain should be adapted (approximate cost of 15,000 €). COAGRI, the cooperative of farmers which is a member of La Rene, would be interested in the adaptation to separate the corn cobs from the grain during the harvesting process.
- The cereal straw is usually sold for animal feed and bedding. Although the quantity available is high, it would not be considered as a feedstock from the beginning due to its high price.
- Regarding agricultural prunings, as it can be seen in the Figure, there is a significant amount that could be used in the logistic centre. However, currently there are no initiatives which promote the harvesting of prunings in large scale in the area. The usual practice is to burn them or to shred them and leave them on the soil. Farmers would be interested in selling the product to a logistic operator that brings his own machinery for harvesting. It is believed that a good quality product can be produced from this raw material and for this reason in this study, the olive tree prunings will be assessed in case a logistics chain is developed in the near future.
  Additionally, it should be highlighted that "Biomass Producers Organisation" of whom, Le Rene is a member of, collects mixed prunings (from different species) from their associates and the people in the area (for 1 €/t), that otherwise would have to pay for their disposal. Currently, this organisation chips this material and sells it as hog fuel of low quality. The cooperative would assess the possibility of upgrading the quality of this material to be able to offer good quality chips from prunings for heat production at a higher price.
- Olive pomace, which is not included in Figure 2, would be considered as a raw material for the logistic centre and would be purchased from the oil mills in the region. The plan of Le Rene would be to purchase the equipment needed to centrifuge the by-product from the olive oil production (the pomace with pits) to obtain olive pits that could be sold in the Toscana market. The separated pomace would be sold for biogas production at 10 €/t.

Therefore, the agricultural residues available for the production of solid biomass are olive pomace, corn cobs, mixed agro-prunings and olive tree prunings. The available yearly quantities, moisture content (weight percentage, as received), months of production and purchasing price without transport are shown in Table 1.

Table 1: Data on the available agricultural residues in a 30 km distance.

Type of residue	Quantity available t/yr	Moisture content w-%, ar	Months of harvest	Purchasing price €/t, VAT excluded	Transportation cost €/t, VAT excluded
Olive pomace	1,500	60	Oct-Nov	15	10
Corn cobs	3,500	35	Sept-Nov	40	10
Mixed agro-prunings	2,500	50	All the year	1	0
Olive prunings	1,900	50	Feb-April	20	10

Since inside Caligi plant, Le Rene rents some yards to a member of the Biomass Producers Organization who produces also wood chips from forest resources, the agro-industry would also like to explore the possibility of mixing them with the ones generated from prunings in order to upgrade the quality of the latter. Forest wood chips can be purchased at 50 €/t (fine chips) and 40 €/t (coarse chips) including transportation (VAT excluded) at 40 % moisture content for both.

5. Bioenergy market potential

In task 4.3 of the SUCELLOG project, an assessment of the bioenergy market has been conducted.

The consumption of solid biomass in the region of the cooperative is mainly seasonal from October to April. Even though the consumption is increasing, it is strictly dependant on the price of petrol. Currently many people, who were using biomass in the past, are using petrol again due to the decrease in the price.

Regarding the type of biomass consumed in the area, it should be said that:

- Households are the main consumers of pellets and olive pits. Pellets are bought in big distribution chains or supermarkets but also in small shops. It should be highlighted that in Italy it is very difficult to sell non-certified solid biomass (DINplus or ENplus). Using non-certified pellets in a boiler may cause the loss of the boiler guarantee. For Italian consumers, dark colour of pellets is associated to bad quality.
- Medium to large consumers (industries, district heating plants, greenhouses) use forest wood chips which are transported to their sites by trucks. They generally request a good quality chip with a standardised moisture content and particle size and demand more and more a certified product.
- There is one consumer in Sardegna which requests hog fuel. Part of the fuel is produced in Toscana region.

In what concerns competitors, there are few very big wood chips producers and several small producers. There are no producers of solid biomass from agricultural residues either chips or pellets (some trials were made to develop a market of biomass from vineyard prunings unsuccessfully).

The types of solid biomass that are used in the region and that are considered as competing products for Le Rene are shown in Table 2 together with their prices (VAT and transport not included).

Table 2: Different solid biomass types consumed in the region of Le Rene.

Type of solid biomass	Price €/t	Price €/MWh	Moisture content w-%, ar	Ash content w-%, db
Olive pits bulk	173	30.9	12	< 2
Olive pits in bags (15-25 kg)	200-209	36.5	12	< 2
High quality wood chips	108	25.4	15	< 1
Medium quality wood chips	54-72	23.8	40	< 3
Hog fuel	25	9.4	40	< 4
Wood pellets bulk	190-200	41-42.0	10	< 1
Wood pellets in bags (15-25 kg)	211-228	46.7	10	< 1

6. Technical assessment of the facility

The technical assessment would be conducted based on the logistical components which are present in the cooperative, pointing out the ones that are compatible for the new business line. These include: drying, pelletising, storage and heat production. The particle size reduction would be performed with a chipper rented from the Biomass Producers Organization.

Figure 3 shows the flow diagram of the current cereal and sunflower treatment line of the agro-industry facility. The equipment that would be used for the new business line as biomass logistic centre is surrounded in red. They would be assessed in details in the next sub-sections.

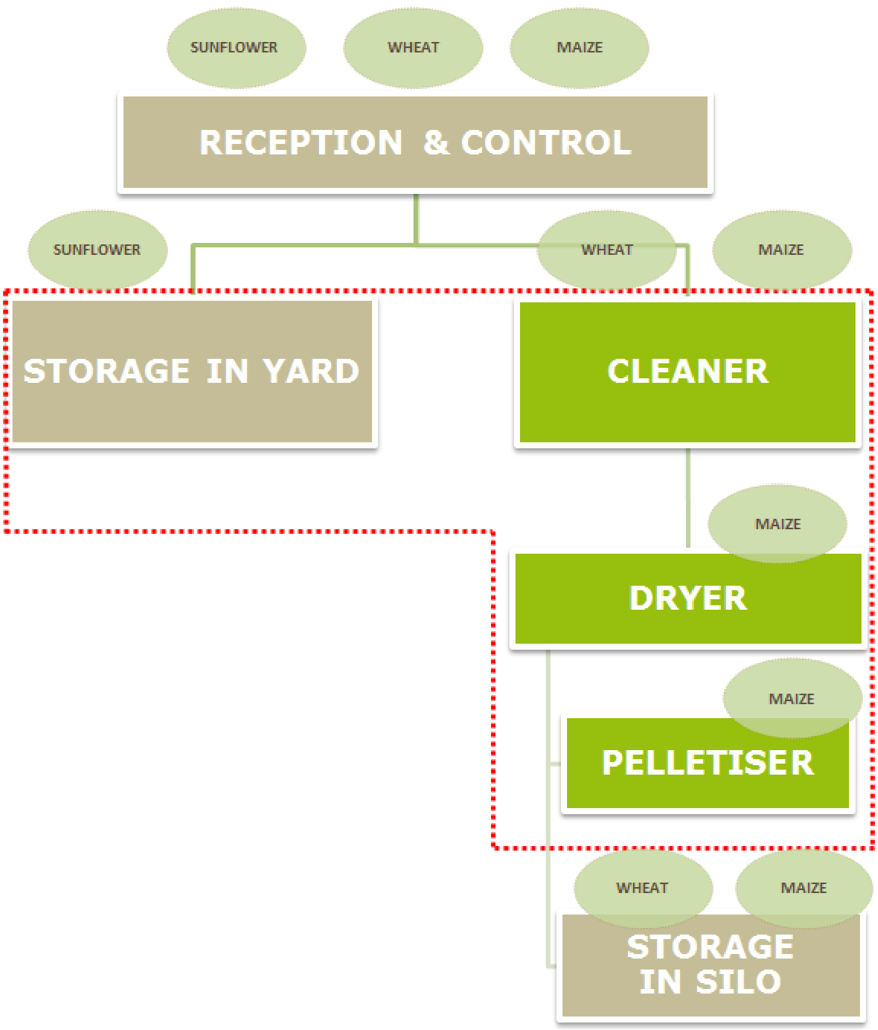


Figure 3: Flow diagram of the current cereal and sunflower treatment lines.

6.1. Particle size reduction

Currently the cooperative could have the possibility to rent 5 wood chippers (1 small, 2 medium and 2 big) which can be used in the new business line to reduce the size of the corn cobs into grits and to chip the prunings. The technical data of the chippers are shown in Table 3.

Table 3: Technical data of the chipper.

Technical description	Value	Unit
Power	1x370; 2x560; 2x840	kW
Chipping capacity	20; 60; 160	t/h

6.2. Drying

The cooperative owns a vertical dryer used currently for corn drying and rarely for wheat drying. After the drying the grain and seeds normally pass through a cleaning system in order to separate husks and broken grains. From all the possible raw materials for the logistic centre, this dryer is only compatible with olive pits. As for the drying of corn cobs and prunings chips, a new dryer should be purchased. The technical data of the dryer is illustrated in Table 4.

Table 4: Technical data of the cereal dryer.

Technical description	Cereal dryer	Unit
Type of dryer	Silo	-
Year of manufacturing	1998	-
Drying capacity	7.4 (maize), 14.48 (suf)	t/h
Current drying capacity	1500	t/yr
Thermal power	2,907.5	kWh
Annual working hours	203	h/yr
Working months	Aug-Nov	months
Working days	6	days
Daily working hours	24	h/day
Hours of maintenance	48	h/yr

6.3. Heat generation

The cooperative owns a burner which runs on natural gas for the existing dryer. Its technical details are shown in Table 5. As it would be explained in the section 7, a scenario which includes the acquisition of a new biomass burner would be considered for assessing its feasibility.

Table 5: Technical data of the boiler.

Technical description	Gas boiler	Unit
Output power	2,907.5	kW
Manufacturer	Scolari	-
Year of manufacturing	1998	-
Working months	Aug-Nov	months
Working days	6	days
Daily working hours	24	h/day

6.4. Pelletiser

Le Rene owns a pelletiser in Coltano site which was used in the past for the production of fodder pellets from cereal seeds. Currently is not in used and therefore would be available for the logistic centre. The main characteristics of it are shown in the following table.

Table 6: Technical data of the pelletiser.

Technical description	Pelletiser	Unit
Manufacturer	TENCHINI s.n.c.	-
Working capacity	0.600	t/h
Power	30	kW

6.5. Storage

The cooperative has an open area of 25,000 m^2 and a warehouse of 2,000 m^3 as a storage capacity. Additionally, for the storage of cereals, the cooperative owns 4 silos of 1,023 m^3 and another 4 silos of 1,571 m^3. For the biomass logistic centre, no silos would be used but only the open area and warehouse.

7. Feasibility of the new business line as an agro-industry logistic centre

The cooperative is interested in starting a new business as a biomass logistic centre, but the produced types and quantities of solid biomass are not defined and depend on the investments in new equipment. Three different scenarios have been proposed by Le Rene and are explored in this study. In the following lines, the raw material, the products and the equipment used in each scenario are explained. The flow diagrams can be observed in Annex I. The economic assessment will be done for those 3 scenarios and the most feasible scenario for Le Rene would then be implemented.

Scenario NI or scenario of no investment. In this case it is considered the generation of 2 products:

- Medium quality wood chips and hog fuel (with bark and leaves) from prunings of permanent crops at high moisture content. The chipper and the screener from Biomass Producers Organization would be rented for that purpose.
- Agro-pellets from mixed prunings wood, residues from the cereal dryer (like broken grains and husks) and sawdust from forest wood (the fines from the production of wood chips by Biomass Producers Organization). This implies the utilization of the pelletiser.

Scenario LI or scenario of low investment. In this case the products are:

- High quality olive pits by the centrifugation of olive pomace purchased to an oil-mill. A centrifugation system would be acquired and the existing dryer and cleaning system would be used. The olive pits will be sold in bags. The residue from the centrifugation would be sold out as well for biogas production at 10 €/t.
- Corn cob grits from corn cobs harvested by COAGRI. The reduction of particle size would be performed with the chipper rented from Biomass Producers Organization.
- Medium quality wood chips and hog fuel from mixed prunings of permanent crops at high moisture content. The chipper from Biomass Producers Organization would be rented for that purpose.

Scenario HI or scenario of high investment. Le Rene would like to explore the possibility of making an important investment for its activity as agro-industry buying a new more efficient dryer to reduce the moisture of the cereal, a biomass burner to supply the energy needed in the dryer and a new screening system. The planned activity as biomass logistic centre would take the opportunity of the new drying (compatible with all possible raw materials considered) and screening system in order to produce high quality products. In that case also some of the sub-products from the logistic centre and from the cereal conditioning would be used for heat generation in the burner.

In particular, the products are:

- High quality olive pits sold in bags generated from the pomace after a centrifugation, drying and screening process.
- Dried corn cob grits sold in bags. Cobs are harvested and chopped as in the previous scenario but with a final moisture content of 15 % due to the reduction of moisture in the new dryer.
- High quality chips and hog fuel from olive prunings and mixed prunings. The material would be chipped in the machinery rented to Biomass Producers Organization and separated into 2 fractions: the fraction with large particles (hog fuel) would be used without drying in the burner for heat generation both for the logistic centre and for the agro-industrial activity; and the fine fraction would be dried, screened and sold as high quality chips.
- Medium and high quality forest wood chips. Forest wood chips bought to Biomass Producers Organization, which coarse fraction is used as a fuel in the biomass burner (37 %) and sold in the market (63 %). The fine fraction is dried, screened and mixed with the products from prunings in order to upgrade their quality.

The produced quantities of solid biomass in the 3 scenarios are shown in Table 7**¡Error! No se encuentra el origen de la referencia.**.

Table 7: Solid biomass types and quantities produced in the 3 scenarios.

Type of solid biomass	Scenario NI Quantity produced t/yr	Scenario LI Quantity produced t/yr	Scenario HI Quantity available t/yr
Olive pits	0	195	195
Olive pomace	0	1,217	1,217
Corn cobs	0	215	203
Mixed agro-prunings fine chips	292	417	294
Mixed agro-prunings hog fuel	1,167	1,667	1,667
Olive prunings fine chips	0	0	45
Olive prunings hog fuel	0	0	255
Forest wood fine chips	0	0	326
Forest wood coarse chips	0	0	1,847
Mixed pellets	529	0	0

7.1. Quality assessment of the new products

As a first approach for this study, it is necessary to clarify the quality parameters for solid biomass which the company aims to produce since it will define its price in the market.

Nowadays, there is an international standard ISO 17225 which normalizes different categories of solid biomass. The standard not only classifies the solid biomass fuels according to their characteristics but also provides guidelines on quality specifications which are important to be followed. The different parts of the standard are:

ISO 17225 – 1: General requirements
ISO 17225 – 2: Graded Wood Pellets
ISO 17225 – 3: Graded Wood Briquettes
ISO 17225 – 4: Graded Wood Chips
ISO 17225 – 5: Graded Firewood
ISO 17225 – 6: Graded non-woody Pellets
ISO 17225 – 7: Graded non-woody Briquettes

In addition, it is necessary to remember that boilers are made in order to use specific types of solid biofuels. For instance, wood pellet boilers or wood pellet stoves can be constructed to burn only wood pellet graded ISO 17225 – 2 Class A1. If it is not the case and other type of fuel is used, the manufacturer may remove the guarantee of his product.

In the following paragraphs some guidelines of quality are provided for the products assumed in this study:

<u>Wood chips:</u> The standard states the maximum moisture content as 35 % and ash contents of 3 %. There are different classifications according to quality characteristics (A1, A2 and B), as it can be seen in the table below.

The aim of the agro-industry logistic centre would be to achieve quality values to produce high quality chips, which in some cases would require a mixture with forest wood chips in order to upgrade the quality values (mainly ash content which can be higher for agro-prunings due to the high share of bark).

However, the cooperative is also interested in the production of medium quality chips and hog fuel since there is a demand in the area. In this case, the quality values of Table 8 can be exceeded.

Table 8: Quality parameters for wood chips according to ISO 17225 – 4.

ISO 17225	Wood Chips ISO 17225-4 A1	Wood Chips ISO 17225-4 A2	Wood Chips ISO 17225-4 B
Moisture (w-% ar)	≤ 10 ≤ 25	≤ 35	be mentionned
LHV (kWh/kg, ar)	min value to be mentioned	min value to be mentioned	min value to be mentioned
Ash (w-% db)	≤ 1	≤ 1,5	≤ 3
N (w-% db)	-	-	1,00
S (w-% db)	-	-	0,10
Cl (w-% db)	-	-	0,05
As (mg/kg)	-	-	1,0
Cd (mg/kg)	-	-	2,0
Cr (mg/kg)	-	-	10,0
Cu (mg/kg)	-	-	10,0
Pb (mg/kg)	-	-	10,0
Hg (mg/kg)	-	-	0,1
Ni (mg/kg)	-	-	10,0
Zn (mg/kg)	-	-	100,0
shrinkage starting temp. (°C)	-	-	-
deformation temp. (°C)	-	-	-
hemisphere temp. (°C)	-	-	-
flow temp. (°C)	-	-	-

Pellets: The international standard states quality values both for wood pellets (ISO 17225-2) and for agro-pellets (ISO 17225-6). In the case of Le Rene, which aims to produce mixed pellets from agrarian and forestry sources, the quality characteristics are ruled by the latter, being the maximum moisture content to be achieved of 12-15 % and the maximum ash content of 6 % for class A and 10 % for class B (see Table 9). Chlorine is another critical parameter to be taken into account when dealing with agrarian residues especially herbaceous. The pellets produced by Le Rene should accomplish these specifications.

Table 9: Quality parameters for agro-pellets according to ISO 17225 – 6.

ISO 17225	AGROPELLETS ISO 17225-6 A	AGROPELLETS ISO 17225-6 B
Moisture (w-% ar)	≤ 12	≤ 15
LHV (kWh/kg, ar)	≥ 4	≥ 4
Ash (w-% db)	≤ 6	≤ 10
N (w-% db)	≤ 1,5	≤ 2
S (w-% db)	≤ 0,2	≤ 0,3
Cl (w-% db)	≤ 0,1	≤ 0,3
As (mg/kg)	≤ 1	≤ 1
Cd (mg/kg)	≤ 0,5	≤ 0,5
Cr (mg/kg)	≤ 50	≤ 50
Cu (mg/kg)	≤ 20	≤ 20
Pb (mg/kg)	≤ 10	≤ 10
Hg (mg/kg)	≤ 0,1	≤ 0,1
Ni (mg/kg)	≤ 10	≤ 10
Zn (mg/kg)	≤ 100	≤ 100
shrinkage starting temp. (°C)	be mentionned	be mentionned
deformation temp. (°C)	be mentionned	be mentionned
hemisphere temp. (°C)	be mentionned	be mentionned
flow temp. (°C)	be mentionned	be mentionned

The case of study, plans the production of pellets with the following mixture (percentages in weight at 10 % moisture content): 79 % of mixed agro-prunings, 19 % cereal spilling and 2 % forest wood residues. With this share, according to bibliography, class A could be fulfilled. However, special attention should be paid to the amount of leaves included in the mixed agro-prunings since ash and Chlorine content are directly linked with its presence. The performance of different production tests is essential in order to evaluate the average quality of the pellet produced, which could make the share of materials to change.

Olive pits: ISO standard 17225 still does not include any part related to pits or shells from the agro-industrial activity. However, there have been some initiatives to guide on the quality issues of this type of product like quality label BIOmasud (specific for Mediterranean solid biomass fuels, http://biomasud.eu/en/downloads) or Spanish standard (UNE 164003 and UNE 164004).

BIOmasud states maximum values according to 2 categories as it can be observed in Table 10. Le Rene should achieve the quality values of any of the two classes to guarantee consumers satisfaction.

Table 10: Quality parameters for olive pits according to BIOmasud quality label.

ISO 17225	OLIVE PITS BIOmasud Class A	OLIVE PITS BIOmasud Class B
Moisture (w-% ar)	≤ 12	≤ 16
LHV (kWh/kg, ar)	≥ 16.0	≥ 15.1
Ash (w-% db)	≤ 1.3	≤ 2.6
N (w-% db)	≤ 0.4	≤ 0.8
S (w-% db)	≤ 0.03	≤ 0.06
Cl (w-% db)	≤ 0.04	≤ 0.08
As (mg/kg)	≤ 0.5	≤ 1
Cd (mg/kg)	≤ 1.5	≤ 3
Cr (mg/kg)	≤ 10	≤ 20
Cu (mg/kg)	≤ 10	≤ 20
Pb (mg/kg)	≤ 5	≤ 10
Hg (mg/kg)	≤ 0.01	≤ 0.02
Ni (mg/kg)	≤ 10	≤ 20
Zn (mg/kg)	≤ 10	≤ 20
shrinkage starting temp. (°C)	-	-
deformation temp. (°C)	≥ 750	≥ 750
hemisphere temp. (°C)	-	-
flow temp. (°C)	≥ 1375	≥ 1300

Maize cobs grits: ISO 17225 does not reflect either recommended quality values for corn cobs. As in the case of the olive pits, it has been the initiative of national organisms, the ones promoting the elaboration of a standard due to their interest in the regularization of cobs use. The Austrian standard ÖNORM C 4003 defines maize cobs requirements for energy use (see Table 11). The agro-industry should therefore produce cob grits that fulfils these specifications.

Main limiting values in this case are ash content (which could be higher with an incorrect harvesting or handling that includes exogenous matter in the feedstock) and Chlorine content.

Table 11: Quality parameters for maize cobs according to ÖNORM C 4003.

ISO 17225	MAIZE COBS ÖNORM C 4003
Moisture (w-% ar)	≤ 20 20 < x ≤ 30 > 30
LHV (kWh/kg, ar)	-
Ash (w-% db)	≤ 4.0
N (w-% db)	≤ 0.7 ≤ 1.5
S (w-% db)	≤ 0.10
Cl (w-% db)	≤ 0.15
As (mg/kg)	-
Cd (mg/kg)	-
Cr (mg/kg)	-
Cu (mg/kg)	-
Pb (mg/kg)	-
Hg (mg/kg)	-
Ni (mg/kg)	-
Zn (mg/kg)	-
shrinkage starting temp. (°C)	-
deformation temp. (°C)	-
hemisphere temp. (°C)	-
flow temp. (°C)	-

7.2. Economic assessment

At a first stage, an assessment of the investment costs for the new business and the related costs will be made in this report. In a second stage, the purchasing costs of the agricultural residues, the pre-treatment, personnel and other costs will be determined. This will be done for the 3 scenarios.

7.2.1. Investment costs

As it was mentioned at the beginning of section **7**, based on the investments in machines and equipment, 3 scenarios will be considered:

- Scenario NI: Only existing pelletiser would be used in this case.
- Scenario LI: In this scenario a centrifugator would be purchased in order to separate the olive pomace and the olive pits. The olive pits would be dried using the current dryer and burner.
- Scenario HI: high investment scenario. In this case, a new dryer, a biomass burner (1.1 MW) and a screening system. Also construction work is foreseen

in order to put in place the newly purchased machines. All products would be dried using the new dryer and burner. Only a part of the investment can be assumed by the logistic centre and will be considered in the study, the rest will be assumed by the agro-industrial activity.

The investments costs in both scenarios are presented in Table 12. The investment cost will be charged in the price of the product. The quota to be allocated per ton of product will be distributed along the equipment life.

Table 12: Investment costs for the new business in the scenarios LI and HI.

Investment items	Equipment costs €	Installation costs €	Capital-related costs €	Maintenance costs €	Total costs €
Scenario LI					
Centrifugator	29,300	1,465	0	0	30,765
Total					**30,765**
Scenario HI					
Centrifugator	29,300	1,465	0	0	30,765
Dryer		25,102	0	0	25,102
Biomass burner		29,149	0	0	29,149
Screening system		13,250	0	0	13,250
Construction		3,375	0	558	3,375
Total					**101,641**

7.2.2. Purchasing costs

The agricultural residues needed for the new business would be purchased from farmers located in the vicinity of the cooperative (maximum 30 km away). Table 13 shows the total costs of the required residues in the 3 scenarios.

Table 13: Cost of raw material purchasing in the 3 scenarios.

Residue type (moisture content w-%, ar)	Quantity for final product	Quantity of raw material	Unit price	Total RM price	Transport cost	Total Transport cost	Total price
	t	t	€/t	€/t	€	€	€
Scenario NI							
Mixed agro-prunings for pellets	417	750	1	750	0	0	750
Cereal bad quality stock and bran	100	100	0	0	0	0	0
Sawdust (forest wood)	12	12	0	0	0	0	0
Mixed agro-prunings (50%w)	1,459	1,750	1	1,750	0	0	1,750
Total							**2,500**
Scenario LI							
Olive pomace (60% w)	195	1,432	15	21,480	10	14,320	35,800
Corn cobs (35% w)	215	265	40	10,600	10	2,650	13,250
Mixed agro-prunings (50%w)	2,084	2,500	1	2,500	0	0	2,500
Total							**51,550**
Scenario HI							
Olive pomace (60% w)	195	1,432	15	21,480	10	14,320	35,800
Corn cobs (35% w)	203	265	40	10,600	10	2,650	13,250
Mixed agro-prunings (50%w)	1961	2,500	1	2,500	0	0	2,500
Olive prunings (50%w)	300	382	20	7,640	10	3,820	11,460

Residue type (moisture content w-%, ar)	Quantity for final product	Quantity of raw material	Unit price	Total RM price	Transport cost	Total Transport cost	Total price
	t	t	€/t	€/t	€	€	€
Forest wood fine chips (50%w)	326	462	50	23,100	0	0	23,100
Forest wood coarse chips (50%w)	1,847	1,847	40	73,880	0	0	73,880
Total							**159,990**

7.2.3. Pre-treatment costs

After purchasing the residues, they need to be pre-treated before being sold as solid biomass products.

In scenario NI, the pre-treatments include the following:

- Mixed agro-prunings would require particle size reduction. After storage the moisture content is expected to decrease to 40 %. The hog fuel and coarse fraction would be sold in the market separately.
- The very fine fraction from the previous chipping would be stored in such a way that natural drying will be promoted. Frequent movement would help the moisture content to decrease. Once dried, the material would be mixed with the cereal spilling and sawdust from the screening and sawing process of forest wood.

In scenario LI, the pre-treatments include the following:

- Olive pomace would require centrifugation, drying (from 20 % moisture content resulting from the centrifugation process to 12 %), cleaning and dust removal. A bagging service will be contracted.
- Corn cobs would require particle size reduction. Natural drying while stored will make the moisture content to decrease from 35 % till 20 %. No additional drying would be performed.
- Mixed agro-prunings would require particle size reduction. No forced drying would be performed but the natural drying while stored (decreasing the moisture from 50 % to 40 %).

In scenario HI, the pre-treatments include the following

- Olive pomace would require centrifugation, drying (from 20 % to 12 %), screening and dust removal. A bagging service would be contracted.
- Corn cobs would require particle size reduction, drying (from 35 % to 15 %), screening and dust removal. A bagging service would be contracted.
- Mixed agro-prunings and olive prunings would require particle size reduction. The fine fraction would require drying (from 40 % after storage to 15 %), screening and dust removal. The other fraction, hog fuel, would not require any pre-treatment and will be sold at 40 % moisture content (achieved after natural drying during storage).

- The fine fraction of the forest wood chips would require drying (from 40 % to 15 %), screening and dust removal. The coarse fraction would not require any pre-treatment.

7.2.4. Personnel and other costs

The personnel costs are calculated based on the working hours of 2 specialised operators, one for the centrifugator and screener and one for the dryer and boiler. The hourly rate of these 2 persons is 13.94 and 15.07 €, respectively.

The number of hours needed for the production of each solid biomass product in each scenario were calculated based on the pre-treatment processes required for each product.

Other costs which would be considered in the assessment are the security costs and general costs, are calculated as 0.5 % and 15 % of the production cost, respectively.

7.2.5. Production costs

The production cost, which is the sum of purchasing costs, pre-treatment costs, personnel costs and other costs, permits to identify the cost of a unit of solid biomass produced. The production costs in all scenarios are presented in Table 14.

It is important to mention that the olive pomace remaining after separating the pits was included in the production cost and its selling has been calculated as a benefit.

Table 14: Production costs of solid biomass products in the 3 scenarios.

Type of Scenario	Quantity produced	Personnel cost	Purchasing cost	Pre-treatment cost	Security cost	General cost	Other cost	Production cost
	t	€/t	€/t	€/t	€/t	€/t		€/t
Scenario NI								
Agro-pellet Class As	529	6.0	1.42	9.87	0.21	6.32	24.66[1, 2]	**48.49**
Mixed agro-prunings chips M40	292	3.73	1.20	23.77	0.11	3.25	-7.13[2]	**24.94**
Mixed agro-prunings hog fuel	1,167	3.73	1.20	23.77	0.11	3.25	-7.13[2]	**24.94**
Scenario LI								
Olive pits from pomace	195	9.90	183.59	14.43	0.73	21.93	0	**168.13**
Olive pomace	1,217	0	-10	0				

[1] Transportation cost internally among plants since the fine fraction is produced in Caligi plant and the pelletiser is in Coltano (5 €/t) and by-products costs under screening material (19.66 €/t)

[2] Revenue and cost sub-product under screening material. The cost of the under screening material has been allocated in the mix pellet production and it has been considered a revenue for the mixed agro-prunings chips and hogfuel

Type of Scenario	Quantity produced	Personnel cost	Purchasing cost	Pre-treatment cost	Security cost	General cost	Other cost	Production cost
	t	€/t	€/t	€/t	€/t	€/t		€/t
Corn cob grits	215	4.30	61.63	13.34	0.40	11.96	0	**91.59**
Mixed agro-prunings chips M40	417	3.49	1.20	10.90	0.08	2.35	0	**18.01**
Mixed agro-prunings hog fuel	1,667	3.49	1.20	10.90	0.08	2.35	0	**18.01**
Scenario HI								
Olive pits from pomace	195	12.64	183.59	12.48	0.73	22.05	0	**169.09**
Olive pomace	1,217	0.00	-10.00	0.00				
Corn cobs grits	203	18.07	65.27	27.17	0.55	16.66	0	**127.72**
Olive prunings fine chips	45	18.21	50.93	32.20	0.51	15.28	0	**117.13**
Olive prunings hog fuel for boiler	255	3.72	35.95	10.90	0.25	7.62	0	**58.44**
Mixed agro-prunings fine chips	294	17.85	1.70	32.12	0.26	7.79	0	**59.72**
Mixed agro-prunings hog fuel for boiler	1,667	3.70	1.20	10.90	0.08	2.38	0	**18.26**
Forest wood fine chips	326	14.62	70.86	16.65	0.51	15.40	0	**118.04**
Forest wood coarse chips	1,171	0.00	40.00	0.00	0.20	6.03	0	**46.23**
Forest wood coarse chips for boiler	676	0.00	40.00	0.00	0.20	6.03	0	**46.23**

7.2.6. Cost price, profit and revenue

The cost price represents the minimum selling price under which the product would not bring any profit. It is the sum of the production cost and the amortised investment cost. The amortisation of the investment is an important issue for decision making: the longer the years of amortisation, the higher are the risks for payback. As explained before, in this study the amortisation years have been considered the equipment life time (12 to 16 years). This quota has been only applied to the products that are sold in the market.

The cooperative wishes to have a minimum profit of 10 % from the production price of each product in order to proceed in its production. The market price for the produced solid biomass is defined in the region of the cooperative except in the case of the cob grits and the agro-pellet Class A, which do not have a real market in the area yet.

Table 15 shows the cost price and the minimum acceptable price that Le Rene has stated considering competitors.

Table 15: Cost price and total revenue in the 3 scenarios.

Type of Scenario	Quantity produced	Production cost	Investment cost quota	Cost price	Min acceptable selling price	Real profit	Total revenue
	t	€/t	€/t	€/t	€/t	€/t	€/yr
Scenario NI							
Agro-pellet Class A	529	48.49	0.00	48.49	80	31.51	42,320
Mixed agro-prunings chips M40	292	24.94	0.00	24.94	55	30.06	16,060
Mixed agro-prunings hog fuel	1,167	24.94	0.00	24.94	25	0.06	29,175
Total							87,555
Scenario LI							
Olive pits in bags	195	168.13	13.15	181.28	205	23.72	39,975
Corn cob grits	215	91.59	0.00	91.59	101	9.16	21,661
Mixed agro-prunings chips M40	417	18.01	0.00	18.01	60	41.99	25,020
Mixed agro-prunings hog fuel	1,667	18.01	0.00	18.01	25	6.99	41,675
Total							**128,331**
Scenario HI							
Olive pits in bags	195	169.09	17.23	186.31	210	23.69	40,950
Corn cobs grits	203	127.72	4.72	132.44	150	17.55	30,449
Olive prunings fine chips	45	117.13	4.72	121.85	125	3.15	5,625
Olive prunings hog fuel for boiler	255	58.44	0	58.44			
Mixed agro-prunings fine chips	294	59.72	4.72	64.44	110	45.56	32,341
Mixed agro-prunings hog fuel for boiler	1,667	18.26	0	18.26			
Forest wood fine chips	326	118.04	4.72	122.76	125	2.24	40,749
Forest wood coarse chips	1,171	46.23	0	46.23	70	23.77	81,974
Forest wood coarse chips for boiler	676	46.23	0	46.23			
Total							**232,087**

From the table of results it can be observed that in scenario NI the profit overcomes the minimum except in the case of the hog fuel from mixed agro-prunings.

In scenario LI, all the solid biomass products have a profit of more than 10 % of the production cost, but the most profitable product seems to be mixed agro-prunings chips M40, followed by olive pits, corn cob grits and mixed agro-prunings hog fuel.

In scenario HI, all the solid biomass products have a profit of more than 10 % of the production cost, except the olive prunings fine chips and the forest wood fine chips. The most profitable product seems to be mixed agro-prunings chips M15 followed by forest wood coarse chips, olive pits and then corn cob grits.

7.2.7. Total profit

Whatever the amortisation rate is, the investment costs would be paid in the first year (in this study it has been considered that this cost would be covered by the own capital of the cooperative).

In scenario LI, if the products are sold at the minimum acceptable price set, even though the investment, the logistic centre would be profitable from the first year.

In scenario HI, even if the high investment performed is shared with the agro-industrial activity and the residues result in savings in heat production for the agro-industry processes, the sales revenue is not enough to make the total profit positive in more than 10 years of activity.

7.3. Risk assessment

The main risk for the new business line as biomass logistic centre would be the generation of products that do not satisfy consumers from the quality point of view. In the case of the scenarios where an investment is made, the risk is obviously higher and linked to the necessity to sell the product to be able to amortize it.

Although a theoretical assessment of quality has been performed in section 7.1, a further analysis of quality differences with competing products is proposed in this section. All possible products for the scenario NI have been evaluated since it is the one selected by the cooperative as the most appealing one.

In this scenario, however, two of the three proposed products exist already in the market (mixed agro-prunings chips M40 which can be considered medium quality wood chips; and mixed agro-prunings hog fuel which can be considered low quality wood products) and therefore the price has been fixed according to quality characteristics that can be observed in Table 16.

In the case of the mixed agro-pruning pellet, a product not existing in the market, the price has been stated according to quality characteristics shown in Table 17

Table 16: Competing products main quality characteristics and prices

	Quality characteristics			Prices	
	LHV (kWh/kg ar)	Bulk density (kg/m³)	Ash content (w-% db)	€/t	€/MWh
Olive pits bulk	5.6	500	< 2	173	30.9
Olive pits in bags (15-25 kg)	5.6	500	< 2	200-209	36.5
High quality wood chips	4.25	250	< 1	108	25.4
Medium quality wood chips	2.65	270	< 3	54-72	23.8
Hog fuel	2.65	300	< 4	25	9.4
Forest wood pellets bulk	4.7	650	< 1	190-200	41-42.0
Forest wood pellets bag	4.7	650	< 1	211-228	46.7

Table 17: NI Products quality characteristics and proposed prices

	Quality characteristics			Prices	
	LHV (kWh/kg ar)	Bulk density (kg/m³)	Ash content (w-% db)	€/t	€/MWh
Agro-pellet Class A	4.00	650	< 6	80	20

From the comparison of prices, the conclusions about possible risks that the agro-industry can face when selling the possible biomass products are the following:

- The quality of agro-pruning chips and hog fuel should be controlled in order to ensure that is comparable to forest products. The main constrain would be the ash content, which is mainly found in the bark and, for this reason, pruning branches should be avoided and up-rooted trees should be a priority.
- Agro-pellets seem to be a highly competitive product in terms of energy compared not only to wood forest pellets but also to high quality chips. However, the amount of ash content is considerably higher and therefore test should be performed in possible consumer's burners in order to assess their suitability as solid biofuel.

7.4. Social assessment

The Social Impact Assessment includes the process of analysing, monitoring and managing the intended and unintended social consequences, both positive and negative of planned interventions (policies, programmes, plans, projects) and any social change processes invoked by those interventions. Its primary purpose is to bring about a more sustainable and equitable biophysical and human environment[3]. The social impacts are generally monitored through a set of indicators. In this study, the main social impacts and the indicators which would be assessed are mentioned in Table 18.

[3] http://www.iaia.org/publicdocuments/sections/sia/IAIA-SIA-International-Principles.pdf

Table 18: Impacts and indicators assessed in the study

Social impacts	Indicators
a. Contribution to local economy	Employment
b. Working conditions	Employment benefits
c. Working rights	Health and safety at work, Gender, discrimination,
d. Land rights	Land rights and conflicts
e. Food security	Land converted from staple crops

a. Contribution to local economy: The implementation of a logistic centre using agricultural residues for the production of solid biomass has a positive effect on the economy from the social point of view as it would create a new employment opportunity or more working hours for part time workers. In addition, buying a currently not used residue from local farmers and therefore giving them an additional income is a positive social impact. Depending on the scenario which would be chosen 700 to 1500 hours are estimated to be required for the new business line. 2 qualified operators would be hired.

b. Working conditions: One of the main areas covered by EU labour law is working conditions. This includes provisions on working time, part-time, and fixed-term work, temporary workers, and the posting of workers. All of these areas are key to ensuring high levels of employment and social protection throughout the EU.

In Le Rene cooperative, the working conditions of the EU are applied. The part time workers have the same working conditions and employment benefits as the full time workers.

c. Working rights: In the EU, workers have certain minimum rights related to

- Health and safety at work: general rights and obligations, workplaces, work equipment, specific risks and vulnerable workers.
- Equal opportunities for women and men: equal treatment at work, pregnancy, maternity leave, parental leave.
- Protection against discrimination based on sex, race, religion, age, disability and sexual orientation.

In Le Rene cooperative, the working rights are all reserved. When dealing with both the raw material and the biomass produced, the workers should wear masks as the risk of inhaling dust particles, which can cause severe health issues, is high. Furthermore, from gender equity point of view, women also are employed for administrative work.

d. Land rights: The issue of land rights is very relevant in light of the increasing practice of land-scarce countries leasing land in developing countries. This leased land could be primarily used for producing strategic food resources. Nevertheless and irrespective of whether food or fuel resources are grown; the issue of land deals or ‘land grabs’ exemplifies the effects of increased demand for land, to which bioenergy development contributes. The practice of land deals raises serious concerns about the respect of customary land rights of small holders.

The concept of SUCELLOG project would not enhance the leasing of new lands for the production of bioenergy as it would use the residues of agricultural products making this impact irrelevant to the case.

e. Food security: Bioenergy production might compete with agriculture on land use leading to possible jeopardising of food security.

The concept of the SUCELLOG project would not affect food security as it is using the residues of agricultural residues creating no competition with food but on the contrary contributing to synergies with the agricultural sector. The only threat that might evolve is the competition on feed as straw for example can be used for animal feeding, but during the biomass procurement study only residues which have no competition with other uses were taken into consideration.

7.5. Environmental assessment

The Environmental Impact Assessment (EIA) is the process of identifying, predicting, evaluating and mitigating the bio-physical, social, and other relevant effects (positive or negative) of development proposals prior to major decisions being taken and commitments made. In the environmental assessment, the impacts, mainly biodiversity, soil, water and air are usually studied.

In this study since we are dealing with agricultural residues, biodiversity and water are not considered to be affected neither positively nor negatively. Therefore impacts on soil and air would be only discussed.

a. Soil: Addition of crop residues to soils is important because they are a major source of organic carbon (C) and nutrients. Organic C positively impacts soil fertility, soil structure, water infiltration, water holding capacity, and bulk density, and it sustains microbial activity. Removing all residues like straw from the field would have therefore a negative impact on soil. In order to have a sustainable process for the production of solid biomass with no negative impact on the soil, it should be taken into consideration during harvesting to keep a percentage of the residues on the field (between 20-30 %). It is important to highlight that, when stating the amount of raw material available in the biomass assessment study (section 4), all these aspects have been already taken into consideration.

Concerning corn cobs, they are considered to have a very limited nutritional value for the soil. Therefore removing all of it would not have negative impact on the soil.

b. Air: two aspects should be taken into account when it comes to air pollution. If the residues are burned in the field, they would emit a lot of pollutants (CO, CH_4, CO_2, SO_2, non-methane volatile organic carbon and ammonia). Therefore using the residues for the production of solid biomass is a good alternative with positive impact.

The report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling (COM(2010)11), recommends that Member States which either have, or introduce, national sustainability schemes for solid and gaseous biomass used in electricity, heating and cooling, ensure that these in almost all respects are the same as those laid down in the Renewable Energy Directive. The directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 established the sustainability criteria for biofuels and bioliquids.

According to COM(2010)11, residues to produce solid biomass should fulfil the criteria of minimum greenhouse gas (GHG) saving values of 35 %, rising to 50 % on 1 January 2017 and to 60 % from 1 January 2018 for biomass produced in installations in which production started on or after 1 January 2017.

In order to check whether these values are fulfilled in the case of the production of agro-pellets class A and agro-pruning chips/hog fuel, BIOGRACE tool (developed by the project BIOGRACE II funded by the Intelligent Energy for Europe programme) has been used. The excel sheet allows the calculation of GHG emissions savings entering the case characteristics and the distance from supplier and final consumer.

In the case of the possible logistic centre to be developed by Le Rene, the GHG reduction is considerably higher than 35 %. For the calculation, the option *“wood chips from forest residues”* and *“wood pellets from forest residues”* was selected since the tool does not have the possibility of permanent crop agricultural prunings origin. The whole logistics chain of the raw material has been considered in the analysis: harvesting and transport of the raw material (maximum 50 km distance), pre-treatment, transport of the product and final conversion. The most adequate values from the ones reflected by the tool have been chosen in each case for the calculation.

8. Summary and conclusions

Società Cooperativa Le Rene is an agro-industrial cooperative whose current activities are: harvesting, treatment and trading of sunflower; cereal drying (mainly maize); pine nuts and olive oil production. The cooperative is interested in exploring the possible synergies between the facility and the agricultural raw materials in the area.

An assessment of both the boundary conditions (biomass resources and market) has shown that:

- The sources of raw material for the logistic centre are varied and their purchasing price is convenient: industrial residues from its own activity, olive pomace from a nearby industry, corn cobs from maize production and prunings from permanent crops. Cereal straw would not be considered in a first step, even though their high availability, because of their price.

- The current biomass market is not as varied as in other countries like Spain, being the solid biomass products offered mainly from forest origin (in chip and pellet format) except the olive pits. The potential consumers of the proposed logistic centre are small to large facilities.

Regarding the possibilities as logistic centre, 3 scenarios have been considered depending on the investment (none, low and high investment) and products are different in any case. The equipment existing in the agro-industry which could be compatible for the pre-treatment of the raw material would be the cereal drier, the cleaning system and the pelletiser. For the production of chipped material, a chipper from Biomass Producers Organization will be rented.

The study has shown that all possible products are feasible from the techno-economic point of view, meaning that the production costs are lower than the minimum acceptable market price. The profit is higher in the case of the mixed agro-prunings and agro-pellets due mainly to the low purchasing cost of the raw materials.

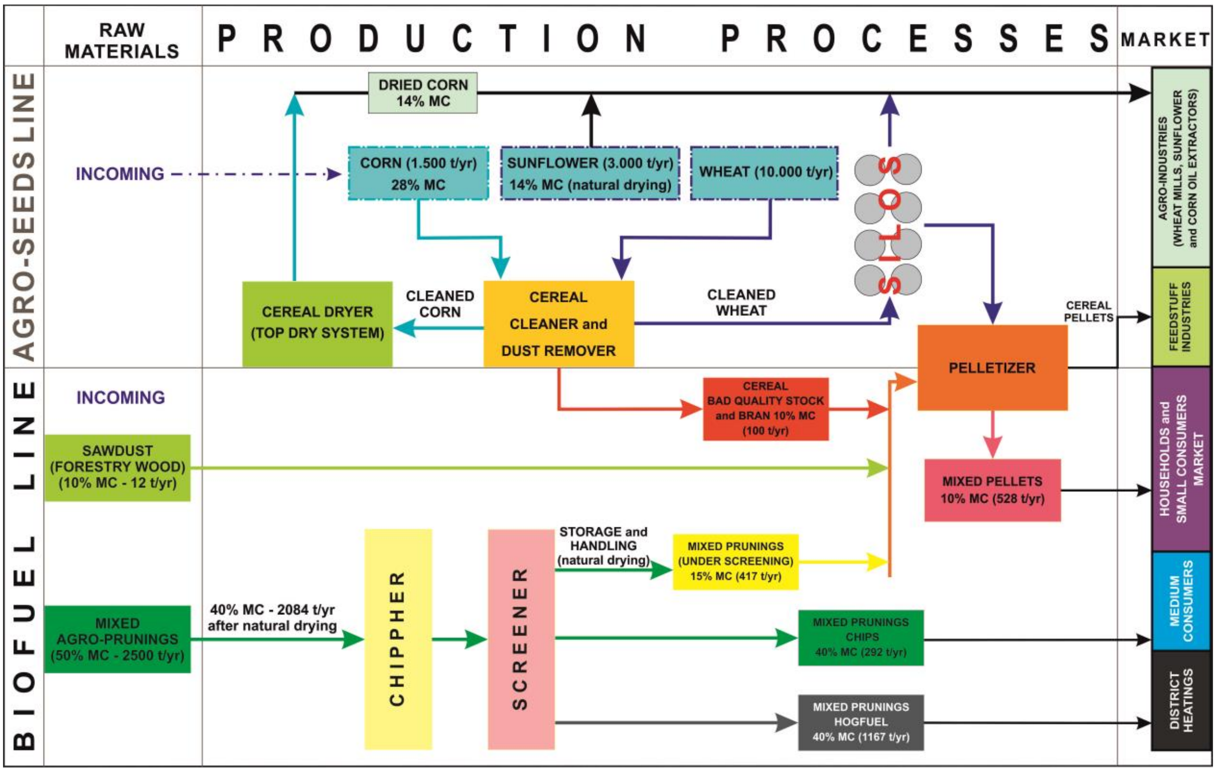
It should be highlighted that the high investment scenario, which considers a wider variety of products and an important transformation of the facility for that purpose, is not feasible from the economic point of view, having a payback of more than 10 years.

In order to minimize the risk for the new activity, from all possible scenarios proposed to the agro-industry the preferred one has been the “No Investment Scenario”, where agro-pellets Class A and mixed agro-prunings chips and hog fuel are generated. While the last two have already a market in the region, the case of the agro-pellets represents a new product. For that reason, it is important to stress the fact that a previous quality analysis (mainly determination of moisture content, calorific value, ash content and Chlorine percentage) of a representative sample of the raw material for the logistic centre is strongly advisable before starting the new business activity. Intensive product quality evaluation will avoid unexpected dissatisfaction from consumers. Initial combustion tests with some target boilers are also highly recommended to test the viability of the product during conversion (evaluation of

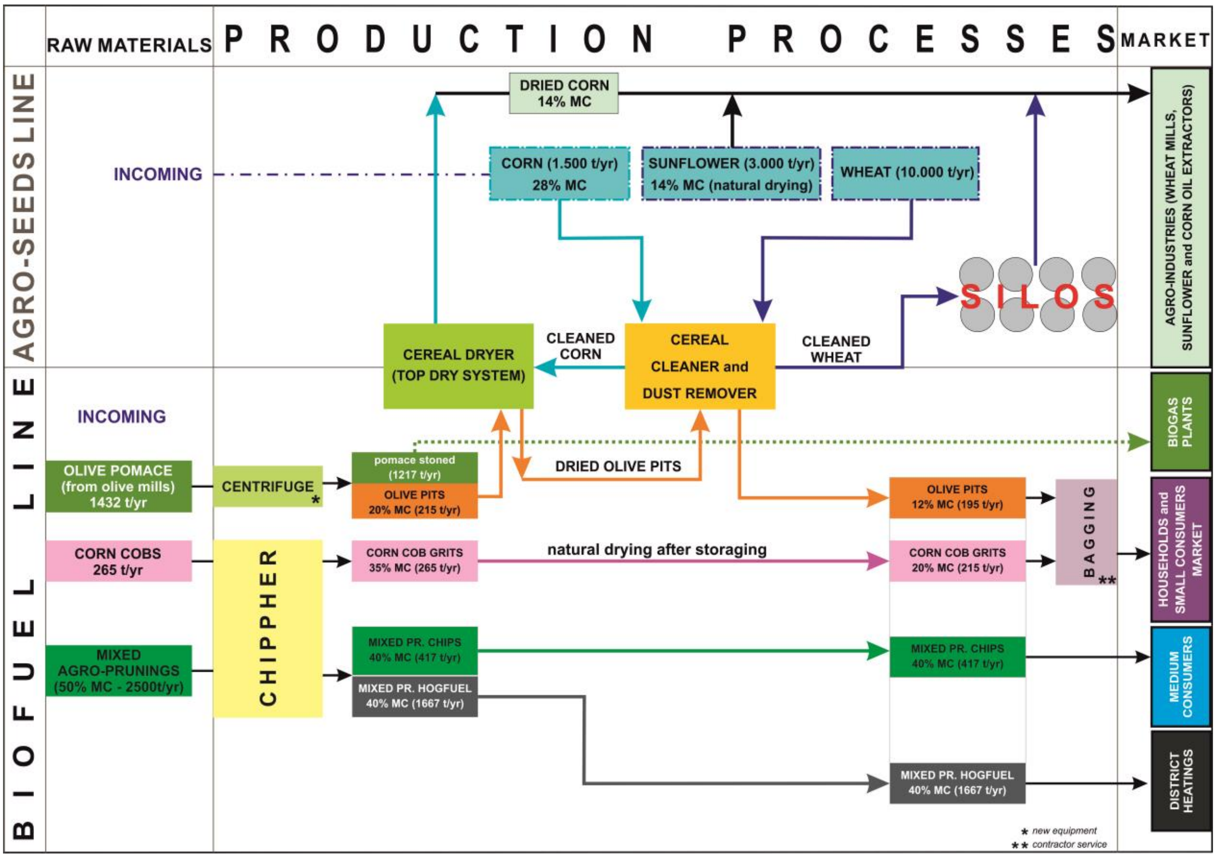
A complete business model has been developed by the SUCELLOG project with new proposals for the new activity as logistic centre producing agro-pellets and chips/hog fuel from mixed agro-prunings (see the document D4.4c available on the website).

The use of agricultural residues as a raw material of the logistic centre production has no social and environmental negative impacts. On the contrary, they contribute to the improvement of the society and the environment. This proves that the concept of the SUCELLOG project is sustainable from the 3 pillars point of view (economic, social and environmental).

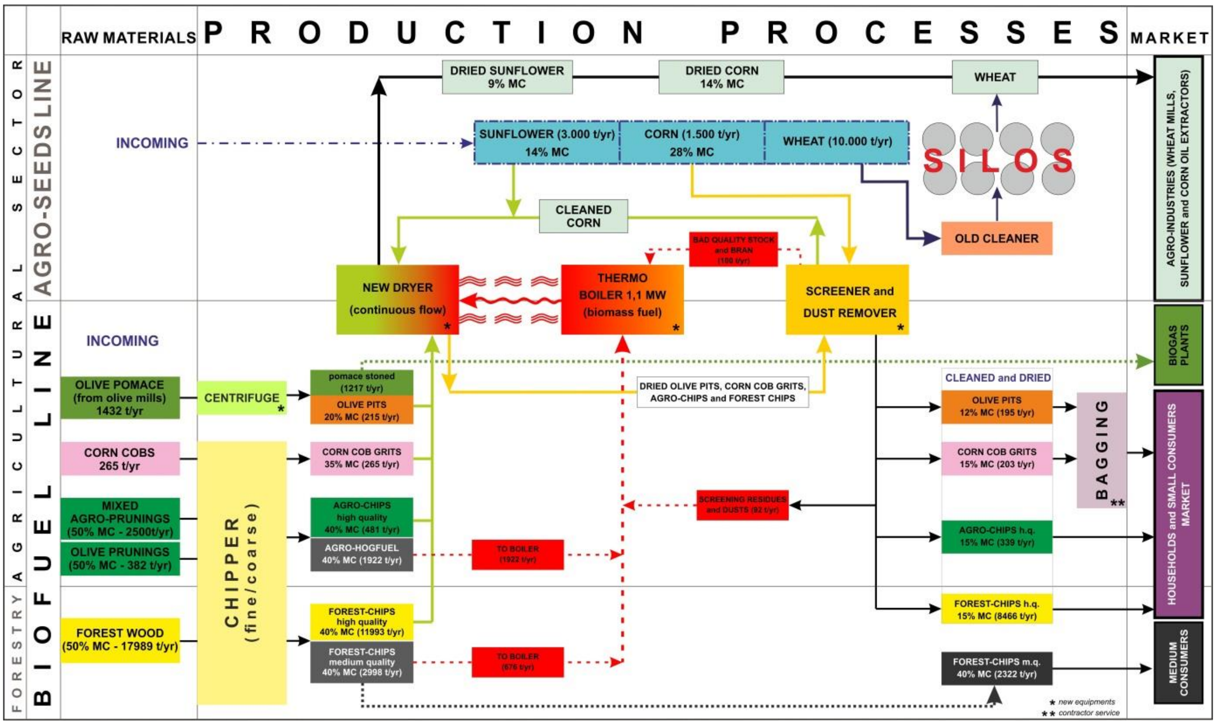
Annex I



Flow diagram Scenario NI



Flow diagram Scenario LI



Flow diagram Scenario HI