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

SUCELLOG: IEE/13/638/SI2.675535

D4.3d
Summary of the current situation of Luzéal-Saint Rémy 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 D4.3a of the SUCELLOG project - Summary of the current situation of Luzéal-Saint Rémy and feasibility study. It has been prepared by:

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1. Introduction

This report includes a description of the current situation of the cooperative Luzéal-Saint Rémy 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 partners UCCF and SCDF through interviews with the company director and other stakeholders. This information constitute 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 Luzéal-Saint Rémy - acting as a logistic centre - would be feasible and most importantly sustainable.

2. Company description

Luzéal-Saint Rémy was conceived recently from the fusion of two cooperatives (Alfaluz and Euroluz) and is currently the most important dehydration cooperative in France. Luzéal-Saint Rémy is working with more than 2,000 farmers in the region and more than 150 employees. The cooperative is located in Champagne-Ardenne, distributed in the entire region in five sites. The site involved in the SUCELLOG project is located in Route de la Croix, Champagne, 51600 St REMY-sur-BUSSY (Figure 1) and is represented by its manager, Hugues du Breuil.

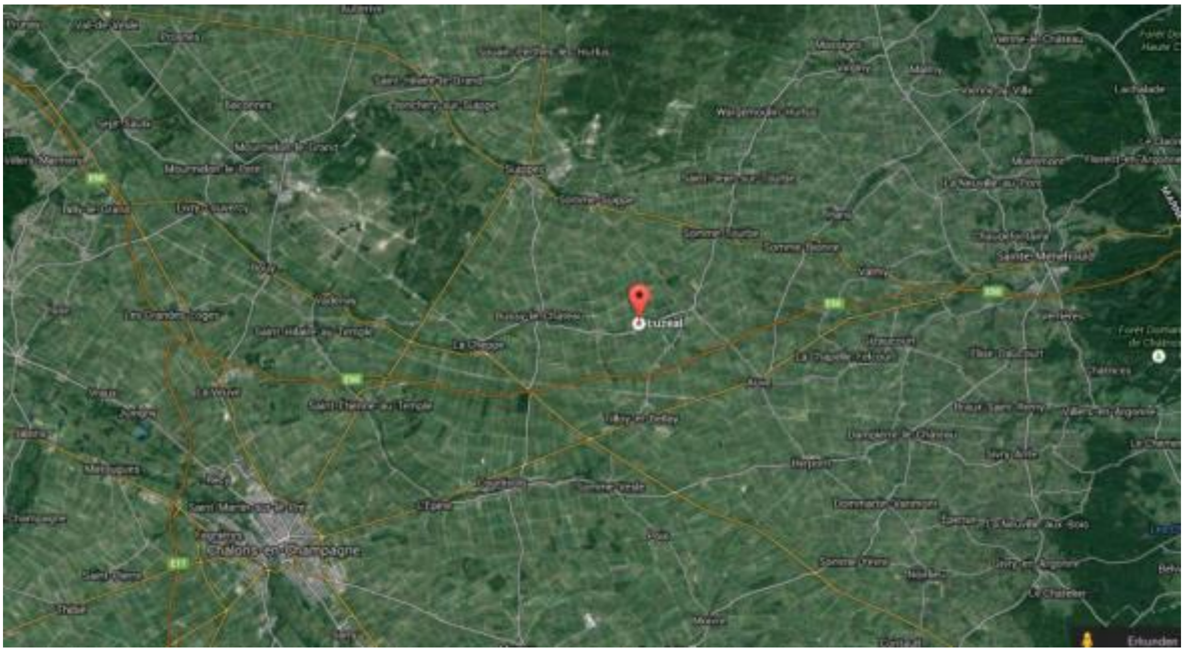

Figure 1: Location of Luzéal-Saint Rémy (Source: Google maps).

The current activity of the company in the site of Saint Rémy is the production of animal feed, more concreately of:

- ➢ Alfalfa pellets and bales (from April to October).
- ➢ Pellets of beet pulp (from September to October).

➢ Pellets of corn (September).

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

Luzéal-Saint Rémy is interested in starting a new business as biomass logistic centre producing and selling 10,000 t of pellets from agricultural residues mainly cereal straw. It is possible to mix these residues with miscanthus, sawdust and wood chips in order to produce standardised agro-pellets.

The aim of initiating this new activity is to reduce the fixed costs of the site by using the existing equipment for the new activity. Consequently the income of the associates would increase. The cooperative would use its current facilities during the idle period from 1 November to 30 April, taking into consideration that 6 weeks for the maintenance are required and that the facility is closed for 2 weeks at Christmas.

4. Biomass resources availability

In task 4.2 of the SUCELLOG project, a biomass procurement and competitiveness assessment has been made for an area of 30 km radio around the company location. The evaluation showed that a considerable amount of agricultural residues is available (no market competition or soil requirements) for the generation of solid biomass for bioenergy production (Figure 2).

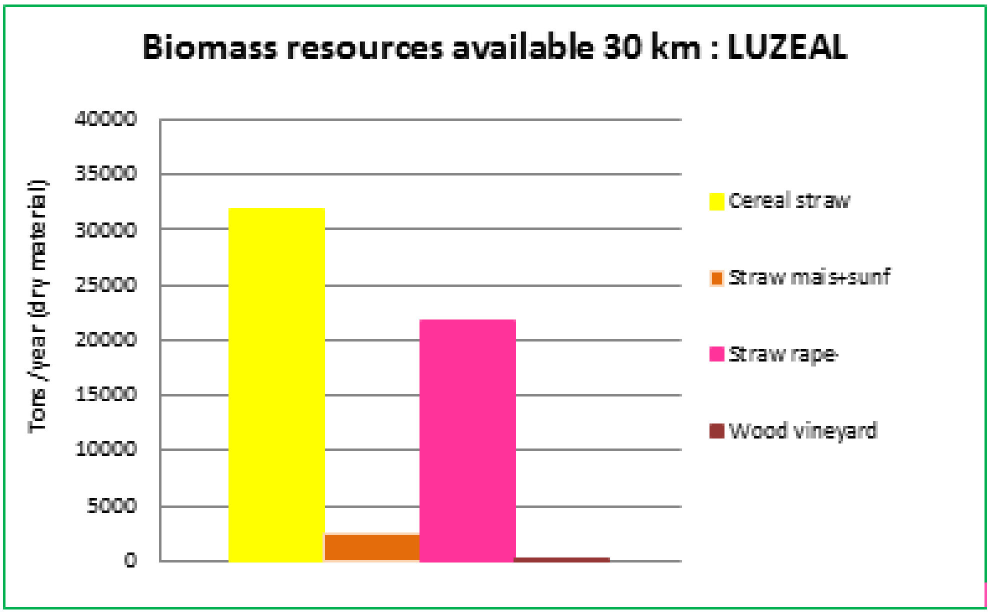

Figure 2: Amount and type of resources available in 30 km radio.

From the analysis of the figure and the interviews hold with the stakeholders (farmers and logistic operators) it can be concluded that:

➢ The quantity of maize stalks is not abundant and harvesting is not a common labour due to the difficulties faced while working in a wet soil in November.

Therefore, it would not be considered as a raw material for the production of solid biomass. In France corn cobs are used as an abrasive so they would also not be considered. the most interesting resources to be taken into account for the logistic centre in order to avoid supply risks are the cereal straw.

- The quantity of vineyard prunings is marginal and the logistical chain for the harvesting and collection is not yet developed in the area. Consequently, it would also not be considered as available feedstock for the logistic centre.
- Availability of cereal is large and its logistics practiced from long ago. It would be considered one of the possible raw materials for the logistic centre although the price varies widely from one year to another.
- Rape is straw should also be considered due to its interesting availability of more than 20,000 t/yr of dry matter. However, it is important to mention that rape straw has a high value as a fertiliser being usually left on the soil for fertilisation purposes and to keep the soil structure. This fact can represent a risk if farmers do not find the means at a reasonable price to compensate the exportation of nutriments. In the biomass assessment study, a 50 % of availability of rape straw taking into consideration sustainable issues (soil) has been considered.

  The harvesting of rape straw should be done while harvesting the rape seeds, which is not a common operation[1]. The main consequence is that the yield of the harvester becomes lower (they employ more time to get the same amount of rape seeds), which can represent also a risk when trying to make a possible supply contract with farmers.

  Due to the mentioned reasons, eventhough the availability is large in the region, the manager does not see a clear opportunity in using this material and it will not be considered in this study.

Therefore, the agricultural residues available for the production of solid biomass would be only cereal straw. The available quantities, moisture content (weight percentage in wet base, w-% ar), months of production and purchasing price including transport are shown in Table 1.

Table 1: Data on the agricultural residues available for agro-pellets production in the cooperative.

Type of residue	Quantity available	Moisture content	Months of harvest	Purchasing price
	t/yr	w-%, ar		€/t (transport included, VAT not included)
Cereal straw	32,000	15	July	67-95 (baled)

[1] In a classic harvesting of rape, the harvester cut just below the seeds part. If straws want be taken out from the field, the harvester should cut lower to get the largest possible of straws. But straws are fresher in the lower parts so that the harvester takes more time to cut them.

As it was mentioned previously and it can be observed, the price of the straw varies widely. The price shown corresponds to the material baled, If the material wants to be purchased in bales but with a reduced stem length of the straw, then 15 €/t should be added. In the feasibility study a price of 75 €/t has been considered since it can be estimated that under a contract this prices can be realistic of the general situation in France.

Additionally, it should be highlighted that appart from using agriculture residues Luzéal-Saint Rémy wishes to consider miscanthus as a possible raw material to be mixed with them since Luzéal-Saint Rémy associates produce this crop. They started to produce it when there was a boom in energy crops policies but later no much use has been given to it. The current availability is 4,400 t/yr.

The prices and availability of sawdust from broadleaved and conifers species have been studied in the region together with the price of wood chips from a mixture of broadleaved and conifers species. These type of high quality products could be required to upgrade the characteristics of the straw depending on the quality aim to be fulfiled. Their moisture content, months of harvest and price is presented in Table 2.

Table 2: Data on non-agricultural residues for the production of mixed agro-pellets in the cooperative.

Type of residue	Moisture content	Months of harvest	Purchasing price (transport included)
	w-%, ar		€/t (VAT not included)
Miscanthus	10	April	110 (bulk)
Sawdust from broadleaves	45	All the year	40(bulk)*
Sawdust from conifers	48	All the year	50(bulk)*
Wood chips (forest origin)	38	All the year	64 (bulk)

*Prices can vary widely frome one year to another

5. Bioenergy market potential

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

Although France is near total independence in the generation of electricity (mainly nuclear), the country remains heavily dependent on fossil fuel imports for heating and transportation. To stimulate sustainable heat, France created a national fund in 2009, *Les Fonds Chaleur*. Those funds have been doubled for the period 2015-2017 (420 million euros) and supported 2,911 projets between 2009 and 2013, including more than 600 biomass projects in the industry, agriculture and services sectors for an annual production of 1,362,501 toe (sept. 2014).

Currently biomass is the leading source of renewable energy consumed in the country (45% of renewable consumption, second in Europe after Germany).

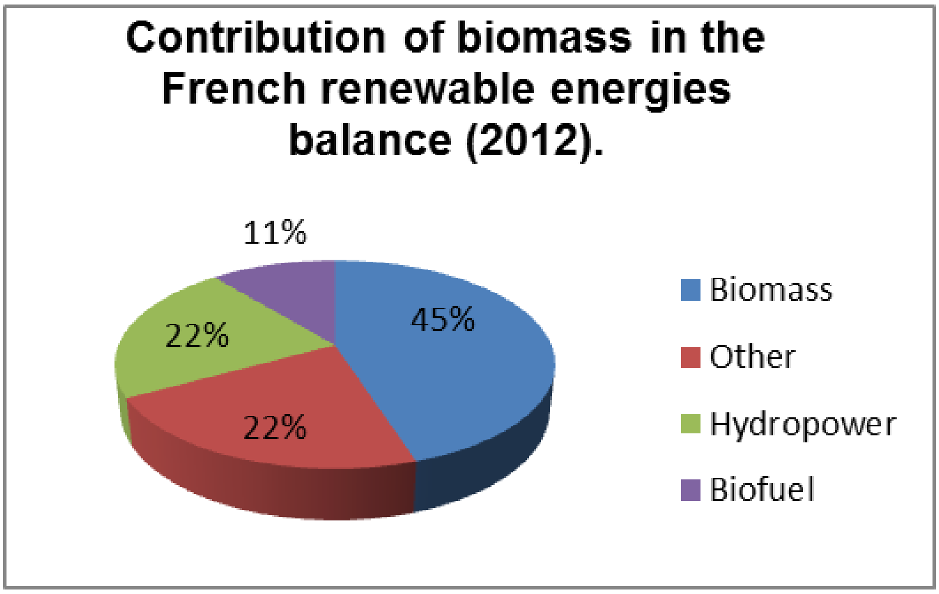

Figure 3 Contribution of renewable energies in the French energy balance (source SOeS).

According to the National Action Plan for renewable energies, renewable heat production should be, in 2020, up to 69.5% from biomass (Source: Ademe). Biomass sector is based mainly on wood energy (wood chips and by-products of sawmill industry).

The agro-pellets market in France is very restricted, no official data are published and only some pilote experiences have been found.

In Champagne-Ardenne, agro-pellets consumers have not been identified, but only some projets using bales of straw. Up to now, the Energy French Agency in the region (ADEME Champagne-Ardenne) and the local farmers have always promoted the biomass coming from forest products. Because of that, wood pellets market is really developed, being household boilers the main consumers.

The technical requirements of boilers using wood feedstock (except the ones that are multi-fuel) do not make possible to use agro-pellets. Therefore, in the case of Luzéal-Saint Rémy agro-pellets production the main target consumers would be industrial boilers. Those, are able to use a broader range of biomass. Nevertheless, tests to figure out the behaviour of agro-pellets in industrial boilers should be carried on.

The project has identified about 40 boilers in a radius of 50 km from Luzéal-Saint Rémy selected site with an estimated consumption of around 150,000 t/yr using mostly wood chips (Figure 4). The majority of the boilers are installed in public buildings (schools, hospitals, etc) (Figure 5).

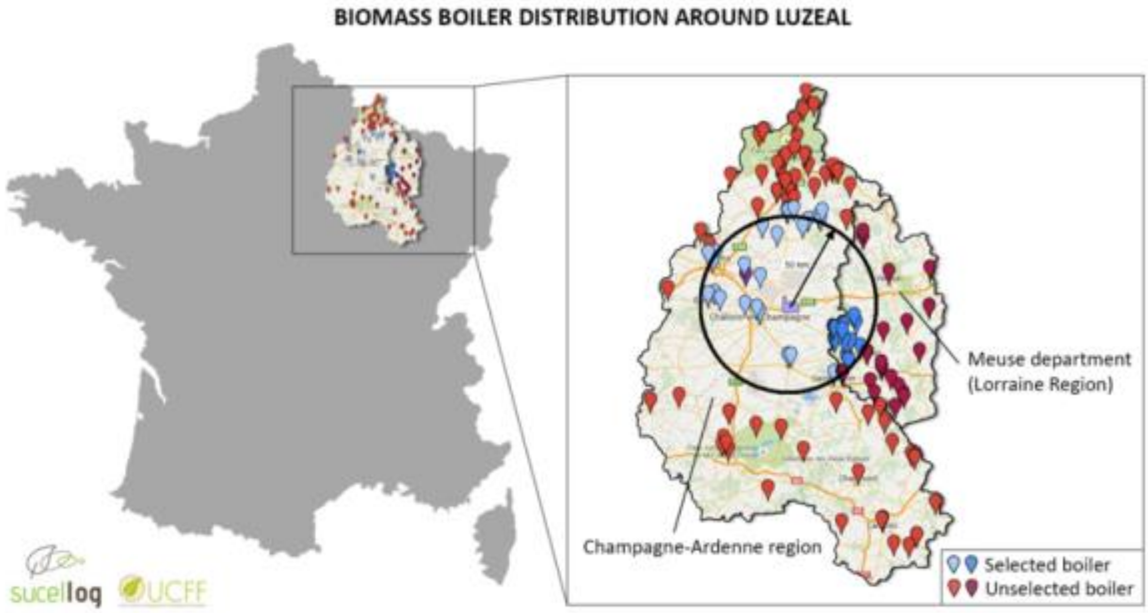

Figure 4: Biomass boiler distribution around Luzéal-Saint Rémy (Source : UCFF-GCF).

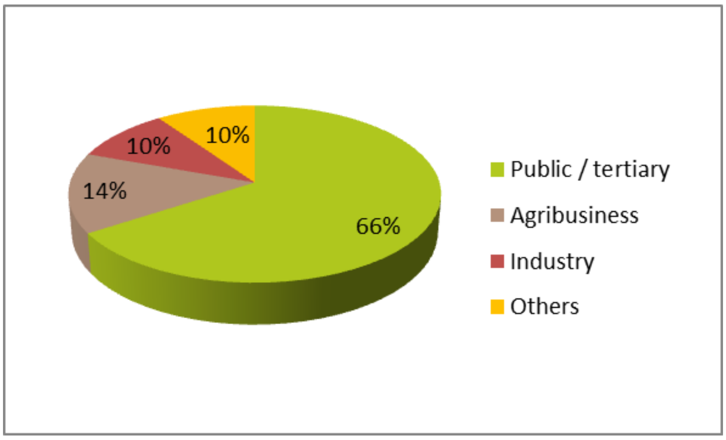

Figure 5: Biomass boilers activity sectors (Source : UCFF-GCF).

From those 40 boilers, the project would mainly focus on the 15 % that consumes the 79 % of the bioenergy market (see Figure 6). In this Figure, four classes of boilers according to their consumption in a radious of 50 km from the selected site are represented (A,B,C and D) and their share of contribution to the total consumption.

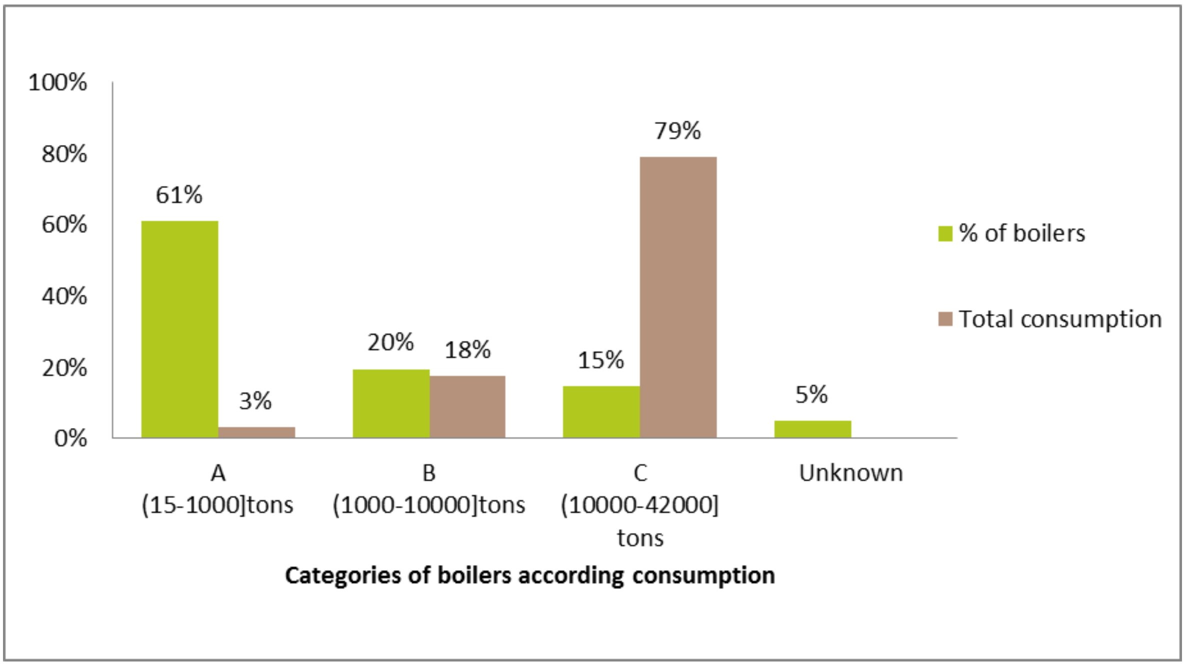

Figure 6: Boiler classes and share of consumption (Source: UCFF-GCF).

According to some interviews conducted throughout the project, some energy companies producing heat (main managers of industrial boilers in France), would be eventually interested to use agro-pellets if they are both conform with their quality requirements (ash content, emissions, combustion behaviour) and economically competitive.

The types of solid biomass that are used in the region and that can be considered as competing products are shown in Table 3.

Table 3: Different solid biomass types consumed in the region of Luzéal-Saint Rémy.

Type of residue	Purchasing price (transport included)	Moisture content	Price
	€/t (VAT not included)	w-%, ar	€/MWh
Wood chips (forest origin)	100	38	33
Wood pellets	250	10	50-60
Agro-pellet Calys [2]	175	10	37

[2] Calys agro-pellets are good quality agro-pellets.

6. Technical assessment of the facility

The technical assessment will be conducted based on the logistical components which are needed for the new business line. The 2 lines of alfalfa pellet production can be used for the production of solid biomass according to necessities. **Figure 7** shows the flow diagram of the current alfalfa production facility. The equipment that would be used for the new business line as biomass logistic centre is highlighted in this diagram and explained in detail in the following sub-sections.

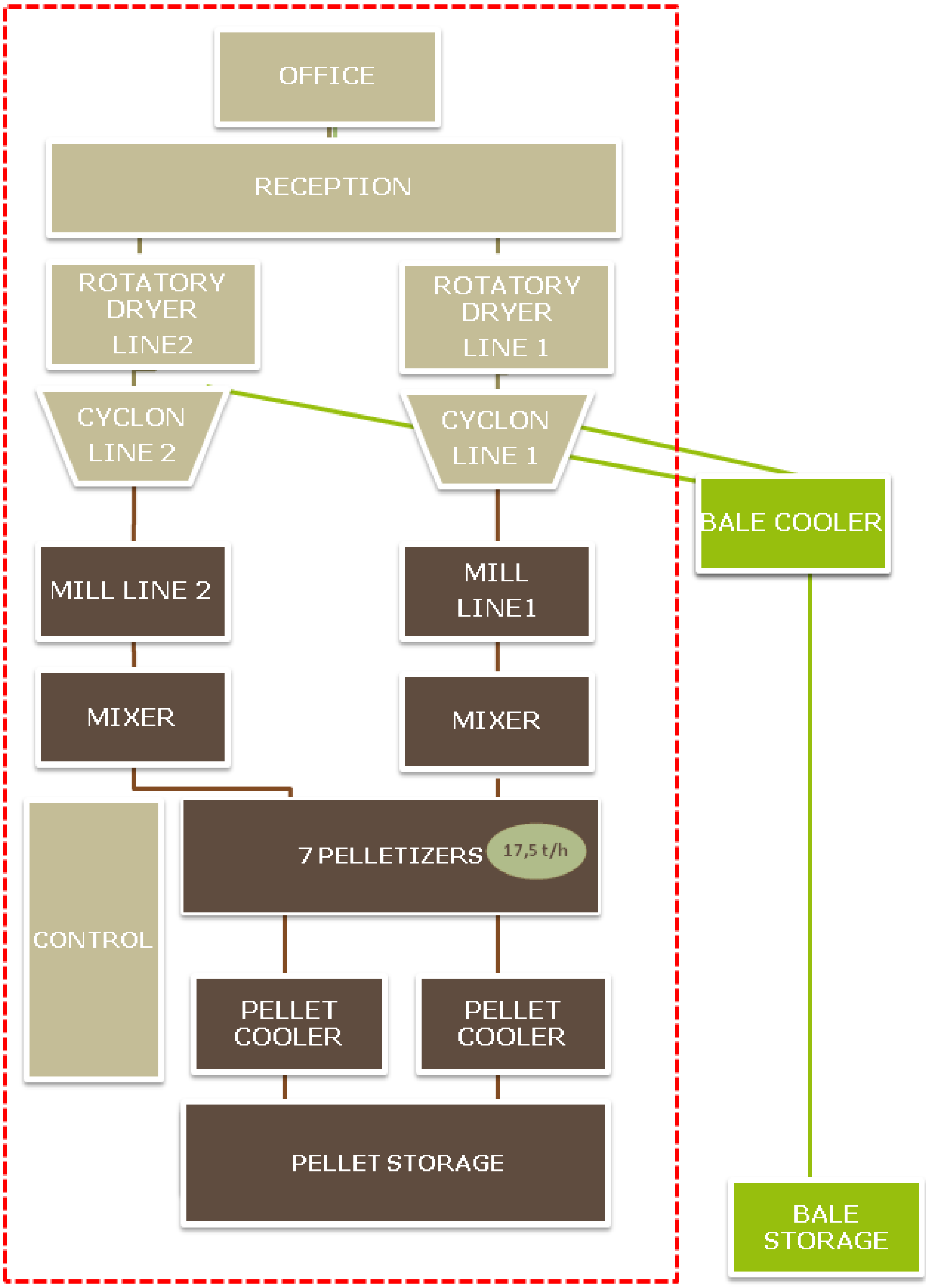

Figure 7: Flow diagram of the current alfalfa pellet production lines.

6.1. Particle size reduction

At the site of Saint-Rémy, currently the cooperative does not own a device in the site to reduce the size of alfalfa since the material arrives to the facility already with the proper particle size. However, for the logistic centre, there would be a need to reduce the particle size of straw and wood chips. A tube grinder is available in another site and could be installed, being totally available for the logistic centre production.

6.2. Drying

The cooperative at the site of Saint-Rémy owns 2 dryers used for the dehydration of alfalfa, one for each line. The project assumes that cereal straw material do not need to be dried in the logistic centre as they are usually left on the soil before harvesting to be dried naturally to 15 % moisture content. Further drying would take place during the storage. Miscanthus also do not need drying. If sawdust and wood chips are used, they would be the only material to be dried before pelletization.

6.3. Milling and pelletising

The cooperative at the site of Saint-Rémy owns 2 milling devices and 7 identical pelletisers used for pelletising alfalfa. The same mills and pelletisers can be used to make the agro-pellets.

6.4. Storage

The cooperative at the site of Saint-Rémy have different storage areas available for the development of the activity. As it can be observed from **¡Error! No se encuentra el origen de la referencia.**, the capacitity is not really high, considering that both the bales and pellets should be stored. Since the purchasing of new silos or additionaln areas is not planned according to Luzéal-Saint Rémy, both on-field storage and production under demand should be fostered.

6.5. Heat generation

The cooperative at the site of Saint-Rémy owns two burners for the dehydration processes the company, one which runs on coal and supply heat to Line 1 and the other one which runs on a mixture of coal and a percentage of bulk miscanthus supply heat to Line 2.

6.6. Maximum capacity for the logistic centre

The maximum capacity of each whole line for alfalfa is 17.5 t/h. It is important to highlight that the line does not work with the same capacity with another type of material different from alfalfa because of the difference in fibre structure and density.

According to the technical responsible of the alfalfa line, the capacity could reach:

- 14 t/h for cereal straw
- 14 t/h for miscanthus
- 8 t/h for wood

These are the flows that would be considered from now on on the feasibility study for the logistic centre.

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

The company is interested in starting a new business as a biomass logistic centre producing 10,000 t/yr of mixed agro-pellets to be sold in the market. In order to start this new business, it is important to check whether this process would be economically and technically feasible and sustainable.

As a previous step, a quality assessment is needed to check if the raw material quality is convenient for achieving agro-pellets according to the standard in force (ISO 17225-6). This will be detailed in the following section.

7.1. Quality assessment of the agro-pellets

As mentioned before, a first approach for this study, it is necessary to clarify the quality parameters for the solid biomass which the company aims to produce.

Nowadays, there is an international standard ISO 17225 which normalizes every category of solid biomass.

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 type of solid biofuels. For instance, a 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 warranty of his product.

This study will focus on ISO 17225 – 6 for the quality of solid biomass to be studied but also on ISO 17225 – 4 and ISO 17225 – 2 in order to compare the quality with other solid biomass currently in the market. Quality requirements are shown in Table 4.

Table 4: Quality parameters for these 3 types of biofuels.

ISO 17225	Wood Pellets ISO 17225-2 A1	Wood Pellets ISO 17225-2 A2	Wood Pellets ISO 17225-2 B	Wood Chips ISO 17225-4 A1	Wood Chips ISO 17225-4 A2	Wood Chips ISO 17225-4 B	AGROPELLETS ISO 17225-6 A	AGROPELLETS ISO 17225-6 B
Moisture (w-% ar)	≤ 10	≤ 10	≤ 10	≤ 10 ≤ 25	≤ 35	be mentionned	≤ 12	≤ 15
LHV (kWh/kg, ar)	≥ 4,6	≥ 4,6	≥ 4,6	be mentionned	be mentionned	be mentionned	≥ 4	≥ 4
Ash (w-% db)	≤ 0,7	≤ 1,2	≤ 2	≤ 1	≤ 1,5	≤ 3	≤ 6	≤ 10
N (w-% db)	≤ 0,3	≤ 0,5	≤ 1	-	-	1,00	≤ 1,5	≤ 2
S (w-% db)	≤ 0,03	≤ 0,05	≤ 0,05	-	-	0,10	≤ 0,2	≤ 0,3
Cl (w-% db)	≤ 0,02	≤ 0,02	≤ 0,03	-	-	0,05	≤ 0,1	≤ 0,3
As (mg/kg)	≤ 1	≤ 1	≤ 1	-	-	1,0	≤ 1	≤ 1
Cd (mg/kg)	≤ 0,5	≤ 0,5	≤ 0,5	-	-	2,0	≤ 0,5	≤ 0,5
Cr (mg/kg)	≤ 10	≤ 10	≤ 10	-	-	10,0	≤ 50	≤ 50
Cu (mg/kg)	≤ 10	≤ 10	≤ 10	-	-	10,0	≤ 20	≤ 20
Pb (mg/kg)	≤ 10	≤ 10	≤ 10	-	-	10,0	≤ 10	≤ 10
Hg (mg/kg)	≤ 0,1	≤ 0,1	≤ 0,1	-	-	0,1	≤ 0,1	≤ 0,1
Ni (mg/kg)	≤ 10	≤ 10	≤ 10	-	-	10,0	≤ 10	≤ 10
Zn (mg/kg)	≤ 100	≤ 100	≤ 100	-	-	100,0	≤ 100	≤ 100
shrinkage starting temp. (°C)	be mentionned	be mentionned	be mentionned	-	-	-	be mentionned	be mentionned
deformation temp. (°C)	be mentionned	be mentionned	be mentionned	-	-	-	be mentionned	be mentionned
hemisphere temp. (°C)	be mentionned	be mentionned	be mentionned	-	-	-	be mentionned	be mentionned
flow temp. (°C)	be mentionned	be mentionned	be mentionned	-	-	-	be mentionned	be mentionned

The comparison of the quality parameters of the possible raw materials with respect to ISO 17225 – 6 standards is therefore essential. Indeed, possible limiting factors that prevent the use of the raw materials to produce solid standardised agro-fuels should be identified. For that reason representative samples of the possible raw materials were collected to Luzéal-Saint Rémy and sent to RAGT for their analysis on ash content, heating value, Chlorine, Nitrogen and Sulfur contents.

A comparison with the information from RAGT bank of knowledge shows that values from the samples analised are between the minimum and maximum stated by RAGT experience. However, the results showed in the case of straw important differences concerning Sulfur and Chlorine contents in comparison with the average value from ISO 17225-1, being considerably lower. Therefore, in this study a minimum and maximum value of ash and Sulfur contents coming from RAGT database will be subject of analysis in the scenarios.

Table 5 shows the different quality parameters of cereal straw, wood and miscanthus together with the standard guidelines for their comparison. The necessity with mixtures with wood or miscanthus to improve quality will be evaluated.

Table 5: Quality of possible raw materials and guidelines from ISO 17225 – 6 standard.

FRENCH CASE - Luzeal	Cereal Straw				Miscanthus		Wood		AGROPELLETS ISO 17 225-6 A	AGROPELLETS ISO 17 225-6 B
Data source	RAGT Bank of knowledge		Value ISO 17225	Luzeal sample	Luzeal sample	Value ISO 17225	SAWDUST: Luzeal sample	CHIPS: ISO 17225-4		
	Mini.	Maxi.	Average	Value	Value	Average	Value	Value	Value	Value
Moisture (en %)	8,69	12,60	5,00	9,80	8,30	10,00	6,57	35,00	≤ 12	≤ 15
LHV (kWh/kg, ar) at 10% moisture	4,23	4,39	4,33	4,28	4,40	4,34	4,54	4,43	≥ 4	≥ 4
Ash (w-% db)	2,94	8,20	5,00	5,61	2,86	4,00	1,37	3	≤ 6	≤ 10
N (w-% db)	0,41	4,16	0,80	0,54	0,25	0,70	0,14	1	≤ 1,5	≤ 2
S (w-% db)	0,08	0,14	0,30	0,09	0,02	0,20	0,02	0,1	≤ 0,2	≤ 0,3
Cl (w-% db)	0,04	0,24	0,40	0,13	0,02	0,20	0,01	0,05	≤ 0,1	≤ 0,3
As (mg/kg)	0,10	1,00	-	-	-		-	-	≤ 1	≤ 1
Cd (mg/kg)	0,40	0,48	-	-	-		-	-	≤ 0,5	≤ 0,5
Cr (mg/kg)	1,00	14,80	-	-	-		-	-	≤ 50	≤ 50
Cu (mg/kg)	3,20	10,00	-	-	-		-	-	≤ 20	≤ 20
Pb (mg/kg)	0,50	5,41	-	-	-		-	-	≤ 10	≤ 10
Hg (mg/kg)	0,10	0,10	-	-	-		-	-	≤ 0,1	≤ 0,1
Ni (mg/kg)	1,50	4,80	-	-	-		-	-	≤ 10	≤ 10
Zn (mg/kg)	7,40	38,40	-	-	-		-	-	≤ 100	≤ 100
Ash softening Temperature (ºC)	907	1066							to be mentioned	to be mentioned

According to this table, it can be said that:

- Agro-pellets graded ISO 17225–6 A cannot be produced with 100 % of cereal straw because the maximum value of ash content and Chlorine content of this raw material is higher than the limit. Consequently the only way to produce an agro-pellet graded ISO 17225 – 6 A is to use a blend with other raw materials with less ash and Clhorine content.

  Evaluating the rest of raw materials to be blended (sawdust, wood chips and miscanthus) a maximum limit of 60 % cereal straw is required to achieve quality Class A. The minimum share of the rest of raw materials (miscanthus, sawdust and wood chips) is therefore 40 %.

- Regarding the production of agro-pellets graded ISO 17225 – 6 B the use of 100% of cereal straw is possible to satisfy quality requirements. All these quality issues will be considered in the economic assessment in order to suggest the possible scenarios to be studied.

7.2. Economic assessment

At a first stage, an assessment of investment costs, purchasing costs of agricultural residues and other raw material, the pre-treatment, personnel and other costs will be determined. At a second stage the revenue from selling the produced solid biomass will be assessed in order to finally determine the possible profit per unit and the total profit.

It is important to mention that this feasibility study takes into consideration only the activities of the new business line and all what is related to these activities.

7.2.1. Investment costs

Cereal straw can be purchased without a need to further particle size reduction but if this is not available and in order to reduce their particle a machine owned by the cooperative but present in another site would have to be transported and set up in the site of the logistic centre. This would result in a cost of around 100,000 € which, according to Luzéal-Saint Rémy, should be paid back in 4 years. The same machine can be used to chip wood.

7.2.2. Purchasing costs

The agricultural residues needed for the new business would be purchased from farmers and straw traders located in the vicinity of the cooperative (maximum 30 km away).

Based on the quality assessment (section 7.1), 5 types of agro-pellets can be produced. Therefore the following 5 production scenarios would be considered:

- Scenario **MSM-A**: Production of mixed cereal straw (60 %) and miscanthus (40 %) Class A agro-pellets
- Scenario **MSS-A**: Production of mixed cereal straw (60 %) and sawdust (40 %) Class A agro-pellets
- Scenario **MSW-A**: Production of mixed cereal straw (60 %) and wood (40 %) Class A agro-pellets
- **Scenario MSMS-A:** Production of mixed cereal straw (50 %), miscanthus (25 %) and sawdust (25 %) Class A agro-pellets. This is a scenario suggested by the agro-industry.
- Scenario **SP-B**: Production of cereal straw (100%) Class B agro-pellets

Table 6 shows the total costs of the required residues including the transportation to the logistic centre. In order to produce the desired respective amounts of solid biomass in each scenario, the quantities of raw material to be purchased should be higher as the moisture content of the raw material is higher than the produced product. Cereal straw, miscanthus, sawdust and wood chips are purchased at a moisture content of 15 %, 12 %, 45 % and 35 % respectively. The pellets produced must have 10 % moisture content. Table 6 and Table 7 shows the quantities of raw materials to be purchased in each scenario and their costs.

Table 6: Cost of raw material to be purchased in the scenarios producing Class A agro-pellets.

Residue type	Mixture	Quantity for final product	Quantity of raw material	Unit price including transport without taxes	Total costs
	%	t	t	€/t	€
Scenario MSM-A					
Cereal straw	60	6 000	6 353	75	476 471
Miscanthus	40	4 000	4 091	110	450 000
Total		**10 000**	**10 444**		**926 471**
Scenario MSS-A					
Cereal straw	60	6 000	6 353	75	476 471
Sawdust	40	4 000	6 545	50	327 273
Total		**10 000**	**12 898**		**803 743**
Scenario MSW-A					
Cereal straw	60	6 000	6 353	75	476 471
Wood chips	40	4 000	5 538	64	354 462
Total		**10 000**	**11 891**		**830 932**
Scenario MSMS-A					
Cereal straw	50	5 000	5 294	75	397 059
Miscanthus	25	2 500	2 557	110	281 250
Sawdust	25	2 500	4 091	50	204 545
Total		**10 000**	**11 942**		**882 854**

Table 7: Cost of raw material to be purchased in the scenarios producing Class B agro-pellets.

Residue type	Mixture	Quantity for final product	Quantity of raw material	Unit price including transport without taxes	Total price
	%	t	t	€/t	€
Scenario SP-B					
Cereal straw (15%w)	100	10 000	10 588	75	**709 118**
Total		**10 000**	**10 588**		**709 118**

7.2.3. Pre-treatment costs

After purchasing the residues, they need to be pre-treated before being sold as agro-pellets: The pre-treatment include: Particle size reduction, drying, milling and pelletising.

- Cereal straw purchased at 15 % moisture content do not need to be dried but before milling and pelletising should be subject of a particle size reduction in a tub grinder that would serve as well to destroy the bale.

- Miscanthus purchased at 10 % moisture content do not need to be dried or pass through a particle size reduction process, going directly to the mill.
- Sawdust and wood chips, purchased at 45 % and 30-40 % moisture content respectively and which would be mixed with cereal straw, require drying to achieve 13 % moisture content before pelletising. Wood chips would need a previous reduction of particle size before the drying process in the tub grinder.

7.2.4. Personnel and other costs

During the idle period some workers are moved to other plants in order to continue working since contract of part-time workers ends with the beginning of the idle period. Due to that, Luzéal-Saint Rémy would be interested in both to be able to keep their workers in the same location during the whole year and make permanent their part-time workers.

7.2.5. Production costs

The production cost, is the sum of:

- purchasing costs,
- pre-treatment costs,
- personnel and other costs,

It represents the minimum price at which the product should be sold in order to cover the expenses. Table 8 and Table 9 shows the production costs of the agro-pellets in the different scenarios.

Table 8: Production costs of the agro-pellets class A in the different scenarios.

Type of Scenario	Quantity produced	Purchasing cost	Pretreatment costs	Production cost
	t	€/t	€/t	€/t
MSM-A	10 000	93	55	**148**
MSS-A	10 000	80	61	**141**
MSW-A	10 000	83	67	**150**
MSMS-A	10 000	88	56	**144**

Table 9: Production costs of the agro-pellets class B in the different scenarios.

Type of Scenario	Quantity produced	Purchasing cost	Pretreatment costs	Production cost
	t	€/t	€/t	€/t
SP-B	10 000	79	65	**144**

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 investment cost of the machine for straw and wood chips particle reduction will be amortised on 4 years. This investment will be considered in all scenarios. Storage and transport price has been estimated to be in this case 10 €/t (mobile floow tracks).

The revenue is the sum of money received when the products are sold. The revenue varies according to the selling price. Since the products offered by the agro-industry logistic centre do not have a real market price yet, an estimation has been made taking into consideration the price of the products that can be competing in terms of quality (calorific value, bulk density and ash content), which in case of class A, is agro-pellet Calys sold at 170 €/t. The agro-pellet class B should not be sold at more than 130 €/t.

Table 10 and Table 11 shows the cost price, profit per unit and the total revenue of agro-pellets class A and class B. Looking at the profit figures, it can be concluded that only scenario MSW-A is not economically feasible with a profit of -3 €/t. The rest of scenarios are economically feasible, being the most interesting the MSS-A with a profit of 7 €/t.

Table 10: Cost price, profit and revenue of agro-pellets class A in the different scenarios.

Type of Scenario	Quantity produced	Amortisa_ tion cost	Production cost	Storage cost	Transport cost	Cost price	Selling price	Profit	Total revenue
	t	€/t	€/t	€/t	€/t	€/t	€/t	€/t	€/t
MSM-A	10,000	3	**148**	10	10	170	170	0	1 700 000
MSS-A	10,000	3	**141**	10	10	163	170	7	1 700 000
MSW-A	10,000	3	**150**	10	10	173	170	-3	1 700 000
MSMS-A	10,000	3	**144**	10	10	167	170	3	1 700 000

Table 11: Cost price, profit and revenue of agro-pellets class B in the different scenarios.

Type of Scenario	Quantity produced	Amortisa_tion cost	Production cost	Storage cost	Transport cost	Cost price	Selling price	Profit	Total revenue
	t	€/t	€/t	€/t	€/t	€/t	€/t	€/t	€/t
SP-B	10,000	3	144	10	10	167	130	-37	1 300 000

7.2.7. Total profit

Since the scenario MSS-A is the most profitable, the total profit of only this scenario will be shown (Table 12).

Table 12: Total profit of scenario MSS-A.

		Year 1-4	From Year 5
Expenses (€)	**Investment costs**	25 000	0
	Purchasing costs	830 932	830 932
	Pretreatment costs	605 365	605 365
	Storage cost	100 000	100 000
	Transportation cost of sales	100 000	100 000
Income (€)	**Sales revenue**	1 700 000	1 700 000
	Savings	0	0
Profit (€)		65 892	90 892

7.3. Risk asessment

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.

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 have been evaluated, even if the economic assessment has proved that some of them are not feasible.

As it was mentioned in section 7.1, the price of the product depends on its quality. This means that not only the comparison in terms of €/t should be evaluated but in terms of price per kWh and storage necessities. Table 13 and Table 14 show their prices regarding their quality characteristics.

Table 13: Main quality characteristics and prices of the competing products.

	Quality characteristics			Prices		
	LHV (kWh/kg ar)	Bulk density (kg/m³)	Ash content (w-% db)	€/t Transport included, VAT excluded	€/kWh	€/m³
Forest wood chips	2.92	250	≤ 3	100	0.034	25
Wood Pellets	4.80	650	≤ 0.7	250	0.052	163
Agro Pellets Calys	4.75	650	≤ 5	175	0.037	114

Table 14: Products quality characteristics and estimated prices.

	Quality characteristics			Prices		
	LHV (kWh/kg ar)	Bulk density (kg/m³)	Ash content (w-% db)	€/t	€/kWh	€/m³
Mixed pellets of cereal sraw (60 %) and miscanthus (40 %) Scenario MSM-A	4,34	650	4,23	170	0,039	111
Mixed pellets of cereal sraw (60 %) and sawdust (40 %) Scenario MSS-A	4,39	650	3,63	163	0,037	106
Mixed pellets of cereal sraw (60 %) and wood Chips (40 %) Scenario MSW-A	4,35	650	4,28	173	0,040	112
Mixed pellets of cereal sraw (50 %), miscanthus (25 %) and sawdust (25 %) Scenario MSMS-A	4,38	650	3,63	167	0,038	109
Pellets of cereal Straw (100%) Scenario SP-B	4,30	650	5,14	167	0,039	109

From the comparison of prices, the conclusions about possible risks that the selling of these biomasses can face are the following:

- The final Agropellet mixed 60% of cereal straw and 40% sawdust (scenario MSS-A) has a price per kWh of 0.037 € which is the more competitive compared to the others formulas. Moreover, the price cost is competitive compared to wood pellets and in the same range of value compare to the agro-pellet Calys. In addition, the space storage requirement for feeding a 50 kW boiler is more than 5 times less important than wood chips (see Table 15).

- The agropellets mixed with 100% of cereal straw is not suitable because the price is too high for an standardized agro pellets quality B.

Finally; it is necessary to say that the quality of raw material is variable. So, the cooperative need to make a sampling plane of their raw material to avoid quality problem during the production process. In addition, it is important to make some previous tests in several boilers to agree on the final formula. Possible additive adjunction may be needed to prevent slagging formation.

Table 15: Storage required for the same energy consumption.

	Biofuel characteristics		Quantity needed for boiler 50 kW (90 000 kWh / year)			
	LHV (kWh/kg ar)	Bulk density (kg/m3)	t	m3	load factor (%)	m3 final needed
Forest wood chips	2,92	250	31	123	60%	205
Wood Pellets	4,80	650	19	29	85%	34
Agro-pellet Calys	4,75	650	19	29	85%	34
Mixed pellets of cereal sraw (60 %) and miscanthus (40 %) Scenario MSM-A	4,34	650	21	32	85%	38
Mixed pellets of cereal sraw (60 %) and sawdust (40 %) Scenario MSS-A	4,39	650	21	32	85%	37
Mixed pellets of cereal sraw (60 %) and wood Chips (40 %) Scenario MSW-A	4,35	650	21	32	85%	37
Mixed pellets of cereal sraw (50 %), miscanthus (25 %) and sawdust (25 %) Scenario MSMS-A	4,38	650	21	32	85%	37
Pellets of cereal Straw (100%) Scenario SP-B	4,30	650	21	32	85%	38

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 16.

Table 16: 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

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

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.

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 Luzéal-Saint Rémy, 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 Luzéal-Saint Rémy, the working rights are all reserved. When dealing with biomass raw material, the workers wear masks as the risk of inhaling dust particles which can cause severe health issues is high. 2 women are working in the administrative department of the cooperative.

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 smallholders.

The concept of the 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 will 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 of cereal 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.

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 Luzéal-Saint Rémy, the GHG reduction is higher than 35 %. For the calculation, the option *“pellets from straw”* was selected since the tool does not have the possibility of evaluating a mixed pellet. The whole logistics chain of the raw material has been considered in the analysis: harvesting and transport of the raw material (maximum 60 km distance), pre-treatment, transport of the product (maximum 60 km distance) and final conversion. The most adequate values from the ones reflected by the tool have been chosen in each case for the calculation.

8. Conclusion

Luzéal-Saint Rémy is an cooperative located in Champagne-Ardenne whose main activities are the production of fodder pellets from alfalfa as well from beet pulp and corn. Luzéal-Saint Rémy also produces bales of dehydrated alfalfa. The cooperative is interested in creating a biomass logistic centre and producing solid biomass from the agriculture residues produced in the area and if possible from their associates.

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

- The agrarian residues available for the logistic centre are mainly cereal straw and rape straw. In both cases, their quantity produced yearly in a radio of 30 km, is significant (higher than 20,000 t/yr). However, since rape straw is a valuable product for soil nutrition and not so easy to harvest, this study has only considered the cereal straw as possible raw material in order to avoid a risk of supply for the logistic centre.
  Additionally, associates from Luzéal-Saint Rémy produce miscanthus, which have been considered together with sawdust and wood chips as possible raw materials.
- The current biomass market in the area does not present a significant amount of agro-fuels but only minor quantities. Forest derived fuels are widely used. The potential consumers of Luzéal-Saint Rémy logistic centre would be industrial boilers as well as those installed in public buildings, which can assume lower quality fuels.
- The 2 current alfalfa production lines can be used for the pre-treatment of the solid biomass. Minor modifications should be made in the pelletisers and a tub grinder (available in another company site) should be installed at the beginning of the production lines to break the straw bales and feed the line.

The quality assessment has shown that to produce agro-pellet Class A, a 40 % of non-agrarian feedstock (miscanthus, sawdust and wood chips) should be included in a blend with cereal straw. This result is based on chemical composition of real samples provided by Luzéal-Saint Rémy from straw, miscanthus and sawdust. The feasibility study has evaluated all the possible scenarios of pellet blends, being the one of 60 % straw- 40 % sawdust, the one in which the production costs are lower. If considering a selling price of 163 €/t (0.037 €/kWh; meaning a profit of 7 €/t produced), the product would be competitive compared to wood pellets and, in the same range of value, compare to the agro-pellet Calys. In addition, the space storage requirement for feeding a 50 kW boiler is more than 5 times less important than wood chips.

It is important to highlight the necessity to make a previous quality analysis (mainly determination of moisture content, calorific value, ash content and Chlorine percentage) of a representative sample of the straw to be used as 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 slagging formation for example). Both can therefore change the share of straw vs other materials and, consequently, the costs associated to the production.

A business model has been developed by the SUCELLOG project with new proposals for the new activity as logistic centre producing Class A mixed agro-pellets (straw 60 %, sawdust 40 %) (see the document D4.4 available on the website).

The use of straw and miscanthus for the production of Class A mixed agro-pellets 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).