INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors

D6.2.1 Country Report Spain

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ABBREVIATIONS

AECOSAN: Spanish Agency of Consumption, Food Security and Nutrition

AEE: Extremeña Energy Agency

AEFA: Spanish Association of Manufacturers of Dehydrated Alfalfa

AICA: Food Information and Control Agency

APPA: Association of Renewable Energy Producers

AVEBIOM: Spanish Association of Energy Valorization of Biomass

CESFAC: Spanish Confederation of Compound Feedstuffs Manufacturers for Animals

CIEMAT: Centre for Energy, Environmental and Technological Research

EAFRD: European Agricultural Fund for Rural Development

EIP-Agri: Agricultural European Innovation Partnership

EU: European Union

ENVIFOOD Protocol: Environmental Assessment of Food and Drink Protocol

FEFAC: European Feed Manufacturers' Federation

IBLC: Integrated Biomass Logistic Centre

INTERAL: Interbranch Organisation of Spanish Animal Feed

LCA: Life Cycle Assessment

LHV: Low Heating Value

MAPAMA: Ministry of Agriculture and Fisheries, Food and Environment

OILCA: Olive Oil Life Cycle Assessment

PNDR: Spanish National Program of Rural Development

R&D: Research and Development

R&D&I: Research and Development and Innovation

SCP: Sustainable Consumption and Production

TPOMW: Two-Phases Olive Mill Waste

PARTNERS SHORT NAMES

CIRCE: Fundación CIRCE

WFBR: Wageningen Food & Biobased Research

ZLC: Fundación Zaragoza Logistics Centre

CERTH: Ethniko Kentro Erevnas Kai Technologikis Anaptyxis

RISE: RISE Research Institutes of Sweden AB

CREA: Consiglio per la Ricerca in Agricoltura e L'analisi dell' Economia Agraria

APS: Agroindustrial Pascual Sanz S.L

NUTRIA: Anonymi Biomichaniki Etairia Typopiisis Kai Emporias Agrotikon

LANTMÄNNEN: Lantmännen Ekonomisk Forening

Processum: RISE Processum AB

SPANISH CO-OPS: Cooperativas Agro-alimentarias de España. Sociedad Cooperativa

INASO: Institouto Agrotikis Kai Synetairistikis Oikonomias INASO PASEGES

AESA: Agriconsulting Europe S.A

UCAB: Association Ukrainian Agribusinessclub

UBFME: University of Belgrade. Faculty of Mechanical Engineer

EXECUTIVE SUMMARY

Spanish agro-industry has a great potential for the start-up of new lines related with the processing of biomass and, thus, for the implementation of Integrated Biomass Logistic Centres (IBLCs). Overall Spanish agro-industries of the targeted sectors (wine, olive oil, grain chain, feed & fodder and vegetable oil) are featured by their small size. Despite this, a small part of those enterprises have a considerable size (and thus, are expected to manage and generate relevant amounts of residues), an important workforce and investment capacity. Besides, there are several industries which already have fully (distilleries, olive pomace oil industries, fodder dehydrators) or partially (grain dehydrators, vegetable oil extractors) compatible equipment with the processing of biomass, which could reduce needed investments if any idle period would be available.

Even those industries that do not possess any available equipment with the processing of biomass (wine cellars, oil mills, semolina and flour industries, animal feed manufacturers, rice and cereal warehouses, breweries) have great chances of becoming IBLCs as they own many other assets (workforce, means of transport, storage sites, etc.) very useful for the IBLC activity. However, given the reduced size of the industries, a centralised collection of the residues could enhance the possibilities of success.

As a general statement it has been noticed that the analysed sectors have shown great strength to face the economic crisis started in 2008 and the following years. Thus, it is expected that these sectors will have a relative steadiness in the following years or even growth in some of the cases. Besides, when considering the European frame, most of these sectors stand out accounting their productions among the highest, proving their significance not only at national level but international one.

According to the Ministry of Agriculture and Fisheries, Food and Environment (MAPAMA), around 11 % of total national production could be generated by means of the agricultural residues produced, showing the great potential that this type of residues has in Spain [MAPAMA, 2012]. Despite of this estimation, it must be considered that not all the agricultural biomass is always available due to the variability among the harvests, yields obtained and other destinies more profitable or with better opportunities in terms of market and stability. In addition, for the exploitation of the agricultural biomass residues, the agro-industries should be able to match their idle periods or to create totally new business lines, which in some cases is difficult due to short idle periods or lack of willingness at the time of investing in the new activities [SPANISH CO-OPS].

Regarding the biocommodities market, most of the sectors have shown opportunities to develop new business lines where the biomass could be processed for obtaining biocompounds or other bio-products that are going to be transformed, addressing pharmaceutical, cosmetic, food or other related industries. However, despite the fact that many feasible products have been identified, a low market activity has also been detected and higher investments are expected in most cases, which very often provokes that the industries prefer other types of valorisations.

The Commission's proposal for a recast of the Renewable Energy Directive, published on 30 November 2016 as part of the “clean energy for all Europeans” package sets a binding European Union target of 27 % RES in final energy consumption by 2030. However, agriculture-based biofuels, bioliquids and biomass fuels must not come from land with high biodiversity value or with high carbon stock or peatland. Therefore, the binding EU target provides the opportunity to the agro-industries to diversify their business activities through the implementation of sustainable IBLCs paralleling to encouraged initiatives by the administration [EPRS, 2017].

In addition, it has to be remarked that bioenergy productions sites will have different requirements according to their production. Therefore, in the previous mentioned recast of the Renewable Energy Directive it is stated that biomass fuels need to fulfil the sustainability and GHG savings criteria only if used in installations producing electricity, heating and cooling or fuels with a fuel capacity of 20 MW and above in case of solid biomass fuels and 0.5 MW and above in case of gaseous biomass fuels. Electricity from biomass fuels, produced in installations with a fuel capacity of 20 MW and above, would have to be produced with high-efficient cogeneration technology as defined in the Energy Efficiency Directive 2012/27/EU [EPRS, 2017].

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1 Introduction

AGROinLOG supports the demonstration of Integrated Biomass Logistic Centres (IBLC) for food and non-food products, evaluating their technical, environmental and economic feasibility. For the European agribusiness (primary and processing sector) the occasion arises to benefit from their position in a sector that has a unique opportunity and potential to develop an infrastructure that enables the supply of biomass feedstock to a new and emerging biobased industry (also including biofuels and bioenergy).

This report is part of the Deliverable 6.2 – Basic analysis of targeted agricultural sectors of AGROinLOG Project, which studies several pre-identified high priority agricultural sectors (per participant country and for the overall EU-28) that are considered to have better synergies for settling an IBLC.

In this report distinct features from those Spanish sectors that were preliminarily considered to have stronger chances of developing an IBLC (wine, olive oil, grain chain, feed & fodder and vegetable oil) have been screened to inquire, more accuracy, where could best opportunities reside. The main targets of this deliverable are to find out the size and relevance of the industries, the estimated availability of surplus agro-processing capacity (or idle periods) and the potential synergies that can be expected from the integration of biomass processing into the existing agro-processing as new business line.

From the 50,000,000 ha that Spain has, close to 50 % of the area is devoted to agriculture and thus, it has associated a strong food industry sector. This provides an idea of the great biomass potential that could be destined to start new business lines and develop the IBLC concept. Regarding the cultivated area from each sector, the wine area has around 956,000 ha of vineyards [OEMV, 2016], olive groves cover of more than 2,600,000 ha [ESYRCE, 2016], cereal production (wheat, barley, maize, oats, rye and sorghum) occupies around 6,000,000 ha [MAPAMA, 2016], fodder crops covered around 1,100,000 ha [AEA, 2015] and around 800,000 ha [Spanish Government, 2015] are used for the oilseeds crop (mainly sunflower and rapeseed), representing all together near 46 % of total Spanish cultivated land.

An exhaustive revision from previous projects and other available literature was carried out to gather the initial information. In a further step, and in order to check the veracity and the rightness of the data contained in the reports, several interviews were performed with sectorial associations, cooperatives, private companies and other related organisations that supported and updated the conclusions included in them. These consultations were part from a parallel deliverable of the AGROinLOG (Deliverable 7.3), where this task was demanded as a warranty for the content quality.

For each sector a general profile and its opportunities for developing the IBLC concept have been presented, focusing in those sub-industries where synergies in terms of equipment or facilities (among others) that could be used for the processing of biomass as well as available amounts of residues or other valuable assets were found.

2 WINE

2.1 Profile of the wine sector

2.1.1 Production

Winemaking is based in the processing of bunches of grapes. While white and red are the most relevant wine products in Spain (see Figure 1), there are other variants (such as rose wine, cava, chacolí, jerez, etc.) with slightly different processes and timing (see section 2.1.2).

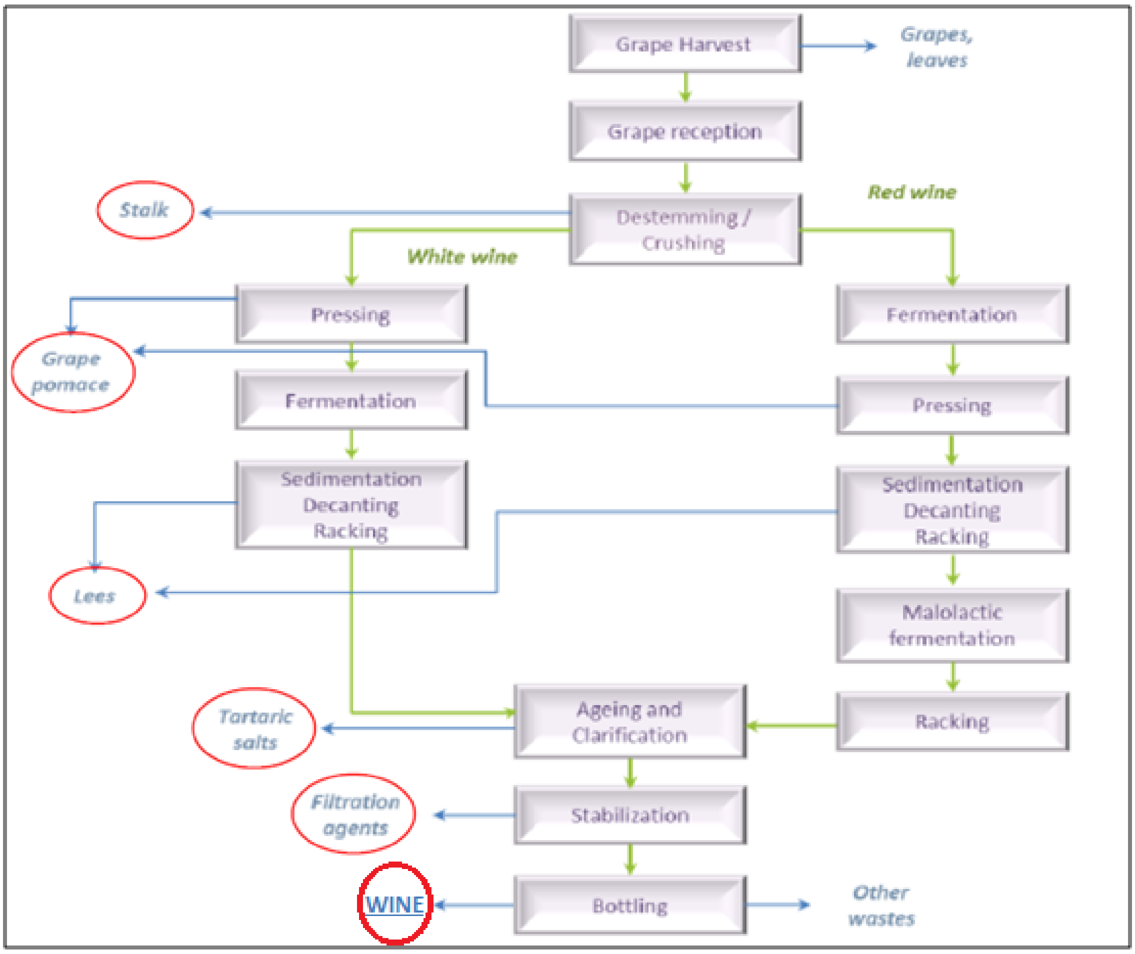

Figure 1. Wine production process residues and by-products generation. Source: UPM, 2017.

Grapes are the main feedstock of wine cellars. These are harvested by vineyard farmers in bunches, together with leaves and grape stalks, and later transported to cellars facilities. After bunches reception, grapes are separated (destemming) from leaves and stalks. Occasionally, a part of the stalks can be crushed together with the grapes to add certain features. Despite of this, most common management of the remnant stalks consist in mixing them with the grape pomace and then sent those to distilleries. Alternatively, sometimes stalks are also managed (see section 2.2.1) by the own wine cellars.

At this point, depending on what final product is pursued (white or red wine), fermentation and pressing stages can be switched in time to achieve different nuances. At the pressing stage the main residue of wine cellars is generated, grape pomace, which is one of the main feedstock of distilleries for the production of alcohol.

Once the fermentation and pressing phases is ended, a combined stage of sedimentation, decanting and raking occurs. In this process, another residue called "lees" is obtained. Similarly to grape stalks and pomace, lees are usually sent to distilleries for their processing, since the regulation requires their removal [BOE, 2016]. Very often the distilleries pay to the wine cellars for the purchase of their by-products and residues, as well as the transport, which is totally or partially funded by the EU [Gestrevin, 2018 and Coviñas, 2018].

Other common procedures for both white and red wine production are the ageing, clarification and stabilization, from where tartaric salts and filtration agents are extracted. Finished the whole process, the final product (wine) is bottled, packaged, or sold in bulk. Since wine contains much more sugar than its residues, it is common that a part of the final production is sold to distilleries.

The distilleries' main activity is the production of alcohol, though many other co-products are usually obtained during the process (tartrate, grape seed oil, grape seed flour, etc.). There are several feedstocks (coming from the winemaking process) that can be used for alcohol production purposes: grape pomace, grape stalks, lees and wine. These feedstocks have different (but significant) amounts of sugar, which is the base of the distillation process (see Figure 2). All alcoholised products in Spain (or derivatives thereof), except vinegar and wine, have an additional tax levy [BOE, 2017], placing wine cellars in an advantageous position over distilleries in this particular aspect.

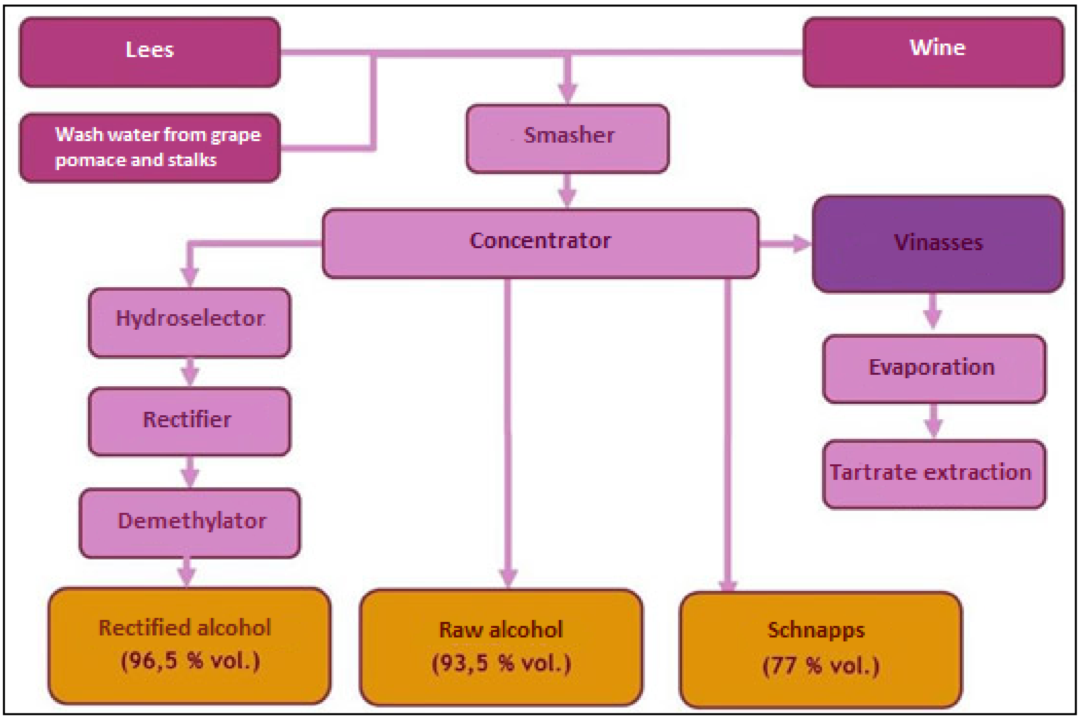

Figure 2. Distillation process. Source: Agralco S.C.L., 2017.

In a first stage of the alcohol extraction process, grape marc is washed in a diffusion band in which liquids called "pickets" are extracted with alcoholic and tartaric richness. Then, resulting pickets are sent to the distillers for obtaining alcohol. Each distiller is composed by several distillation columns, producing different types of alcohol, depending on which columns are used. Lees and wine follow a parallel distillation process, similar to the picket's treatment.

Another product of distilleries is the tartrate (see Figure 7). The dealcoholized pickets and lees are transferred to the tartrate extraction section, in which dissolved tartaric salts are recovered in a 4-step process (acidification, neutralization, concentration and drying). Lime tartrate, which has 50 % richness in tartaric acid, is sent to the chemical industries for the manufacture of pure tartaric acid. Grape seed is also separated and obtained by most distilleries.

2.1.2 Volume of the sector

Spanish vineyard occupy the widest wine area cropped all over the world (956,000 ha in 2016) [OEMV, 2016]), positioning Spain among the three main wine producers. Thus, wine sector companies represent one of the most relevant industries of the country. A record figure was achieved in 2013, when a production of 52.5 million hectolitres of wine was reached, having accounted an average production for the 2011-2015 period of 38 million hectolitres and 5,900,000 tonnes of grape [AEA, 2012-2016 and MAPAMA, 2016]. While wine sector exports have multiplied by five over the past 25 years, national consumption has been reduced to half during the last 20 years, standing current consumption lower than 20 litres per person per year [FEV, 2017].

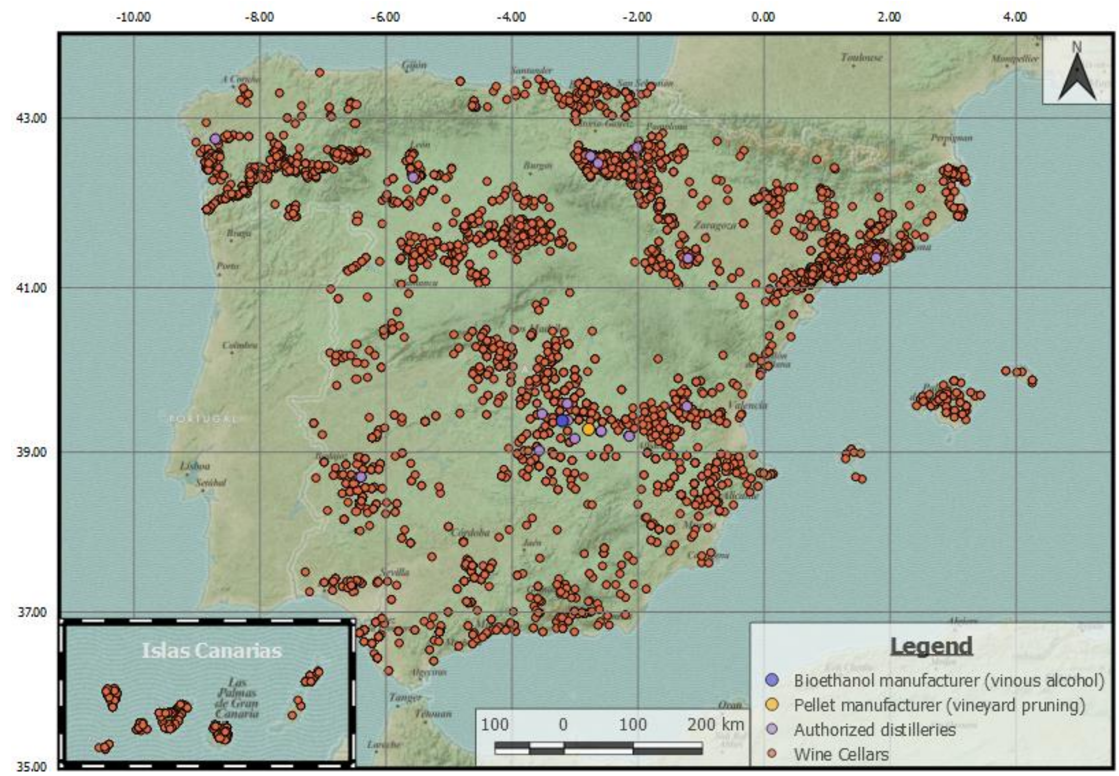

Figure 3. Locations of Spanish wine sector and related industries. Source: SPANISH CO-OPS (elaborated from Designations of Origin, 2017; AECOSAN, 2017; BioDieselSpain.com; 2017 and APPA, 2011/2017 data).

Regarding sector volume, Spain has around 4,000 wine cellars and around 20 distilleries (see Figure 3), with more than 4,050 industries (wine cellars, distilleries and other related companies) associated to wine sector at the beginning of 2015 (representing the 14.3 % regarding the number of total food industries). It is worth to remark that there is also one company currently manufacturing pellet from the vineyard pruning residue and another one that produces bioethanol from vinous alcohol (see Figure 3). Though this last is not within the scope of activities performed in an IBLC (since the vinous alcohol is not a residue), it has been included to show innovative activities related to bioenergy in the sector.

Between 2010 and 2015, wine sector experienced a small decrease of 1.7 % in the number of industries and an increase of its product sales by nearly 20 % (see Figure 4). This reflects the overall stability that this sector has found, balancing the loss of domestic consumption with exports [MAPAMA, 2017]. Since the regulation enforces (see section 2.1.1) wine cellars to dispose their residues (grape pomace, grape stalk and lees), most of these industries sell those to distilleries. Regulations also contemplates (legislation aspects will be further explained in section 2.2.1) other possibilities such as a controlled withdrawal or the sell to the vinegar sector which, in fact, has a small significance in Spain [MERCASA, 2013]. Therefore, distilleries currently process huge amounts of wine cellars residues and, thus, generate a great waste volume which, if valorised by them, could provide an opportunity to develop an IBLC.

Concerning wine cellars, some areas with a higher agglomeration of industries can be clearly distinguished (see Figure 3). These are strategic places where IBLC's could be implemented with success due to the great amounts of residues and pruning from vineyards that are generated. Transport costs to distilleries would also be avoided by implementing logistics centres in these strategically placed wine cellars.

2.1.3 State of the sector

Considering that the average total net sales of the Spanish wine sector industries for the 2009-2014 period amounted to 5,460 million € (see Figure 4) and that, in the same period, there were some 4,070 industries [MAPAMA, 2016], it can be roughly estimated an average sales income per company and year of approximately 1.35 million €. This, combined with the fact that over 84 % of the wine sector industries had less than 9 employees (see Figure 5) indicates that, in general, companies from this sector are not going to have enough economic strength to perform needed investments for developing an IBLC. However, as the number of wine sector industries in Spain is important, it must be taken into account that hundreds of companies from this sector (around a 15 %) could, indeed, own the needed resources for implementing the IBLC concept in their facilities.

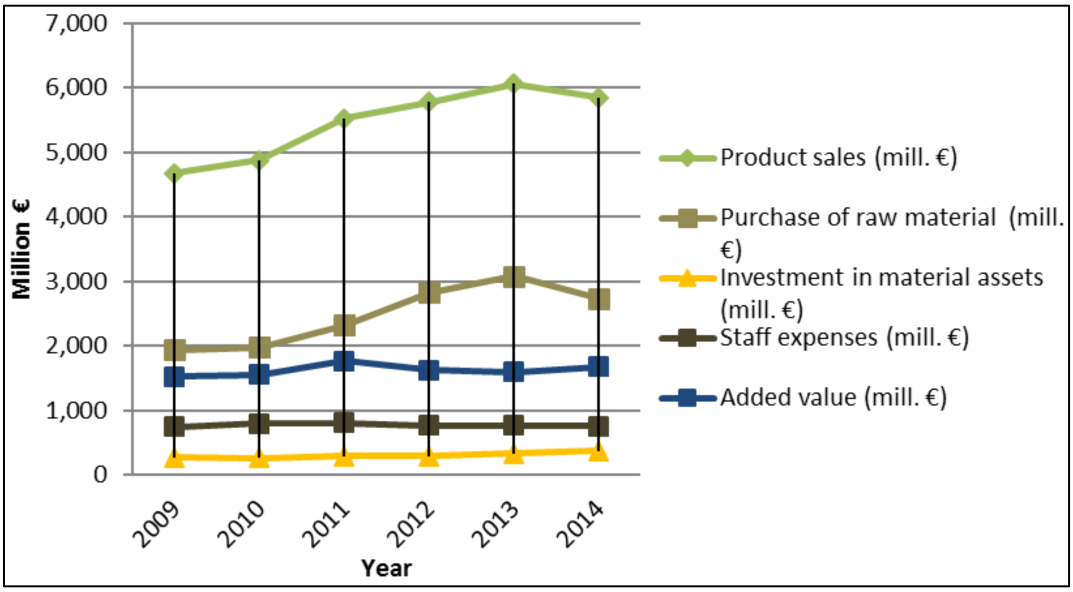

Figure 4. Wine sector industries financial features. Period 2009-2014. Source: SPANISH CO-OPS (elaborated from MAPAMA data, 2015).

When analysing Figure 4 above for the period 2009-2014, it can be noticed an overall stability of this sector during the crisis years. In fact, a slight increase of both the product sales and employment can be observed (for the overall period), which shows the relevance that this sector currently has in the Spanish industry and an expected growth tendency for next years.

In the following table, a list of the main wine cellars of the sector (2015) is presented (see Table 1), and therefore, those industries which could be in best position for making investments in biomass related activities such as the development of an IBLC. It has to be remarked that most of the wine cellars that appear in the following list are bottlers [Coviñas, 2018].

Table 1. Top 10 wine sector industries. Source: MAPAMA, 2017.

Nº	Company	Sales 2015 (mill. €)	Employment 2015
1	J. GARCIA CARRION, S.A.(JGC)-GRUPO*	698	866
2	FREIXENET,S.A. - GRUPO	510	1.800
3	FELIX SOLIS AVANTIS, S.A. (GRUPO)	263	400
4	MIGUEL TORRES, S.A. (GRUPO)*	263	1.500
5	GRUPO OSBORNE, S.A.*	241	850
6	CODORNIU, S.A. (GRUPO)	234	830
7	GONZALEZ BYASS S.A. GRUPO *	211	500
8	UNITED WINERIES ESPAÑA S.A. (GRUPO ARCO)	150	150
9	PERNOD RICARD WINEMAKERS SPAIN	119	332
10	BARÓN DE LEY S.A.	93	191

Data include business lines in other sectors

Focusing on the distilleries, Alvinesa is currently the one with more relevance, followed by Viuda de Joaquín Ortega S.A. and Alcoholera de la Puebla S.A. In the cooperative sector, Agralco S.C.L. leads this group, placed as well among the main distilleries of Spain and followed by Destilerías San Valero S.C. [SPANISH CO-OPS, 2017 and Gestrevin, 2018].

2.1.4 Typical size of the companies

In relation with the number of employees per industry (see Figure 5) it must be highlighted that, during the 2014-2015 period, half of the Spanish industries belonging to the wine sector were micro enterprises (54.7 %) with very few workers (between 1 and 9), followed by those with no employees (29.5 %) and small enterprises (between 10 and 49 employees). Only few of them had more than 50 employees (1.7 %), but no one more than 500 [MAPAMA, 2016]. However, since the smallest distillery (Gestrevin) has 20 employees, the size of these industries seems to be significantly higher than the overall industry, and so, healthier financial systems are expected.

Around 24,000 people (on average) were working over the 2009-2014 period in wine sector companies. As stated in the previous section, around a 15 % (more than 600 hundred industries) of total wine sector companies could be considered potential stakeholders (better financial assets and management capacity of residues) for implementing the IBLC concept, though it is more likely that just the 1.7 % (around 68 industries) would have optimal economic conditions for activity diversification.

In the same way, knowing the average production for the 2011-2015 period (near 38 million hectolitres of wine and must and 5,900,000 tonnes of grape) [AEA, 2012-2016 and MAPAMA, 2016], and the presence in the wine sector of around 4,000 companies, it is possible to estimate an average production per industry and year of about 9,500 hectolitres of wine [INFOVI, 2017].

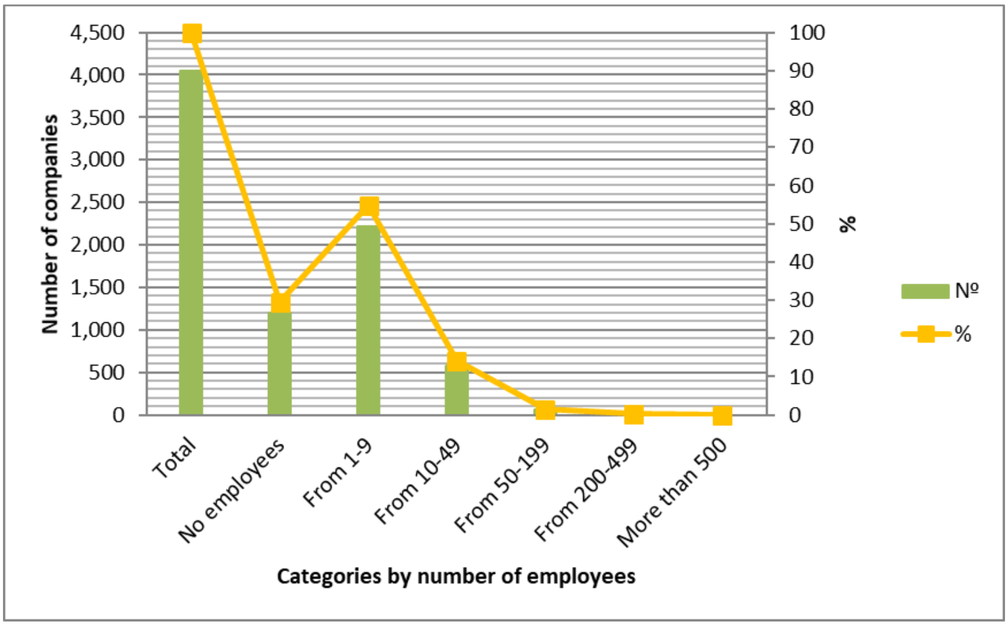

Figure 5. Typical size of wine sector companies (by number of employees). Source: MAPAMA, 2016.

It can be concluded that most part of Spanish wine sector industries are micro and small enterprises with small production and low investment capacity. This supports the idea that only particular companies (such as the ones from **Table 1**) of this sector seem to have the adequate conditions for developing an IBLC (such as the distilleries), even more considering that wine cellars do not possess any compatible equipment and so, higher investments would be required (see Section 2.1.5).

2.1.5 Distinctive facilities of the sector

Wine cellars are the most representative industries (by number) within the wine sector. Despite of this, contrary to other industries in which there exist compatible machinery for the processing of biomass (distilleries), cellars do not posess any specific equipment (such as pelletizers or dryers) to do so. However, these industries have places for the residues storage, laboratories where the biomass features could be analyzed and other elements designed to extract the residues from the winemaking process [Sucellog, 2017].

Despite distilleries represent quite a small part of wine sector (only 20 industries), these industries have great opportunities for becoming IBLC's, since they own compatible equipment with the processing of solid biomass and the extraction of bioactive compounds [BIOACTIVE-NET, 2006], the horizontal dryers (see Figure 7). Driers are used in a pre-treatment stage for the grape seed oil extraction and solid biofuel production [Destilerías San Valero, 2017 and Agralco, 2017]. Besides, due to the fact that the grape pomace, the grape stalk and the lees produced in cellars are processed in the distilleries, there is a close contact between both industries (regulation enforces wine cellars to remove grape pomace and lees) [BOE, 2016].

2.1.6 Degree of innovation

In accordance with the data provided by the Technological Platform of Wine (PTV, founded in 2011), it is estimated that the average wine sector investment on research and development (R&D) for the last five years was around 170 and 180 million € per year. This represents between 12 and 13 % of total expenditure in R&D of the food and beverage sector [PTV, 2017]. However, the recent creation of this platform can be considered as a sample of the interest that this sector has in improving the innovation.

Regarding the beverages sector, 30 % of the companies stated in 2009 their intention of investing in innovative issues or did have already working groups developing specific R&D projects. Only a few of them (12 %) had a team or department performing activities specifically focused on innovation or R&D in general. In the same line, almost 70 % of the companies stated to be destining less than 1 % of their turnover to R&D and innovation, another 25 % spent among 1 % and 5 % of their invoices and the rest, up to 6 % [MAPAMA, 2009].

Wine sector in Spain is framed within two bigger sectors, the agricultural and the beverages sector. It is interesting to remark that conglomerate sector from food, beverages and tobacco were in 2015 far up beyond from average with a 21 % of innovative companies (total Spanish innovative companies remain near 13 %). However, the one from agriculture, cattle rising, forestry and fish hardly achieved 5 % of innovative companies [INE, 2015]. These figures give a contrasting image of the wine sector situation which, on one side is anchored to a sector sometimes reluctant to innovation (agrarian sector), and on the other side to another that is standing out on these issues (food, beverages and tobacco). When combining with the impressions that were stated in the previous sections, data seem to remark that only a residual part of the wine sector companies would be interested in being involved into innovative actions like the start-up of an IBLC.

Wine cellar industries are focusing innovative efforts in the final product (format, label, bottle, etc.) as well as in the improvement of the yeast varieties. Though with minor significance, wine cellars are interested in producing their own energy requirements from biomass resources. According to the information provided by Coviñas, part of the leaves from a vineyard (owned by a different cellar) variety called "Bobal" is destined to the production of infusion in France.

In addition, the manager of the Gestrevin distillery stated their collaboration in a project with the Universidad Politécnica de Valencia (UPV) where the obtaining of resveratrol from grape pomace is being studied. Though this distillery is the smallest of Spain, they are producing biogas from their own and other wastewaters, planning to reduce some 50 % of their electric bill by self-consuming it. In the cooperative frame, Dcoop S.C.A. was awarded in November 2017 with "The European Awards for Cooperative Innovation" (see Section 3.1.6).

2.1.7 Miscellaneous

Regarding other items that could influence the development of future IBLCs in wine sector, one common problem that could be raised as an opportunity concerns the management of wine industry wastewater. These are usually pre-treated and then discharged into to the rivers, commonly after the payment of a canon tax. Due to the large volumes that the wine cellars generate during the harvest time, this could cause sustainability problems (pH, organic matter, eutrophication, etc.). Several distilleries in Spain (Agralco S.C.L., Gestrevin, etc.) are already solving this problem by reducing the organic matter content in the wastewaters through partial conversion in anaerobic digesters into biogas.

Another issue that could enhance the success of an IBLC regards the biomass handling. Wine sector industries have wide experience in the management and transport of residues from wine cellars to distilleries. Besides, the latter have also a large background in residues processing.

Having the opportunity to extract many bioactive compounds and other useful products in the industry, Spanish wine distilleries could become suppliers of choice in the semi-finished products and raw materials sectors for pharmaceutical, food and beverage companies all over the world. The same idea arises for both distilleries and wine cellars, as they could also become local bioenergy suppliers, providing solid biofuels (manufactured from exhausted grape pomace, grape stalks, pruning, etc.) and biogas (from the processing of wastewaters, lees, vinasses, etc.). Lack of standardization of agriculture biomass provokes uncertainty and issues of social acceptance.

Concerning sustainability analysis from wine products or Life Cycle Assessments (LCA's) in the Spanish wine sector, a few projects (Análisis del ciclo de vida del vino de Rioja, 2012 and HAproWINE, 2013) have recently been carried. Through them a wide experience has been gained on the subject. More specific efforts have been made in this sector on the carbon footprint calculations for the industries to include this information in their bottle labels, highly demanded by the consumer. In this sense, the European Food SCP (Sustainable Consumption and Production) Round Table adopted the ENVIFOOD Protocol 1.0, which aims to "establish a scientifically reliable, practical and harmonised environmental assessment methodology for food and drink products across Europe including information along the food chain" [Food SCP Round Table, 2013].

Due to the growing interest in LCA, several methodologies have raised to measure impacts through production processes (i.e., environmental, ecological, carbon or water footprints). Despite of this, as no regulation is yet set on those issues, these methodologies not always consider the whole life cycle and only measure a part of it.

Sustainability issues derived from the fertiliser manufacture, energy spent into irrigation, machinery and transport consume for primary sector should be considered, as well as other issues like the removal of agricultural residues and the impact that this might have on soil quality. Therefore, the implementation of IBLC's could have a huge impact on the wine sector industries product label since the footprint of the main product would be shared between the different residues, creating a competitive advantage.

2.2 Opportunities IBLC

2.2.1 Sector related residues

Several by-products (those that already have an alternative use) and residues (those which are discarded without any valorisation) are obtained in the winemaking and alcohol production processes, as well as in related activities (vineyards crop).

Although grape pomace and lees are commonly used as raw materials for the distillation of alcohol in distilleries, Spanish regulation has not included those in the "by-products list" yet, and thus, they are still considered as "residues" [BOE, 2016]. The implications derived from this fact affect those autonomous communities where no specific legislative framework has been developed on this issue (most autonomous communities are already considering them as by-products). Direct effects derived from the "residue" denomination can be summarized in a harder red tape process and stricter regulation in relation with their "removal" or valorisation possibilities. In this sense, regulation contemplates their disposal in distilleries, vinegar industries or other specific management [BOE, 2016]. However, a formal request was sent to the MAPAMA asking for the establishment of a common national frame.

As mentioned before (see section 2.1.2), wine cellars have easy access to vineyard pruning. This residue is usually chipped and returned to soil or left near the vineyards for burning, without any other remarkable valorisation. The complexity of the pruning collection has to be highlighted (technical barrier) since Spanish farmers grow the vines in several ways (vase, espalier, etc.) conditioning the mechanization of the collection and thus, the economic feasibility of the process. Furthermore, the vineyard pruning requires some specific cuts that must be performed manually, making the collection much more expensive.

Several field trials have been carried out in the Vineyards4Heat Project on this issue, where the valorisation of the vineyard pruning as fuel in biomass boilers was tested in real cases (district heating of La Girada neighbourhood in Vilafranca and biomass boiler of the Vilarnau wine cellar) [Sucellog, 2017 and Vineyards4heat, 2018].

In this sense, it must be noticed that there is one company in Spain which main activity is the production and marketing of pellets made from the vineyard pruning (Pellet Combustibles de la Mancha S.L., see Figure 3). The existence of this company proves that it can be a feasible business.

The valorisation of the pruning was also well studied and considered during the past years by the Coviñas Group (wine cellar of second degree placed in Valencia that bottles the wine produced by other associated cooperatives of first degree) together with Acciona S.A., but the lack of profitability due to logistic problems prevented the implementation of the project. However, since the pre-pruning can be mechanised, it has been detected as an opportunity to collect part of the vineyard pruning in a feasible way. Nevertheless, several modifications in the current machinery should be carried out.

The estimated yield of the vineyards pruning ranges between 1-4 ton/ha (fresh matter) per year, with slightly variations linked to the implanted crop system [Europruning, 2014]. Since from the current vine crop extension in Spain (956,000 ha) [OEMV, 2016], approximately 30 % (286,700 ha) is planted in espalier and the rest with other systems (669,000 ha) [ESYRCE, 2012], a total amount between 1,250,000 and 2,500,000 ton/year (fresh matter, 40% moisture content) from vineyard pruning would be available [Europruning, 2014]. Low heating value for the vineyard pruning is around 3,870 Kcal/Kg of dry matter (15 % of moisture content) [Sucellog, 2017].

Grape pomace is generated during the pressing process in cellars. It is composed of grape skins, grape seeds, grape pulp leftovers and remnants from grape stalks after destemming. Estimated amount of fresh grape pomace lies around 12-14 % of the total incoming grape and so, some 710,000-830,000 tonnes/year (50 % moisture content) would be generated every year in Spain [AGENEX, 2009; AGRALCO, 2017 and Sucellog, 2017]. Complying with legislative residues requirements most wine cellars send those to distilleries.

After vinous alcohol extraction process, exhausted grape pomace and vinasses (wine related wastewaters) are generated (see Figure 7). Exhausted grape pomace can be used for the extraction of biocompounds (such as polyphenols, tartaric acid or grape seed oil), feed manufacturing, compost production or as a solid biofuel (when properly treated). This residue has a low heating value of 3,800 Kcal/Kg of dry matter (12-13 % moisture content) [LIFE SINERGIA, 2006 and AGENEX, 2009]. Since in the washing of the grape pomace the weight loss can be despised, then, considering the initial water content (50 %) and a final one of about 12-13 % [AGENEX,2009], between 180,000 and 210,000 tonnes of exhausted grape pomace (12-13 % moisture content) are generated per year. However, most of the distilleries separate the exhausted grape pomace components, obtaining different products (and so, the exhausted grape pomace residue would be almost non-existent).

Once separated, grape seeds can be used for grape oil extraction (see Figure 7), grape seed flour obtainment, compounds extraction and solid biomass production (low heating value of 4,070 Kcal/Kg of dry matter, at 13 % of moisture) [Borges, 2018]. In fact, there are several distilleries such as Agralco and Alvinesa as well as some vegetable oil companies such as Borges and Migasa, that are currently extracting grape seed oil in Spain, mainly addressed to the Asian market [Gestrevin, 2018].

In the same process grape seed flours are produced (see Figure 7). In 2016, the production of grape seed oil in Spain reached 11,000 tonnes [Fediol, 2017].

Regarding grape stalks, most part come directly from the wine cellars destemming stage (though sometimes, part of them, can be added to the fermentation process) and then, very often, they are mixed with the grape pomace and sent to distillery or managed by the own wine cellar [Gestrevin, 2018]. Once separated their moisture content can reach 60 %, but it can be sun dried to decrease the moisture content to 15-20 %. Several valorisations such as the compost manufacture, bio compounds extraction (tannins or resveratrol) or as solid biofuel (it cannot be destined as feed for the cattle due to the high content in lignin and cellulose) could be addressed at the time of managing this residue. Grape stalks have a low heating value of 3,000 Kcal/Kg (20 % of moisture content) and amounts around 5 % of the processed grape, some 295,000 tonnes per year (60 % moisture).

Other residue generated during the winemaking processes are the lees (obtained in the sedimentation, decantation and raking phases of wine cellars), which are commonly sent to distillery as a complementary raw material in the vinous alcohol extraction. However, lees could also be destined to compost manufacture. Lees suppose between 4 and 14 % of total grape production, some 236,000-826,000 tonnes per year [AGENEX, 2009; AGRALCO, 2017 and Sucellog, 2017].

Vinasses are the resultant wastewaters derived both from winemaking and alcohol extraction processes. After the alcohol obtainment in distilleries, wastewaters are used as raw material for tartrate extraction (which are usually later sold to other industries for tartaric acid production). Vinasses can be also used in animal feed production, for fertilizer manufacture or conducted to sewage treatment plants, where an energetic valorisation can be achieved through the production of methane in anaerobic digesters. Overall, all the distilleries extract tartrate from the vinasses, as well as alcohol and grape seeds. Furthermore, Alvinesa elaborates its own tartaric acid from the tartrate extract [Gestrevin, 2018].

2.2.2 Potential synergies & benefits

Synergies between agro-industries and generation periods of some of the above-mentioned residues are showed in the next chart (see Figure 6):

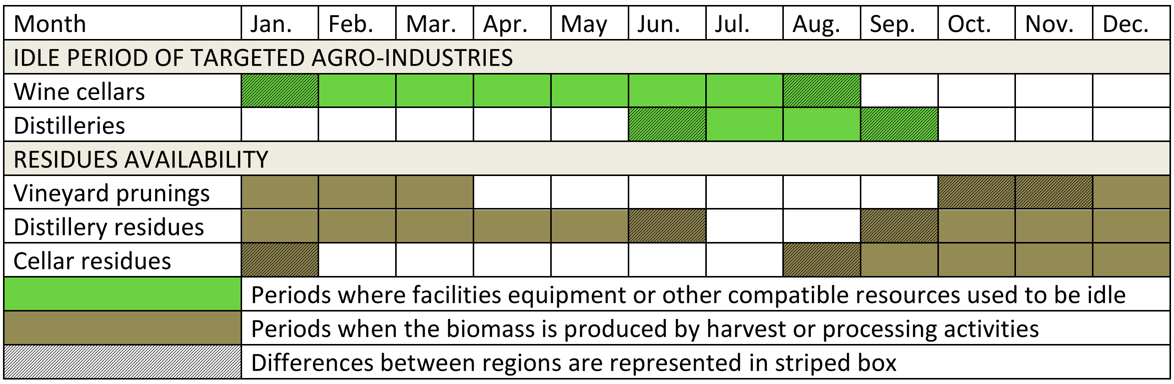

Figure 6. Synergies between agro-industries idle period and residues availability. Source: Sucellog, 2017, Europruning, 2014, SPANISH CO-OPS, 2017 and Gestrevin, 2018.

Those periods in which facilities, equipment, personnel, or other compatible resources from the agro-industries have no activity (indicated in green), could be complemented with the processing of biomass residues into bio-commodities and bioenergy production, working as an IBLC.

In spite of the fact that wine cellars do not have equipment that is compatible for the processing of biomass, these industries have easy access to agrarian residues (such as the pruning) or the own agro-industry wastes obtained during the wine and distillate elaboration (see Figure 7).

Usually, the idle period of the wine cellars last from January till August (see Figure 6). However, there are several companies, such as the Coviñas cellar –second degree cooperative which bottles the wine produced at bulk by the associated first degrees cooperatives– that have continued activity through all the year [Coviñas, 2018]. For those cellars with idle periods, the processing of biomass activities would bring the opportunity of start-up a new bussiness line. However, since expensive machinery must be purchased, large investments are expected, which could pose a great barrier given the small size that features these industries. When possible, association of a number of similar companies of the area is advisable, as they will collect more residues (solving the size problem), share the investment costs and thus, reduce risk [Sucellog, 2017]. As an example, the union of cooperatives of first degree to create a new one of second degree is a very common formula of our cooperatives to achieve this but it would be the same for private companies

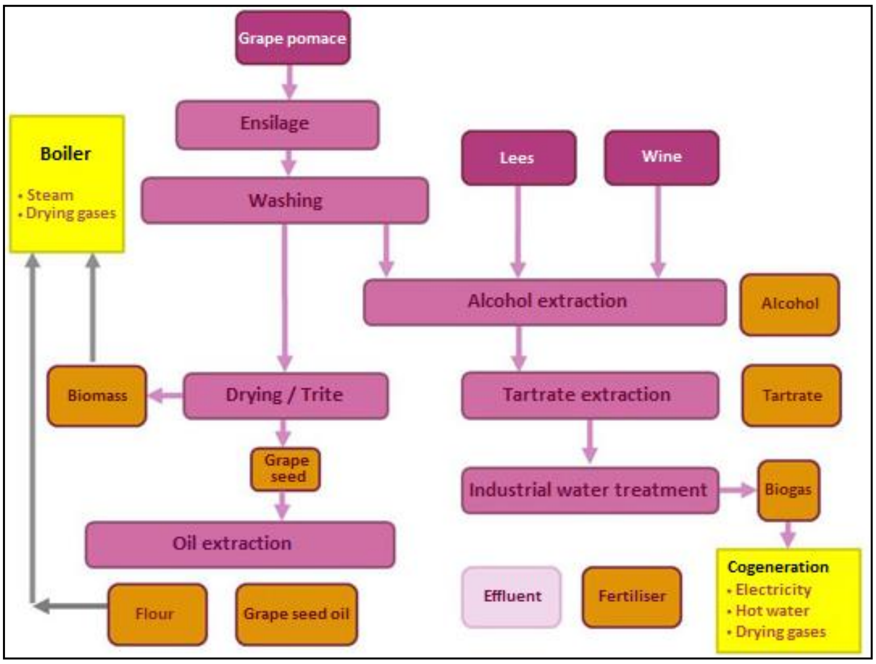

Figure 7. Residues and wine process of a Spanish cooperative distillery. Source: Agralco S.C.L, 2017.

Regarding distilleries, as it has been previously mentioned (see section 2.1.5), they usually own equipment compatible with the processing of biomass: the dryers. Besides, during the alcohol extraction process (see Figure 2), residues such as exhausted grape pomace, vinasses, lees and fermentation sludges are produced. Previous chart (see Figure 7), shows winemaking residues treatment that the Agralco distillery (cooperative) is currently carrying out with both economic and technical success.

The idle period of distilleries is short (from June to October in Spain) compared to other agro-industries (see Figure 6). In some cases, these idle periods could be non-existents for those distilleries which were supplied with enough raw materials to keep their activity ongoing through all the year, since these can be stored for long periods [Gestrevin, 2018]. Considering their wide experience in residues management, the ownership of compatible equipment with the biomass processing (less investments) and the great amounts of raw material that the few distilleries usually receive from the wine cellars, these industries are very likely to become succesful IBLC's. In addition, as it has been mentioned in the previous section, many of the distilleries currently perform biomass valorisation activities, both addressing the biocommodities and bioenergy markets. In this sense, some distilleries cogenerate energy (at least Agralco, Cades Penedes and Gestrevin) or just produce thermal energy (Alvinesa) for self-consumption from the valorisation of biomass [Gestrevin, 2018].

Concerning employment, both wine cellars and industries IBLC's would increase the number of employed people and/or the length of current contracts, as the activities in an IBLC would require maintenance, training and supervision. The manufacture of the required equipments for both industries (pelletizers, mills, dryers in wine cellars, etc.) would also require workforce in short term.

In conclusion, the implementation of IBLC's in these industries will have positive local impact both on employment and environment, since there would be a decrease in the CO_2 emissions due to the substitution of fossil fuels by biofuels (with a much more balanced cycle).

2.2.3 Market developments

Wine sector residues offer the opportunity to extract several biocompounds with a wide range of benefits applied to different fields and, thus, arising as a chance for targeting different markets from food, feed to biobased ones. These biocompounds can be classified in three main categories:

- Polyphenols: Mainly resveratrol, anthocyanins, enocyanine, procyanidins, quercitin and catechins for colorant or dyes purposes, healthy benefits (antioxidant characteristics) or fibres manufacture.
- Tartrate: Usually extracted by the distilleries and sold to second industries that turn it out to tartaric acid, though there are exception such as the Alvinesa case where the tartaric acid is directly produced in their facilities [Gestrevin, 2018].
- Tartaric acid: It can be used in the pharmaceutical industry as an excipient for the manufacture of effervescent pills and in the construction, as a setting retarder (cement and plasters). Regarding the cosmetic industry, it is currently used as a base compound for many natural body creams. Besides, in the chemical sector it can be useful for galvanic baths, electronic components and as a mordant in textile industry [Gonzalo Castelló, 2017].
- Grape seed oil: It has cosmetic and healthy applications. This oil has a rich content in antioxidants that prevent circulatory and cardiovascular diseases and some types of cancer like the breast, colon or prostate [Vinetur, 2014 Galicia 6+7, 2014].

Regarding biocommodities related activities, Natac company (an organization devoted to the development of innovative and differentiated Mediterranean extracts) acquires a special relevance given the differentiation that they have implemented in their process. After forging a strategic alliance with the Alvinesa distillery, they implemented a process in which several biocompounds are extracted from their residues without modification of their features. In this way Alvinesa can still perform the current valorisation (grape seed oil or other compound extraction, etc.) without altering their process. Natac products are mainly oriented to human nutrition, pharmaceuticals, cosmetics and animal feeding (additives market) [Natac, 2018].

Other possible ways for the valorisation of wine sector residues are the manufacture of biofuels (bioenergy market) such as biogas (from anaerobic digestion of vinasses components) or solid biomass (pellets, chips, briquettes or others coming from vineyards pruning, exhausted grape pomace, grape seeds, etc.). Moreover, one of the main cooperative distilleries (Destilerías San Valero) is involved in the European Life Ecoelectricity project. The aim of this project is to generate and use electrical energy from low-quality alcohol waste (produced in the distillation) with little commercial value. To this end, a pilot plant will be designed based on catalytic reforming technologies, allowing the energy exploitation of impure alcohol fractions [Innovagri, 2017].

The existence of one company (see Figure 3) currently selling pellets manufactured from vineyard pruning show that bioenergy valorisation from wine sector residues is a feasible and unexploited activity. Fertiliser industry can also be attained through the direct apply of vinasses on the field (after pre-treatment) or the production of concentrated fertilisers. Otherwise, grape skin, grape pomace, lees and sewage sludge can also be composted and sold directly to farmers or agro-industries.

Although wine cellars in Spain seem to have many barriers to achieve these markets, they could easily reach the bioenergy market through the utilisation of vineyards pruning and their own residues for producing solid biofuels, which could later be sold or self-consumed. Distilleries seem to have few significant barriers to become IBLC's since already several existing companies are developing activities with similarities. Alvinesa and Agralco S.C.L. cooperatives in Spain, and Caviro in Italy, are successful pioneer companies (distilleries) which valorise wastes thereby targeting different markets. Besides of the production of alcohol, extracting biocompounds or burning biomass in thermal plants they are currently producing biogas from the purification of vinasses and other wastewaters [Agralco, 2017; Caviro, 2017].

2.2.4 Non-technical barriers

Despite all abovementioned aspects related with the ownership of equipment, facilities or other resources useful for the processing of biomass and the existence of coinciding idle periods (technical barriers), there are other kind of issues which could make fail the successful implementation of an IBLC.

Main non-technical barriers of Spanish agro-industries for implementing the IBLC concept are summarized in Table 16 (Annex A of this report). Although many of these barriers can be extrapolated to most of the sectors, there are some others related to the legislation, financial and other aspects that specifically attain certain sectors and are explained hereafter.

Although law forbids the burning of vineyard pruning in Spain, in some cases, local authorities allow these practices to farmers in determined periods, which discourage the seek for alternative ways to manage the residues and stimulate them to keep performing practices that do not add any value to their activity. Therefore, a combination of regulatory (inappropriate public administration consent) and knowledge and awareness barriers (lack of information from farmers) have been detected in the wine sector, which are currently holding back the development of new initiatives.

On the other hand, wine sector is not properly mechanised to undertake the collection and processing of biomass in the crops. This has to deal both with the traditional way of managing the vineyard by the farmers (usually pruning was left in the soil waiting to be burned and thus, there was no need of developing any technical implement) and also due the different ways of cultivating the vineyard (technical barrier, see Section 2.2.1).

Other issues are derived from the current classification established by the regulation (legislative barrier) in which the wine sector by-products are established as residues (see Section 2.2.1), implying more red tape tasks and, in some cases, it can also discourage stakeholders at the time of researching or implementing alternative uses.

For the wine cellars, the lack of suitable equipment for the processing of biomass leads to higher investments, which could represent a significant financial barrier in many cases.

According to the information provided by Natac, there is a great market barrier for some biocommodities. Despite they stated that it was relatively easy to obtain a good profit for most of the high value marketed products (between 25-500 € per Kg), but in many cases only a small part of the product stock can be sold due to the lack of demand. For this reason, several biocommodities of a lower market value have been developed, with the aim of getting a balance between those products with high added value (required in small volumes) and those with low added value (demanded in great amounts), such as additives for animal feeding.

Difficulties at the time of developing new markets and the lack of places were to run the necessary production tests were also pointed out [Natac, 2018]. In addition, the necessity of handing out the profits with the different stakeholders of the chain was referred as something necessary to achieve an overall agreement. Another foreseeable barrier by the Natac company could be a legislative modification in which stricter requirements were settled for the biocommodities production (i.e. requirements for the use of natural compounds instead of synthetics), which could hinder the competitiveness with other countries.

Both Natac and Coviñas companies stated that there was also an important knowledge barrier, since the agro-industries do not have the required technical assets to develop many of the activities proposed by the IBLC concept. However, they stated that this could be solved by making associations with other expert companies [Coviñas, 2018 and Natac, 2018].

Finally, the pursuing of a reduction in the carbon footprint was shown as a double-edged sword, since to achieve that objective, exportations should be reduced (though there are other ways) in pro of local consumption, hindering the current structure of the business [Coviñas, 2018].

3 Olive oil

3.1 Profile of the olive oil sector

3.1.1 Production

Olive oil sector is an aggregation of several industries with specific roles through all the olive oil production process stages. Oil mills, oil refineries, oil packagers and the olive pomace oil industries could be considered as one of the most relevant ones. However, due to the synergies with the AGROinLOG scope, only oil mills and olive pomace oil industries are addressed. Several types of oil are produced within the olive oil production process (Figure 8), which are classified according to their quality.

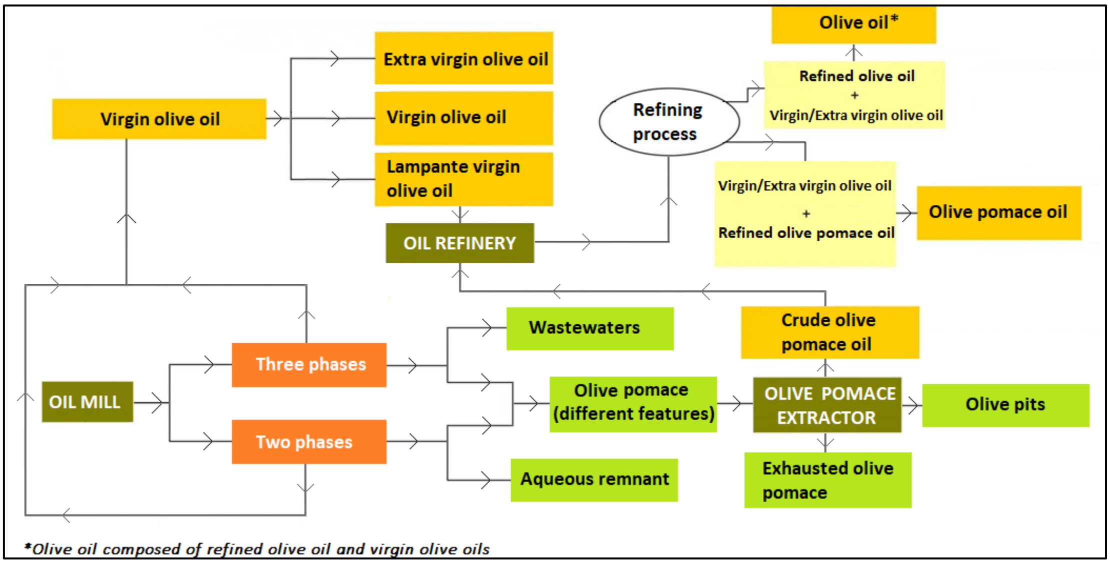

Figure 8. Olive oil production process. Source: SPANISH-COOPS, 2017.

Olive oil mills are distinguished by the different milling and extraction systems they can implement on their facilities: traditional (milling with rotary stones), three-phases (mechanical milling and centrifugation), two-phases, and mixed (those industries that use two or more systems combined in their production process). The Spanish olive oil sector has transformed their industries in past years and so, nowadays most olive oil mills (87 %) use a two-phases system (replacing the old three-phases system) for the extraction of virgin olive oil. Despite of this, a few companies still produce both with traditional (5.5 %), three-phases (4 %) and mixed (3.5 %) systems [AICA, 2017].

Olive pomace oil industries recover the crude olive pomace oil from the Two-Phases Olive Mill Waste (TPOMW) generated in the virgin olive oil extraction process. This extraction is usually achieved using dissolvent or centrifuges. Crude olive pomace oil must be later refined and mixed with virgin olive oil to enable human consumption. Oil refining, performed in refineries, consists of correcting oil defects by applying physical or chemical processes and mixing the resulting oil with virgin olive oil in the coupage process [Esencia de Olivo, 2017].

3.1.2 Volume of the sector

Spanish olive grove represents 23 % from world olive crop area and produces about a 44 % of total production. These facts remark the worldwide leadership that the olive oil industry of Spain has in this sector. As stated by ESYRCE, the 2,623,000 ha of olive groves cultivated in Spain on 2016 implies around 14 % of total agrarian surface. Besides, in the previous decade, production has increased over 23 %, paralleling with the implementation of irrigation systems (around 28 % of olive groves surface) [GEA, 2017 and MAPAMA, 2017]. Average yield for the last six campaigns in Spain was of around 1,080,000 tonnes of olive oil [AICA, 2017].

Olive oil sector accounted, during the 2016-2017 campaign, 1,813 oil mills, 67 olive pomace oil industries and 26 refineries (see Figure 9), which represented around 6.7 % of total food industries in Spain. In addition, there are around 7 companies where the olive oil residues are valorised with bioenergy purposes [APPA, 2011/2017]. Regarding the oil mills corporate organization, 52 % have a cooperative status and produce 67 % of total Spanish olive oil production, and the other 48 %, with different legal forms, reach 33 % of total production [AICA, 2017].

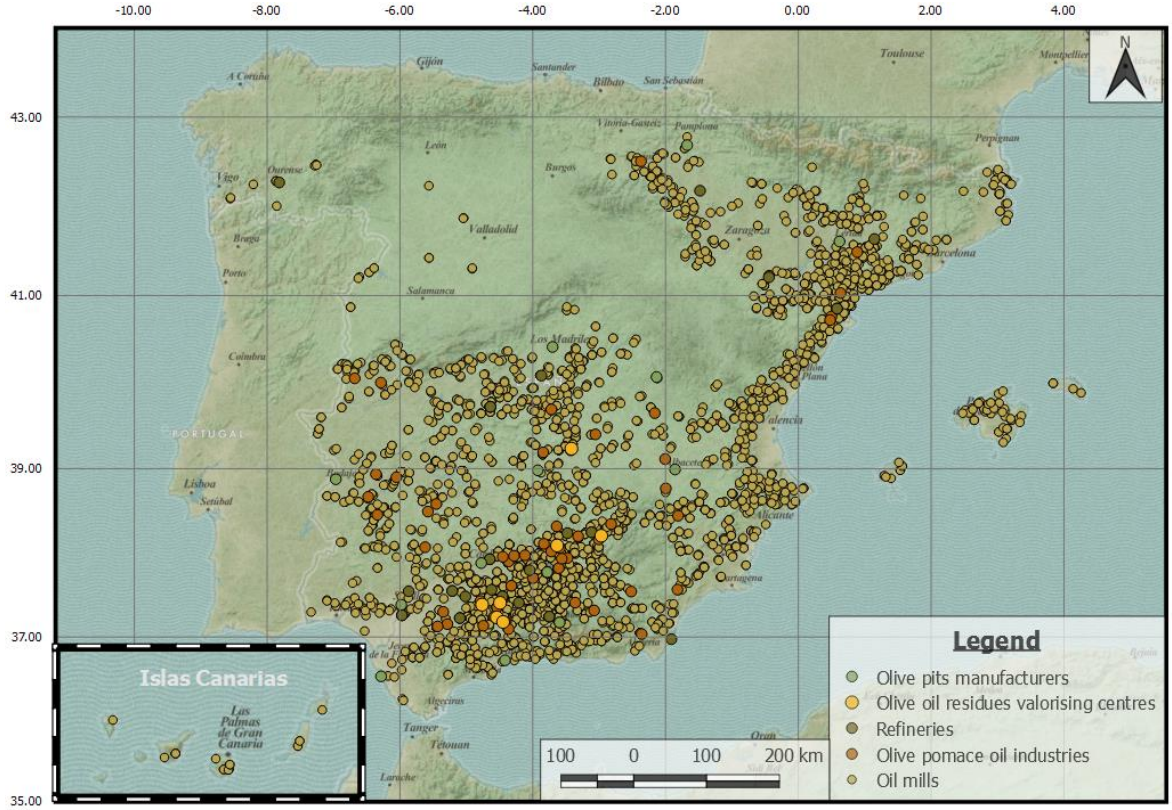

Figure 9. Location of Spanish olive oil sector and related industries. Source: SPANISH CO-OPS (elaborated from AICA, 2017; ANEO, 2017; AECOSAN, 2017; Expobiomasa, 2017 and APPA, 2011/2017 data.

It is easy to observe (see Figure 9) that most olive oil sector industries are agglomerated on the south (Andalucía) and east costs (Cataluña and Valencia) of the country. Even though Castilla-La Mancha is the second autonomous community with more oil mills, its large territory favours the spreading of these industries [AICA, 2017].

3.1.3 State of the sector

Spanish olive oil sector is included in the MAPAMA Food Industry sectors classification under a wider ranking called "fats and oils sector", which also includes those industries from the vegetable oil sector (see Chapter 6 of this country report) and other fat derived product manufacturers. The average product sales for the fats and oils sector during the 2009-2014 period was 8,200 million € (see Figure 10).

However, since oil mills average market value (determined through the price at source) for the last seven campaigns was some 3,270 million € (see Table 2) [MAPAMA, 2015; AICA, 2017; SPANISH CO-OPS, 2017] and, considering that olive pomace oil subsector accounted (on average) around 150 million € for the 2010/2011-2015/2016 campaigns [Olimerca, 2017], olive oil represents, at least, 40 % from fats and oils sector product sales. In addition, considering that the oil mills market value (estimated by the price at source instead from the consumption point) does not include other industries such as the oil refineries or oil packagers, average olive oil sector market value is expected to be quite higher and could over exceed the 4,000 million € [SPANISH CO-OPS, 2018].

Table 2. Spanish olive oil sector product sales evolution. Period 2010-2016. Source: SPANISH CO-OPS, 2017.

Spanish olive oil sector product sales evolution							
Campaigns	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Market value (million €)	2,413	2,531	2,590	3,232	3,471	3,857	4,767
Variation (%)	-	4.90%	2.32%	24.79%	7.38%	11.12%	23.6%

Considering the number of oil mills (around 1,800) and the given average market value (3,270 million €), it can be estimated a gross income per oil mill of 1.8 million € [AICA, 2017]. Similar calculations can be made considering the number of olive pomace oil industries (67) and the above mentioned average turnover for these industries (150 € million), estimating a gross income per olive pomace oil industry of some 2.24 million € [Olimerca, 2017 and SPANISH SCO-OPS, 2018].

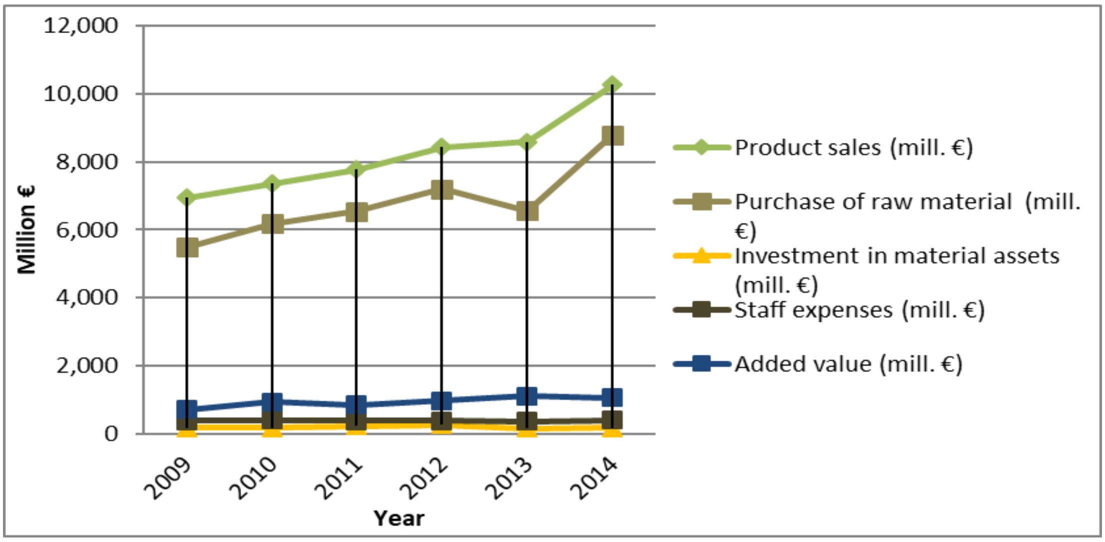

Figure 10. Fats and oils sector industries financial features. Period 2009-2014. Source: SPANISH CO-OPS (elaborated from MAPAMA data, 2015).

Analysing the agglomerated "Fats and Oils sector" data evolution, it can be appreciated that added value was significantly lower than in the wine sector which, in combination with higher production costs, resulted in lower margins (see Figure 10 and Figure 4). Considering these low margins and incomes, it is expected that most olive oil sector industries will not be able to afford extra investments for developing an IBLC. Moreover, since the great majority of the companies from "Fats and Olive Oil sector" have a "micro enterprise" size (see section 3.1.4).

People employed in fats and oils sector was near 12,000 people in 2014 [MAPAMA, 2016] and the consumption of olive oil in Spain was 12.3 kg/person in 2012 [GEA, 2016].

The above information (see Figure 10 and Table 2) show a clear patron of growth for the product sales, intensified in the last two years. This highlights the strength and stability that the olive oil sector industries have showed during the crisis years. Following table (see Table 3) presents the main companies operating in the olive oil sector:

Table 3. Main olive oil sector companies, 2017. Source: Alimarket, 2017 and SPANISH CO-OPS, 2017.

Main olive oil sector companies		
Ranking	Company	Turnover (million Euros)
1	Miguel Gallego S.A. (Migasa)	1,050*
2	Deoleo S.A.	695*
3	Dcoop S.C.A.	690
4	Sovena España S.A.	615*
5	Aceites del Sur-Coosur S.A. (Acesur)	523*
6	Borges Branded Foods S.L.U.	345

*Data show total turnover of the company, which can include non-related activities with the olive oil production and thus, modify the ranking.

Most of these companies (see Table 3) produce both olive and vegetable oil. This fact provides them of useful synergies since they have access to the residues of both sectors (see Chapter 6 of this country report) and it could solve related problems with raw material seasonality. As it can be observed, in the previous ranking (see Table 3) the cooperative Dcoop S.C.A. appears among the first three companies, showing the relevance that the cooperative cluster has achieved in this sector during the past years. Next is presented a list (see Table 4) with the main oil mill cooperatives from the olive oil sector:

Table 4. Main oil mill cooperatives, 2017. Source: Alimarket, 2017 and SPANISH CO-OPS, 2017.

Main olive oil sector cooperatives		
Ranking	Company	Turnover (million Euros)
1	Dcoop S.C.A.	690
2	Jaencoop S.C.A.	176
3	Almazaras de la Subbética S.L.	103
4	Oleoestepa S.C.A.	97

Concerning olive pomace oil industries, those are leaded by Oleícola El Tejar Nuestra Señora de Araceli S.C.A., followed by San Miguel Arcángel S.A. and Aceites del Sur-Coosur S.A. –Acesur– (first is a cooperative and the second one a cooperative owned private company).

3.1.4 Typical size of the companies

Analysing the size of the companies from the fats and oils sector, around 80 % of them have less than 10 workers (see Figure 11), near 18 % employ 10 to 49 labour, another 2.1 % from 50 to 499 and just a 0.1 %, more than 500 employees. In line with the previous section, these data state that only a marginal part of olive oil industries seem to have the required financial and logistic conditions for developing an IBLC.

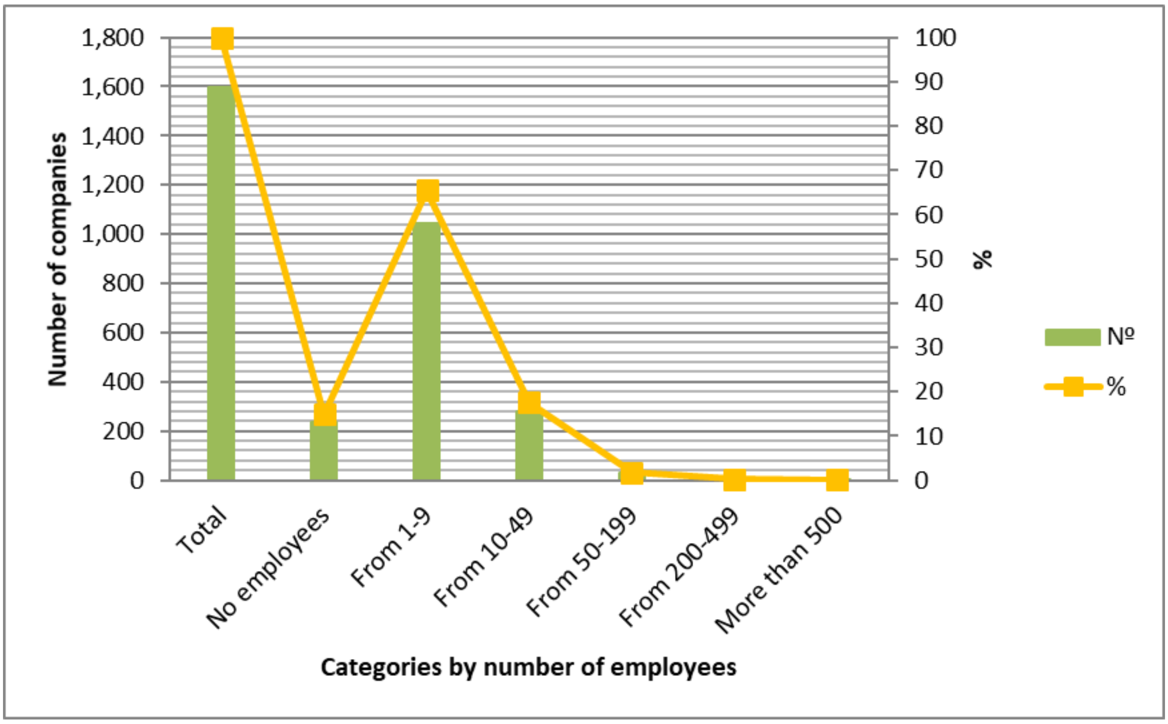

Figure 11. Typical size of fats and oils sector companies (by number of employees). Source: MAPAMA, 2016.

However, extrapolating these data to the total olive oil sector target industries (near 1,900), the fact should not be neglected that around 40 companies (2.2 %) seem to have optimal conditions for developing a new business line for the implementation of biomass activities (considering their size and associated financial assets).

In addition, considering that the average yield for the last six campaigns in Spain (from 2011 to 2016) was of around 1,080,000 tonnes of olive oil, an average production per oil mill (around 1,780 oil mills on average from the 2012-2013 and 2016-2017 campaigns) of near 600 tonnes of olive oil can be estimated [AICA, 2013 and 2017]. However, the extreme variability of the yields from year to year makes desirable to provide a range that represents better the sector seasonality. Thus, considering the AICA (Food Information and Control Agency) data, which establishes that the lowest yield accounted for last years (from 2011 to 2016) was 618,000 tonnes of olive oil –obtained from the grinding of nearly 3,342,000 tonnes of olives (2012-2013 campaign)– and, the highest was 1,570,000 tonnes of olive oil –obtained from the grinding of around 8,500,000 tonnes of olives (2011-2012 campaign)–, a production per oil mill and year between 341 and 866 tonnes of olive oil (depending on the year) can be estimated [AICA, 2014; 2017 and SPANISH CO-OPS, 2017].

All this supports the conclusion that, although most of the companies from the olive oil sector do not have adequate conditions for the implementation of the IBLC concept in their facilities, a considerable number of them seem to possess enough workforce and financial assets to ensure the success for the biomass related activities. Olive pomace oil industries have even better expectations as they will require (in general) less investing efforts (see sections 3.1.5 and 3.2.2).

3.1.5 Distinctive facilities of the sector

Olive oil mills do not own any compatible equipment with the processing of biomass that could be used during their process activity (see Figure 12), neither in a two-phases system (more spread technology) nor any other available.

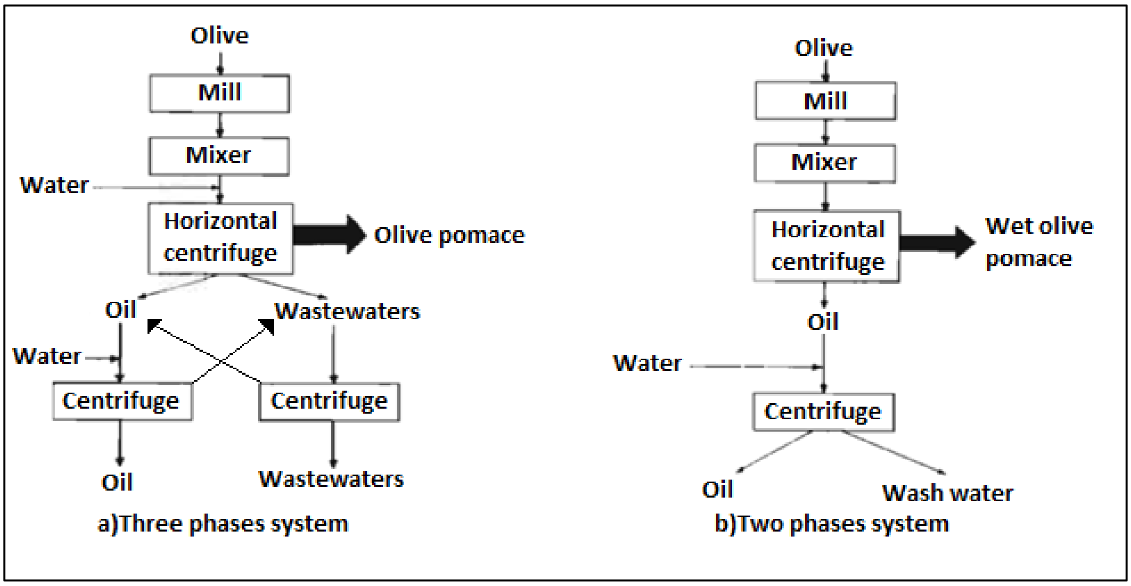

Figure 12. Comparison between three and two-phases systems. Source: Expoliva, 1993.

Nevertheless, as it happens with wine cellars industries in the wine sector (see section 2.1.5), oil mills have other assets that could be of great interest for developing an IBLC. Among these can be accounted the labour, transport, warehouses, conveyor belts and other machinery for biomass management (scales, tractors with spades, etc.), providing a useful advantage at the time of dealing with a new activity related both with biocommodities manufacture or bioenergy production.

First process stage of the olive pomace oil industries is based on the removal and drying of the incoming fresh grape pomace, prior to the oil extraction. Therefore, to perform the drying operations, these industries need horizontal rotary dryers, which are compatible with biomass related activities. The ownership of theses driers prevents olive pomace oil industries from the need of performing large investments. Besides, olive pomace oil industries also have other assets of interest for the IBLC concept such as warehouses, workforce or means of transport. All these resources place these industries in an exceptional position to start-up new business lines related with the biomass.

3.1.6 Degree of innovation

Several public organisations (MAPAMA, EIP-Agri) and private entities (CITOLIVA, CEAS, Aceites de Oliva de España) are currently carrying out initiatives, both at national and European level, to develop innovative solutions in different areas of the olive oil production chain. This stands the olive oil sector in a better position than others in relation to innovative actions.

One of the most pro-active entities in this sector (regarding innovation) is the Interbranch Organisation of Spanish Olive Oil (Aceites de Oliva de España), a non-profit organisation that brings together all the links in the production and marketing chain of olive oils. Several thematic have been addressed during the past years by this organisation [Aceites de Oliva de España, 2017]:

- Management of liquid residues from oil mills (June 2015).
- Fat intake effect on breast cancer (June 2015).
- Strategies to combat the Verticillosis disease (June 2015).
- Extra virgin olive oil intake effect on gestational diabetes (August 2015).
- Influence of the extraction atmosphere composition in the final product quality (August 2015).
- Evolution of ethyl esters over time in extra virgin olive oils (August 2015).
- Development of reliable, fast, easily reproducible and competitive technology, to classify the different commercial categories of virgin olive oils (August 2015).
- Mechanisation issues within MECAOLIVAR Project (November 2015).

From all these approaches, there is one of special interest for the IBLC concept; the research about "Management of liquid residues from oil mills". The motivation for this research line was the huge volume of effluents that the oil mills (three-phases systems) generated every year in Spain together with the prohibitive regulation in relation with the discharge into public riverbeds. The effects (over crop and soils) of applying those wastewaters (as fertiliser) into the olive groves are still in a testing stage. In addition, the outcomes of this research are expected to promote changes in some legislation respects [Aceites de Oliva de España, 2017].

A recent event that shows the strong concern and compromise from Spanish olive oil sector industries with the innovation, is the creation (September 2017) of the "Sensolive-Oil" Operational Group. This group aims to promote innovation in the field of the characterization of virgin olive oils and their official control. It is also a proof of the collaboration among innovative organisations, as it is led by the Interbranch Organisation of Spanish Olive Oil in collaboration with MAPAMA and EIP-Agri (Agricultural European Innovation Partnership).

In this line, within olive oil sector agro-industries, the case of Oleícola El Tejar Nuestra Señora de Araceli S.C.A. acquires a special relevance. This cooperative forged an alliance in 2011 with Natac (an organization devoted to the development of innovative and differentiated Mediterranean extracts) and, together, founded another company: Innovaoleo S.L. Through this alliance, new innovative products derived from the olive are being developed and produced at very competitive prices (see Section 3.2.1) [Natac, 2017].

Within the cooperative frame, Dcoop S.C.A. was awarded in November 2017 with "The European Awards for Cooperative Innovation" for the category "Information and Comunication Technologies (ICT)/Digitalization", which are organised by the European Agri-cooperatives (COGECA). This award is a recognition for the integration of the technological developments in the cooperative and their involvement in the European Project "Internet of Food and Farm 2020 (IOF2020)" and confirms that the larger companies are the ones with more proclivity to perform innovative actions.

Completely aligned with the AGROinLOG goals, it must be noted the coordination (2012) by a group of cooperatives (Jaencoop, cooperative of second degree) of the Interconecta project: "Biotechnological use of olive by-products from Andalusia for the food and agriculture sector (AEOSAN)". This project aimed to promote R&D&I in the Andalusian olive sector through the valorization of the different by-products (coming from oil mills and olive pomace industries), for the extraction of biocomponents (polyphenols and triterpene acids) and addressing both the animal feeding and the food industry markets [Grupo Jaencoop, 2018].

3.1.7 Miscellaneous

Two-phases system is the most modern and spread olive oil extraction technology in Spain. During the virgin olive oil process, wet olive pomace (TPOMW, Two-Phases Olive Mill Waste) and a small part of wastewaters are produced. TPOMW has a higher water content (60-70 %) [ORIVA, 2018 and Oleícola El Tejar Nuestra Señora de Araceli S.C.A., 2018] than olive pomace obtained in three-phases system. However, since no water is added to the mixing stage (see Figure 12), total water consumption is much lower and just, occasionally, a small wastewater volume is generated. Once transported to olive pomace oil industries, water is evaporated in the olive pomace oil extraction process. Instead, three-phases system generates virgin olive oil, olive pomace and a large volume of wastewaters, leading to environmental problems.

Therefore, two-phases system (see Figure 12) has been widely implemented by most Spanish oil mills to avoid the sustainability problems that the wastewater implies. Despite of this, it still represents a challenge for those oil mills that have not implemented this system (about 70 industries in Spain). since oil mills wastewaters are very pollutant due to their high organic load and solids percentage and, thus, legislation [BOE, 2017] forbid their pouring to riverbeds. Besides, these wastewaters are very rich in polyphenols, which hamper their treatment in conventional sewage purification plants [Cabrera. F, 2003]. This could influence the optimal development of possible future IBLCs.

To solve this problem, most extended solution consists of evaporating wastewaters in low depth rafts, causing odour, leaking and other environmental issues in the area. However, the use of wastewater as fertiliser (see Section 3.1.6) could be a feasible solution. This valorisation is still in a research stage as previously mentioned (see Section 3.1.6) due to the uncertainty of possible groundwater contamination and phytotoxicity problems associated to polyphenols [Aceites de Oliva de España, 2017].

Both oil mills and olive pomace oil industries have a large experience with biomass handling, since they are accustomed to generate, manage and transport their own biomass residues (see Figure 8).

Similar with the wine sector, the extraction of several bio-compounds from olive residues such as polyphenols is a feasible option (addressing mostly pharmaceutical and food companies). In the same way, several residues (see section 3.2.1) generated in the olive oil production process can be used for bioenergy production, offering olive oil sector industries new possible business activities. In fact, there are some successful examples of olive oil sector agro-industries that are currently taking advantage of these opportunities both at national (Oleícola El Tejar Nuestra Señora de Araceli S.C.A., Troil Vegas Altas S.C., Sansa de l'Ebre) and European level (Leo Verde Società Agricola-Italy, Nutria-Greece) as they produce and/or self-consume biosolid fuels, biogas and bio-commodities from olive residues (see Section 3.2.1) [Europruning, 2014, SPANISH CO-OPS, 2017 and Sucellog, 2017].

Usually, oil mills send their TPOMW to olive pomace oil industries. There, once extracted the olive pomace oil, the resultant exhausted olive pomace is occasionally returned to those oil mills adapted to biomass consumption, as they require it to meet their thermal necessities in the mixer and milling stages (see Figure 12).

Very often, the residual exhausted olive pomace is used in the own olive pomace oil industries for their drying process. In addition, is important to remark that both olive pit and exhausted olive pomace markets (solid biofuels) have already been developed and well established in Spain [Sucellog, 2017]. Standardization of olive pit residues has already been developed by the Spanish Association of Energy Valorization of Biomass (AVEBIOM) and the Center for Energy, Environmental and Technological Research (CIEMAT) under the BIOmasud label (UNE 164003). However, lack of standardization in other olive oil sector biomass, such as exhausted olive pomace, provokes uncertainty and issues of social acceptance [Sucellog, 2017].

On the other hand, it is also worth to remark the existence of an already finalised European funded project, OILCA (Olive Oil Life Cycle Assessment). This project aimed to improve the competitiveness of the olive sector in the south-western Europe region, including Spain, Portugal and the South of France. The OiLCA methodology was based on life cycle assessment (LCA) and life cycle cost (LCC) to identify opportunities for the optimisation of olive oil production. Through the life cycle of this project a tool was created with the aim of helping olive oil producers to make decisions in relation to their residues management, cause less environmental impact and improving economic profitability [OILCA, 2017].

Outcomes from this Project could be exploited by olive oil sector industries to implement an environmental label to differentiate the product. This label could be used both as an instrument for communicating the sector's contribution to the mitigation of the climatic change as well as for increasing sales due to the consumers' preference for a sustainable product [OILCA, 2017].

3.2 Opportunities IBLC

3.2.1 Sector related residues

Olive grove yields fluctuations lead to variable olive productions between 3.5 to 8.5 million tonnes per year (see Section 3.1.4).

As a result, generated TPOMW amount could vary from 2.5 to 7 million tonnes per year [Junta de Andalucía, 2010; Sucellog, 2017 and AICA, 2014/2017]. Same problem appears with the other olive oil sector residues, causing uncertainty to the valorisation industries.

Oil mills have easy access to olive grove pruning and generate several residues during the olive oil extraction process (see Figure 12). As stated by the Europruning Project, olive pruning production in traditional olive grove system varies between 1 and 4 tonnes per hectare and year. Considering previously provided data (see section 3.1.2) about Spanish olive grove area (over 2,600,000 ha), an available amount between 2,600,000 and 10,400,000 tonnes of olive pruning (fresh matter, 40 % moisture) per year has been estimated [Europruning, 2014].

However, since 30 % of the olive groves are cultivated in an intensive way (irrigation systems with higher associated yields), significant variations could arise from the previous estimations. On the other hand, logistic and feasibility problems will have to be overcome to ensure profitability since the manual pruning and transport lead to high costs (low density and value from some feedstocks).

Traditionally, the pruning of olive groves was burned on the field after completion of the collection activities. In fact, despite burning is forbidden by law, many farmers continue performing these kind of practices (illegally or through specific permissions). This poses environmental problems (CO_2 emissions, loss of nutrients, risk of fire, etc.) and energy waste. Subsequently, the incorporation of these remnants into the soil was put into practice after some crushing and splintering treatments. However, an alternative valorisation path is to use the pruning remnants for the production of electric or thermal energy considering that olive pruning residue has a low heating value (LHV) of 4,800 kcal/kg [AEE, 2013].

Regarding oil mill residues, the preparation process of the olives (performed outside of their facilities) for the olive oil extraction generates leaves (LHV of 4,500 kcal/kg) and branches (LHV of 4,300 kcal/kg), though these residues can be also collected while performing the harvesting of olives. Main applications for its valorisation are the manufacture of solid biofuels, compost or animal feed [AEE, 2013]. A higher added value alternative consists in the extraction of oleuropein, main phenolic component of the leaves and responsible of the bitterness from the olives, since it can be used in the pharmaceutical industry due to its beneficial effects for health (see Section 3.2.3).

One of the main cooperatives of the sector, Oleícola El Tejar Nuestra Señora de Araceli S.C.A., is currently producing shredded biomass from collected leaves and pruning, which will be later self-consumed in electrical cogeneration plants owned by the cooperative. Collection is performed with specific machinery for that purpose, after manual windrowing and pre-shredding of the pruning. Another possible valorisation for the leaves is the obtainment of methanolic extracts.

Besides, some 820 kg of TPOMW are obtained per tonne of processed olive in the horizontal centrifuges from the two-phases system oil mills, later stored in ponds. Although this wet olive pomace could be used either as fertiliser, bio-compounds extraction (performed by Innovaoleo S.L.) [Natac, 2017], compost manufacture or as an animal feeding ingredient, it is usually valorised as feedstock for the olive pomace oil extraction.

Olive pomace contains around 3 % of oil, some 54.5 % of water and the remaining 42.5 % are solids [Junta de Andalucía, 2010]. After the olive pits removal and drying stages exhausted olive pomace residue is generated during the pomace oil extraction.

A total amount between 0.7 and 3 million tonnes per year of exhausted olive pomace (dry matter) can be estimated at national level [Junta de Andalucía, 2010, Sucellog, 2017 and AICA, 2014; 2017]. This residue is usually intended for bioenergy production purposes and is currently exploited in many oil mills as well as in olive pomace industries for their production activity [Sucellog, 2017]. In this sense, some of them use this residue for biogas production (Sansa de l'Ebre, Nutria, etc.), combustion or gasification purposes (Bioland Energy) [Revista Almaceite, 2017]. Alternative valorisation routes for exhausted olive pomace are animal feeding, compost manufacturing or biocompounds extraction (addressing pharmaceutical industry mainly). It has a LHV between 3,950 and 4,200 kcal/kg (dry basis) [Esencia del Olivo, 2017 and San Miguel Arcángel S.A., 2018].

Wastewater generation from two-phases oil mills can be considered insignificant (only 15 kg of wastewater is produced per 1,000 kg of processed olives) when compared with wastewaters volume generated in three-phase systems (around 730 kg of wastewater per 1,000 kg of processed olives). Those industries that are still using two-phases alternative systems must evaporate or try to valorise their wastewaters (i.e., fertiliser), since these are very pollutant [Junta de Andalucía, 2010]. Oil mills wastewater can be also valorised through the extraction of hydroxytyrosol (an antioxidant beneficial to health, also performed by Innovaoleo S.L.) range of products.

A range between 0.28 and 0.7 million tonnes of olive pits (dry matter) is estimated to be obtained every year from both oil mills and olive pomace oil industries [Sucellog, 2017 and AICA, 2014; 2017]. Besides, table olive processing plants separate about half of the olives they process (to market the boneless olive), which represent about 0.022 million tonnes per year [Esencia del Olivo, 2017]. This allows to estimate a total average production of olive pits between 0.3 and 0.73 million tonnes per year. Olive pits have excellent features: high density, low moisture content around 15 %, very uniform geometry and LHV near 4,500 kcal/kg (dry basis). Since it is very suitable for thermal applications, a market for this residue has been growing little by little during the past years (addressing either industrial and residential customers). Due to the lack of data about these issues, surveys have been prepared by AVEBIOM to collect some market figures [AVEBIOM, 2018].

As it has been mentioned (see Section 3.1.7), specific certification label was developed under the BIOmasud Certification System (funded under the European Regional Development Fund, EDRF) for the olive pit [BIOmasud, 2018], which shows the degree of maturity that the market of this raw material has acquired recently.

3.2.2 Potential synergies & benefits

Synergies between agro-industries and generation periods of some above-mentioned residues are showed in the next chart (see Figure 13):

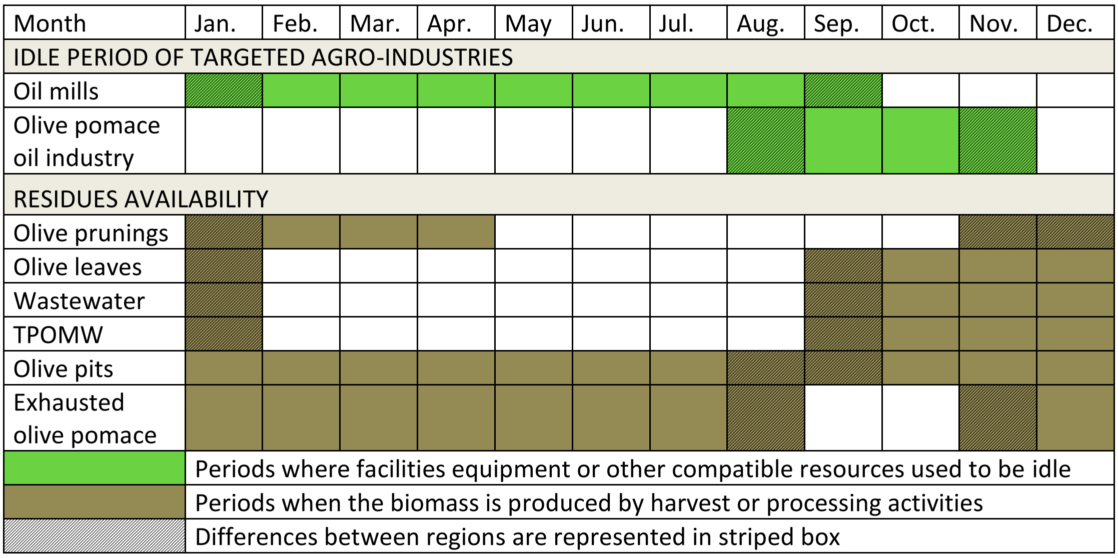

Figure 13. Synergies between agro-industries idle period and residues availability. Source: Sucellog, 2017, Europruning, 2014, SPANISH CO-OPS, 2018 and Nuestra Señora del Pilar, 2018.

Oil mills present longer idle periods when compared with olive pomace oil industries (see Figure 13). Despite firsts do not own any equipment specifically compatible with the processing of biomass, those could take advantage from their numerous assets (see Section 3.1.5) as well as from the easy access to olive pruning residues and the longer idle periods for the development of an IBLC. However, the lack of compatible machinery would probably imply larger investments than the needed in olive pomace industries. Considering the small size that features these industries (see Section 3.1.4), this could challenge the adequate implementation of IBLC concept. When possible, the association of similar companies from the same area is advisable, as they will collect more residues (solving the size problem), share the investment costs and thus, reduce risk.

Olive pomace industries have compatible equipment with the procesing of biomass. This equipment is able to process large amounts of oil mill residues (see Section 3.2.1) and also generate their owns. All this advantages provide great synergies to these industries for developing an IBLC. Moreover, as it has already been mentioned (see Section 3.1.7), several olive pomace industries in Spain have already developed business activities related to the valorisation of residual biomass coming from oil mills (San Miguel Arcángel S.A., Bioland Energy, Oleícola El Tejar Nuestra Señora de Araceli S.C.A., etc., Troil Vegas Altas S.C.), both with bioenergy and biocommodities obtainment purposes. This fact supports the hypothesis of a greater feasibility of IBLC concept implementation for these industries.

It is expected that the development of IBLCs both in oil mills and olive pomace oil industries will increase both the employment and the length of current contracts due to the implementation of new activities and related tasks required. Moreover, current workers would propably need training programs to diversify their activities. In addition, the implementation of IBLC's in these industries will bring a positive impact over the environment (fires risk could be reduced since part of the biomass from the olive would be removed, also, the emissions of CO_2 will decrease due to the substitution of fossil fuels by renewable sources).

3.2.3 Market developments

Olive oil sector agro-industries generate several residues during their process activities (see Section 3.2.1) that provide the opportunity to manufacture several biocommodities demanded by markets (different from the food and feed ones), such as the pharmaceutical, energy or fertiliser. Following are summarized some of the marketed biocompounds derived from olive residues [Natac, 2017]:

- Hydroxytyrosol: Obtained from oil mills wastewater concentrates (see Section 3.2.1), this polyphenol has antyoxidant and anti-aging properties useful in the pharmaceutical industry.
- Oleuropein: This glycoside, extracted from the olive leaves, helps regulate tension and thus, is useful in the pharmaceutical market.
- Triterpenes: These terpenes, extracted from olive pomace oil, are used in the pharmaceutical industry for cardiovascular health treatments and glucose control.
- Methanolic extracts: Methanol extraction was found to produce the highest number of phenolic compounds and antioxidant activity [Olive Oil Times, 2017]. Those extracts are obtained from olive leaves and pruning [Oleícola El Tejar Nuestra Señora de Araceli S.C.A., 2015].
- Biofertilizer production: It can be produced from the collection of olive washing sludge and olive leaves, its subsequent digestion (5-7 months) and maturation [AGRIFORVALOR, 2018]. TPOMW can be also used to produce compost and has been founded to be a feasible alternative bussines line by some agro-industries in Spain [Grupo Jaencoop, 2018].

In addition, after some specific pre-treatments and conditioning of the olive oil industry residues (see Section 3.2.1), energy valorisation can be also attained (bioenergy market). In this way, different solid biofuels (briquettes, chips, pellets, bulk, etc.) can be produced from the processing of several feedstocks, such as exhausted olive pomace, olive pits and pruning. Anaerobic digestion of the exhausted olive pomace is also feasible and is currently carried out by some industries (Sansa de l'Ebre, Nutria, etc.).

It has to be remarked that olive pits and exhausted olive pomace have already developed markets addressing both agro-industry and household consumers (in some cases public administration is the customer) and are well established. The cooperative Nuestra Señora del Pilar (oil mill) is a very representative case since they use part of their own olive pits to produce the energy required in the olive oil extraction process –selfconsumption– and another part is packaged and sold to farmers or partners from the cooperative. In a similar way, the olive pomace industry San Miguel Arcángel S.A. (owned by cooperatives) uses all the olive pit they receive to produce part of the process energy, another part must be purchased to other agro-industries and the exhausted olive pomace is sold to a biomass plant (La Loma) [Nuestra Señora del Pilar, 2018]

Moreover, to reinforce the feasibility of the energy valorisation and according to the information provided by the Association of Renewable Energy Producers (APPA), it is worth mentioning the existence of several companies (see Figure 9) in Spain which main activity is the valorisation of residues (such as La Loma in Jaén) from the olive oil sector for electric and thermal energy generation [APPA, 2011/2017].

Main barrier detected to reach all these potential markets concerns oil mills and their lack of suitable equipment for the processing of biomass. However, olive oil pomace industries do not present any significant barrier. In fact, several companies are already developing similar activities to the proposed by the AGROinLOG IBLC concept (see Section 3.1.7).

3.2.4 Non-technical barriers

In spite of the mentioned existence of several technical problems at the time of developing an IBLC's within the olive oil sector industries (see sections 3.1.5 and 3.1.6), other general non-technical barriers are presented in Table 16 (Annex A of this report). Though most of these barriers can be extrapolated to other sectors, following are presented some problems specifically linked with olive oil sector.

Olive oil sector is featured by its high seasonality, which implies strong variability from year to year regarding the harvest yields (see Section 3.1.4). This non-technical barrier has a significant weight when considering the implementation of an IBLC, since this new business activity will require a certain security in the raw material supply.

Similar than in the wine sector, the burning of the olive pruning is forbidden by law, but though, allowed by some public administrations in specific cases. This prevents the development of new valorisation ways for these residues [BOE, 2018].

Concerning legislative aspects, AVEBIOM is trying to modify the denomination of the olive pits to by-product instead of residues. Though this classification not always implies a problem in all the autonomous communities (some of them have their own legislative frame that allows the marketing of the olive pits), it causes uncertainty to the new biomass manufacturers as occasionally they are asked to become waste managers [AVEBIOM, 2018].

The same barriers reported (see Section 2.2.4) by the Natac company for the wine sector case apply as well in the olive oil sector. Finally, since oil mill industries will need to perform strong investments for the acquisition of compatible equipment, this could represent a significant financial barrier to consider, since many of these industries will not probably beat it (small size, see Figure 11).

4 Grain chain

4.1 Profile of the grain chain sector

4.1.1 Production

Spanish grain production represents a large part of the agricultural territory, with an average of 6 million hectares of crops such as maize, barley, wheat, rice...and much smaller areas of rye, oat and others. Considering that most of them grow on rain fed lands and semi-arid conditions, typical yields for wheat vary from 1.5 to 2.5 tonnes per hectare and from 4 to 6 tonnes per hectare on irrigated lands.

After harvesting, both maize and rice need to reduce their humidity rate to allow a better conservation along the food chain. This operation commonly gets underway on vertical dryers owned by cooperatives or cereal traders. Contrary to other countries, neither wheat nor barley need to be dried through a thermal treatment, since the Spanish weather is enough dry and, thus, after the harvest they are simply stored until their sale.

In addition, after reception into the bulk silos and to prevent infestation of grain, a gas or thermal treatment is carried out. Some operations; screening, scouring, brushing and aspiration are made for cleaning the grain and removing other rests. In the process of conditioning, the grain is slightly wet or steamed. This fact will facilitate the separation between bran and endosperm of the grain on later stages. Then corrugated rollers start the milling process, turning the grain into finer particles. After each step of this process grading is done to screen the bran, germ and endosperm. Fine micro particles of endosperm constitute the flour. Other intermediate particles are known as semolina. Durum wheat semolina will be used for pasta producing.

Once the grain has been dried (naturally or by means of a thermal treatment), raw materials are dispatched to the different value chains. Generally, barley is addressed at two main industries, brewery and animal feed plants while main destination of soft wheat is the industry of flours and bakery. By other hand, durum wheat is highly appreciated on pasta industry for its physical characteristics. Regarding summer cereals, rice is prepared in specific industries where the husk is removed. Then grain is polished and turns white. Its main market is the direct consume without further transformations. However, maize is usually a feedstock for the animal feedstuff industry, though it could be destined to the production of iso-glucose for sweetens purposes. Wheat, barley and maize could be also used for bioethanol production on industrial plants.

In accordance with the AGROinLOG preliminary expectations to assess potentialities as IBLC, those facilities where the grain is directly received would have better opportunities to start-up new business lines. Therefore, the sites to be analysed will be dryers of maize and rice, malt industries in barley, semolina producers in durum wheat and flour mills in soft wheat. Other important related industries are the animal feed plants, largely assessed in another chapter (see chapter 0 of this country report).

4.1.2 Volume of the sector

According to MAPAMA, the previsions estimate a cereal production in the EU for the 2016-2017 campaign of 293.8 million tonnes over an area of 57,334,000 hectares. In this campaign, Spain would be the fourth producer with 23.4 million tonnes, advancing the United Kingdom (22.6 million tonnes) and just behind France (55.3 million tonnes), Germany (45.5 million tonnes) and Poland (30.2 million tonnes) [MAPAMA, 2017].

Volume may be considered from all the perspectives of the value chain; production, industrial sector or value of the different final products (bakery, brewery and so on). On this sense, considering grain as an international commodity with low margins and added value in their commercialization and transformation (except the last stages of the chain close to consumer). As mentioned before (see Section 4.1.1), spot will be targeted to the first stages of the chain. Value of the grain produced in Spain (rice included) reaches figures above 3,500 million Euros (see Figure 15), representing 12.6 % of total vegetable production value [Eurostat, 2016]. Other relevant figures concern the value of the industrial main destinations of the grain. Flour milling and starch sectors had total sales of near 3,000 million in 2014 [INE, 2014] while bakery and pastry sector achieved in the same year almost 6,570 million. In addition, the value of animal feed industries reached near 8,820 million [INE, 2014].

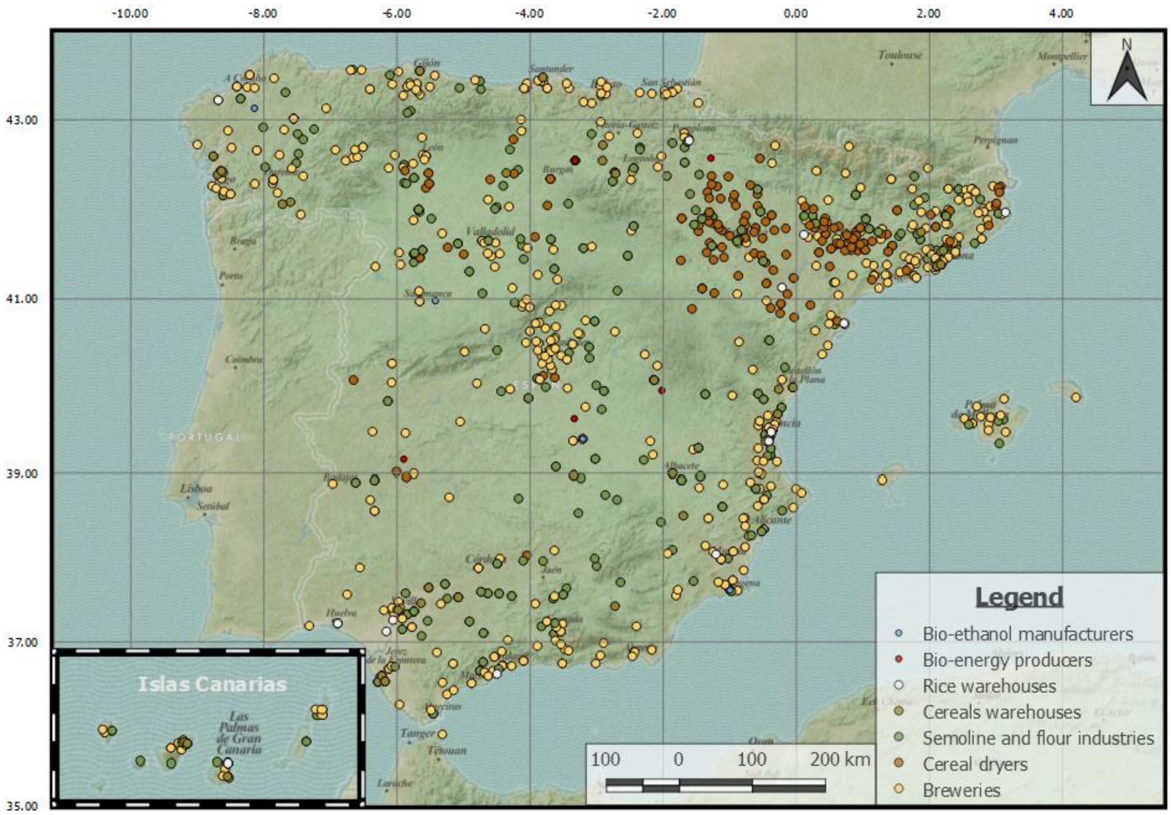

Figure 14. Location of Spanish grain chain sector and related industries. Source: SPANISH CO-OPS (elaborated from APPA, 2011/2017; Cerveceros de España, 2017; AECOSAN, 2017 and AFHSE, 2017 data).

Map above depicts the distribution of the main industries linked with the grain sector (see Figure 14). On it, some 300 flour and semolina industries, 500 breweries, 70 warehouses, 10 bioenergy producers (included bioethanol manufacturers) and 150 dryers are represented. However, there is an important number of drying and storage sites that have been impossible to locate since only some regions fed the national data bases [AECOSAN, 2017; APPA, 2017; SPANISH CO-OPS, 2017 and Cerveceros de España, 2017].

According to MAPAMA data for 2016, cereal production in Spain (over 19 million tonnes) was headed by Castilla y León (37 %), followed by Castilla-La Mancha (15 %), Aragón (15 %) and Andalucía (11 %) [MAPAMA, 2016].

4.1.3 State of the sector

Grain sector is completely price-dependent and subordinated to the balance between demand and supply in the international markets. Since there is a deficit in the cereal supply market in Spain (due to the lack of cereal lands), every year relevant imports must be carried out. Consumption in the 2016-2017 campaign was around 34.5 million tonnes, while production barely reached 23.3 million tonnes [MAPAMA, 2017]. On average, during the past years Spanish farmers produced around 15 million tonnes of winter cereals and more than 5 million tonnes of summer cereals (maize and rice).

This production-consumption gap has increased due to the constant growing of the animal feeding necessities (see Section 5.1.3), backing the intensive poultry and pig rearing sectors. Second relevant factor is the climatology, especially concerning the annual rain regime, with high variability between the drought seasons productions and the rest. This also affects the availability of several residues (i.e., straw). In the following chart (see Figure 15) the constant swings associated to the production value can be observed.

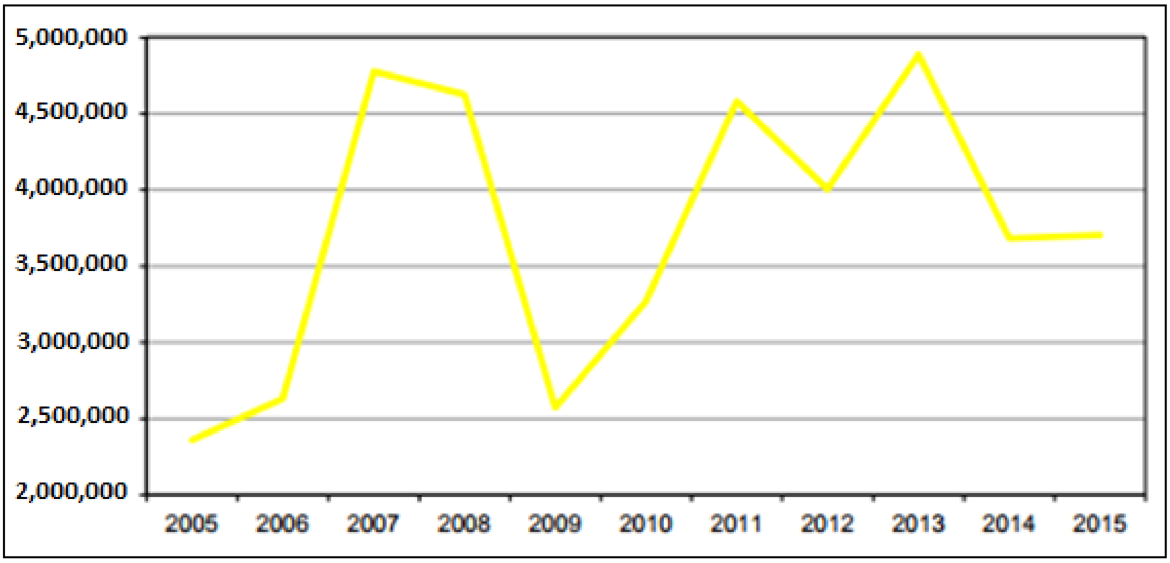

Figure 15. Grain cereal value evolution. Source: MAPAMA, 2017.

Despite of this fact, lack of clear alternatives for the development of other crops different other than cereals allow to foresee steadiness in the sector, and thus, it is also expected that industrial sector linked to cereals will remain stable. In addition, it must be remarked that the high demand of their products will be fed either by national or international supplies.

Main companies from the mill and starch (see Table 5), beverage (see Table 6) and bakery and pasta sub-sectors (see Table 7) are next presented:

Table 5. Top 10 mill and starch sector industries. Source: MAPAMA, 2017.

Nº	Company	Sales 2015 (mill. €)	Employment 2015
1	HARINERA VILLAFRANQUINA, S.A.*	347	285
2	GRUPO HARANTICO*	329	296
3	HARINERIA LA META, S.A.	85	70
4	GURIA, S.A.	62	59
5	HARINERAS VILLAMAYOR, S.A.	48	80
6	NUTRIGAL SDAD ARAGONESA DE MOLINERIA S.L.	40	28
7	HARINERA ARANDINA S.A.	35	49
8	ANTONIO CANO E HIJOS, S.A. *	35	40
9	HARINERA RIOJANA S.A.	33	70
10	AGRI-ENERGIA S.A.	29	29

Table 6. Top 10 beverage sector industries (wine excluded). Source: MAPAMA, 2017.

Nº	Company	Sales 2015 (mill. €)	Employment 2015
1	MAHOU S.A. - GRUPO	1.178	2.820
2	S.A. DAMM (GRUPO)	963	3.125
3	HEINEKEN ESPAÑA, S.A.	930	1.667
4	HIJOS DE RIVERA, S.A.	328	478
5	COMPAÑÍA CERVECERA DE CANARIAS, S.A. (CCC)	129	367
6	LA ZARAGOZANA, S.A.	79	99
7	INSULAR CANARIAS DE BEBIDAS, S.A. (GRUPO HEINEKEN)	40	79
8	GMODELO EURROPA, S.A.	100	38
9	S.A. VALLE, BALLINA Y FERNÁNDEZ (GRUPO EL GAITERO)	19	73
10	CERVEZAS MORITZ, S.A. (GRUPO LA ZARAGOZANA)	17	30

Table 7. Top 10 bakery and pasta sector industries. Source: MAPAMA, 2017.

Nº	Company	Sales 2015 (mill. €)	Employment 2015
1	GALLETAS SIRO, S.A. GRUPO*	602	4.092
2	EUROPASTRY, S.A.*	508	1.311
3	GRUPO PANRICO*	350	2.087
4	GRUPO BIMBO*	345	1.000
5	GALLETAS GULLÓN, S.A. GRUPO	307	1.250
6	GRUPO DULCESOL*	303	1.850
7	BERLYS CORPORACIÓN ALIMENTARIA S.A.U.*	224	1.200
8	GRUPO PANSTAR	210	1.080
9	GRUPO PASTAS GALLO*	197	351
10	KELLOGG ESPAÑA, S.L.*	155	130

4.1.4 Typical size of the companies

Comparing with big traders on international markets, such us Bunge or Cargill (that also operate widely in Spain), the rest of the companies trading with cereals in Spain are relatively small. Cereal warehouses devoted to the purchase and sales of the grain are usually linked with other operations such as the drying, dehydration or seeds and agrochemical distribution.

Considering their staff, the following table (see Table 8) outlines the size of the companies. As it can be observed, the vast majority (96.9 %, on average) falls inside of microenterprise category (from 0 to 9 workers) and small companies (from 10 to 49 workers).

Table 8. Typical size of grain sector and related companies.

Typical size of grain sector and related companies								
Sector		Total	Employees					
			No employees	From 1-9	From 10-49	From 50-249	From 250-499	More than 500
Mill and starch sector companies	Nº	447	93	240	97	14	2	1
	%	100	20.81	53.69	21.7	3.13	0.45	0.22
Beverage sector companies (wine subsector excluded)	Nº	486	230	224	18	6	5	3
	%	100	47.33	46.09	3.70	1.23	1.03	0.62
Bakery and pasta sector companies	Nº	10,183	2,706	5,992	1,221	138	16	10
	%	100	26.57	58.84	11.99	1.36	0.16	0.10
AVERAGE	%	100	31.57	52.87	12.46	1.91	0.54	0.31

Taking into account the previous data (see Table 8), most of the grain sector industries are not going to present an adequate size (neither of employees, processing capacity, residues availability or economic strength) that will allow them to implement an IBLC within their facilities. Despite of this, near to 2 % of the industries seem to have an interesting size for developing these centres (due to the expected associated assets and resources).

4.1.5 Distinctive facilities of the sector

Moisture removal from cereal in dryers (maize and rice) is considered a preservation method. By reducing the water content, the opportunity for microbial deterioration is reduced and the rates of other deteriorative reactions are minimum. In addition, the loss of the water leads to important reductions of the product mass and volume, improving the efficiency of product transportation and storage. Temperature and moisture content are critical parameters for the cereal quality.

Most of the industrial grain dryers are vertical dryers (see Figure 16), not as suitable for biomass as the rotary horizontal ones [Sucellog, 2017]. Therefore, a new line for drying may be required since not so many biomass formats are compatible with these dryers (only granulate material but no straw or chip).

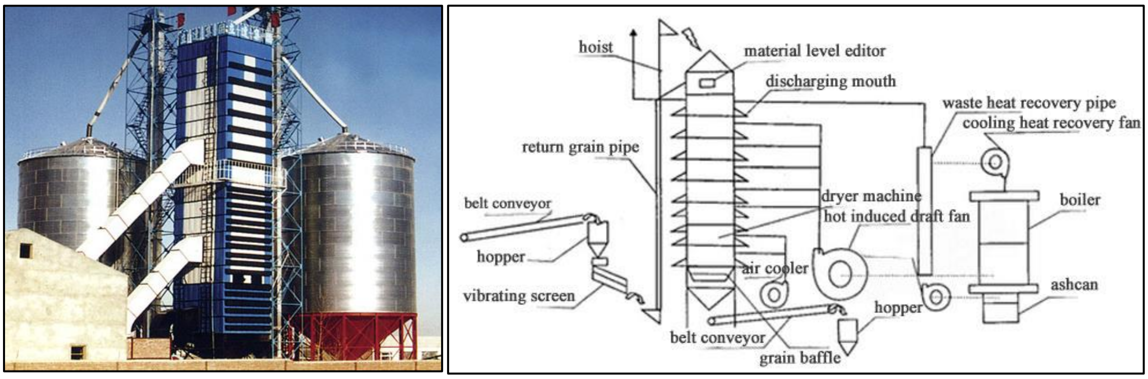

Figure 16. Grain dryer and storage silo. Source: Kefan, 2017.

In general, grain processing stages do not match very well with processes linked with the preparation of biomass. Despite this, cereal drying industries show an interesting IBLC potential: idle periods of around 8 months, screening and handling equipment, silos for storage and in some cases, pelletizers. All this equipment could be used without any barrier [Sucellog, 2017].

4.1.6 Degree of innovation

Considering innovation willingness of grain sector, it is clearly influenced by the size of companies, with large variations between the innovation effort of big companies and the rest. Available data of innovation in food industry, which concerns specifically the milling and starch sector, show that near 16.6 % of milling and starch industries allocated more than 4 % of the budget for R&D [MAPAMA, 2009].

The Institute of Agrochemistry and Food Technology (IATA), dependent from the Superior Council of Scientific Investigations (CSIC) has a specific researching team focused in the innovation, quality and development of cereal products. This research is being used to scientifically develop new products with added value and provide solutions to meet the demands of consumers, such as people suffering from celiac disease.

The collaboration between Spanish research centres (UPM and CSIC) and agro-industries (Mahou and Createch) has allowed to develop bones regeneration materials from the bagasse. These new materials (biocommodities) represent an alternative to prostheses formed from processed ovine bones or synthetic materials, whose manufacturing processes are much more expensive and aggressive for the environment [UPM, 2014].

Several research projects have been developed during the past years to find different ways to produce biofuels, functional foods and cosmetics from the bagasse (residue generated in the breweries, see Section 4.2.1) [UCA, 2011 and Cátedra Ecoembes, 2012]. In the same line, the obtainment of biobutanol (from the bagasse), a biofuel with great advantages due to its similar octane to the one of gas, is still under development in the Valladolid University (UVA) [Efeagro, 2016 and UVA, 2016].

In addition, researchers from the Almería University (UAL) are studying, through the Greenbiorefinery Project (in collaboration with Mahou and other breweries), the valorisation of the wastewaters generated in the beer production process. The target of this project is the utilisation of the breweries wastewater as feed for microalgae that, being used for water purification, can be used later as nutritive feed for the cattle [UAL, 2015].

Within the framework of the European project SOSTRICE, in which several research centres and other organizations participate (IAT, AINIA, LUDAN, CITAGRO and CTAER), the first semi-industrial pilot plant that generates biogas and biofertilizers from rice straw has been put into operation in Valencia [AINIA, 2016].

Similarly, several entities (FEIQUE, Técnicas Reunidas and CICYTEX) have collaborated in the development of the WALEVA Project, which aims to recover the waste rice straw through its transformation into Levulinic Acid, a product of high industrial demand. The WALEVA project provides a sustainable solution for farmers in the rice growing regions, linked to the principles of circular economy and waste valorisation, which avoids the usual burning of straw and its polluting effect, due to the CO_2 emissions they emit into the atmosphere [FEIQUE, 2017].

Moreover, rice straw has been tested (CSIC) for the protection of burned soils and the vegetation cover regeneration. Results have demonstrated that straw significantly reduces erosion losses from burned soil and is more effective than other techniques used such as seeding grasses [Residuos Profesional, 2013].

Finally, some other projects have been carried out in the Valencian Region focusing on the conversion of rice straw into a new organic feed for livestock (the straw is mixed with orange peel), to elaborate a high-quality compost or manufacture of certain street furniture [Residuos Profesional, 2017].

All this research project activity states an important will from the industries to invest in innovation and, in many cases, very aligned with the AGROinLOG interests.

4.1.7 Miscellaneous

Grain sector industries are very used to manage biomass resources, as they must treat, transport or storage those. Thus, this experience is a valuable asset from which grain industries could take advantage at the time of implementing an IBLC.

Regarding LCAs, several studies have been released in Spain, mostly focused on the crop of different cereals for the production of bioethanol in Spain and in the comparison between the bioethanol and the gasoline. Among the objectives of these studies were the quantification of the environmental impacts from crops that could be used as raw materials in the bioethanol production and to identify and assess the opportunities to reduce those impacts through the life cycle of the crop [CIEMAT, 2005].

4.2 Opportunities IBLC

4.2.1 Sector related residues

According to the Sucellog Project, cereal dryers are usually located in areas where there are important cereal extensions. Farmers supplying the grain to be dried in the facilities produce large quantities of straw, of which the current main destinations are the livestock feeding, cattle bedding and substrate for mushroom cultivation. However, the obtainment of other biocommodities from wheat straw, such as furfural and levulinic acids, paper, glucose, micro- and nano fibrillated natural fibres, non-food sugar (basis for the production of bio fuels and other chemicals) [AGRIFORVALOR, 2018], component in the manufacture of panels, insulation and filler solid in building materials, artificial manure, aeration agent and/or carbon source for the composting of pasty or excessively nitrogen-rich waste, have been also studied and proved as alternative options [RSC Advances, 2014 and Infoagro, 2018]. Moreover, the exploitation of straw for bioenergy purposes (mostly combustion) is, at the time being, the most feasible option, since there are some successful experiences in Spain (the Agropal cooperative uses the straw as a fuel to provide all the energy required by their cheese factory and a dehydration plant) [Acciona Energy, 2017 and Agropal, 2018]. However, quality issues (related with ashes and chlorine contents) may affect when it comes to competing with woody materials [Sucellog, 2017].

In this sense, depending on the year, a considerable amount of straw produced cannot be sold for any conventional destination. Some studies consider that, one year out of three, the straw (from cereals, maize, etc.) can be used for energy purposes (one third of the total amount of straw is left on the soil). Other studies have reported that the available potential biomass (biomass without any other competitive use and, therefore, with potential to be used as biomass for energy or for manufacturing biocommodities) is about 20 % of the total agricultural residues produced per year for winter cereals and 70 % for maize.

The production of bioethanol from cereal straw could be an alternative valorisation whenever this raw material is considered as a residue, but not when is directly produced for bioenergy purposes, since this last option is not the purpose targeted within the AGROinLOG Project. According to APPA, there are four industries in Spain (see Figure 14) that are currently producing bioethanol (one of them using residues from the wine sector as feedstock, see **Figure 3**)[APPA, 2017].

Maize processing industries have also several unexploited residues such as the corn cob, leaves or stalks that could be potentially valorised both for bioenergy and the manufacture of biocommodities. One of the auditing studies performed within the Sucellog Project was carried out in the Spanish Cooperative "Agraria de Miralcamp", where there was an interest in valorising the corn cob residues for bioenergy self-consumption or its commercialization.

For this purpose, and following the successful activities carried out by the agro-industrial company Tschiggerl Agrar GmbH (also supported by the Sucellog Project to create an agroindustry logistic centre), research was performed on the combined harvesting of the maize grain and corn cobs by a modified harvester [Sucellog, 2017].

In addition, researchers from the Michigan University (USA) developed on 2013 a process able of producing isobutanol (biofuel with better properties than the ethanol), from the maize leaves and stalks. This process was also intended to produce bioplastics (biocommodities) [Renewable Energy Focus Journal, 2013 and ABC Ciencia, 2013].

Furthermore, rice mills can be used as storage facilities to keep rice crop residues that can be exploited for bioenergy and biofuels. In order to reduce the operational fuel costs of the dryer, the consumption of rice husks as fuel can be applied. Rice husk is an unexploited by-product of rice milling process with low acquisition costs (usually only the transportation costs are paid by the purchaser).

The main solid residue from breweries is the bagasse, resultant from the boiling of malt. Very often, breweries in Spain (i.e., Grupo Damm) allocate this residue to cattle feeding due to its high protein content (more than 25 %). Later, the excrements of the cows are used as fertilizer in the barley crops, closing the cycle [El País, 2017]. Another way of bagasse valorisation is the production of biofuels (such as biobutanol, see Section 4.1.6), functional foods or materials to regenerate bones (see Section 4.1.6) and cosmetics.

4.2.2 Potential synergies & benefits

Considering the potential synergies for the grain chain industries, it is necessary to differentiate between two main groups. On the one side, there are installations located near to production areas involved in first transformation. On the other, there are industries that perform second transformation processes and are generally located in points that cover greater areas of activity (like crossroads, harbours or important logistic and industrial real states or cities). In the second group would be starch producers, large malt industries, pasta producers and so on. Matching the IBLC concept with this second group of industries seems complicated.

First group show higher affinity with the IBLC concept as they have strategic location. Warehouses of wheat and barley with high logistic capacities are also well positioned. Besides, medium size and well-located flour mills and small breweries with willingness to look for a business diversification could be included.

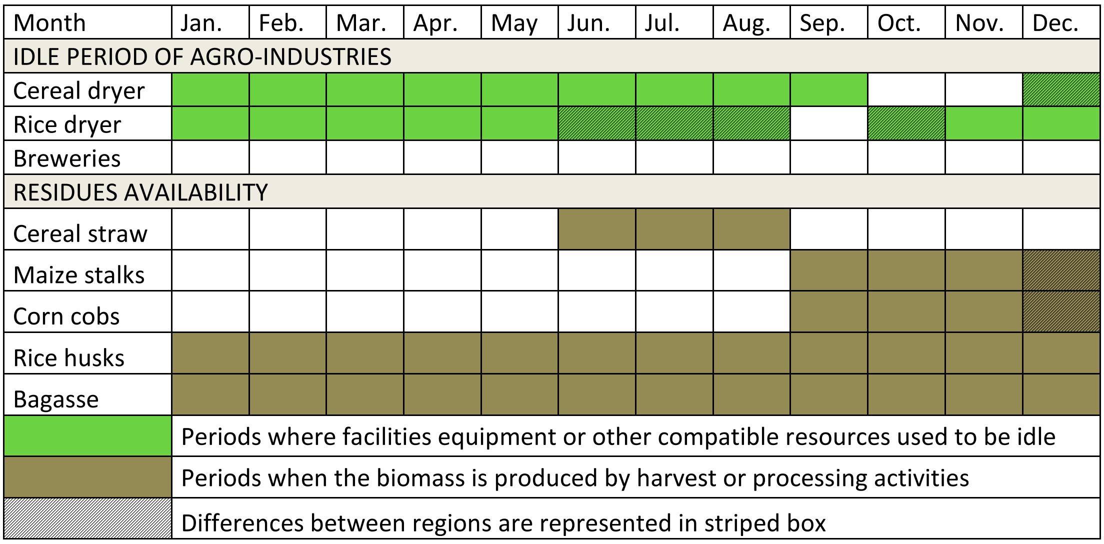

Figure 17. Synergies between agro-industries idle period and residues availability. Source: Sucellog, 2017.

When observing the above chart (see Figure 17), it can be noticed that cereal and rice dryers have long idle times that coincide with several grain chain sector residues availability periods. Therefore, grain dryers, having both compatible equipment with the processing of granulated biomass and long idle periods, could implement an IBLC devoted to these activities or even purchase new equipment for the processing of other biomass formats (depending on the size and possibilities of each industry).

4.2.3 Market developments

As stated in a previous section (see Section 4.2.1), several grain chain sector residues could be used for attaining bioenergy markets through the production of solid biofuels (self-consumption or sell to other agro-industries, public buildings and households) or the development of new bio-commodities (i.e., prosthesis, microalgae for animal feeding, etc.).

Every year, production conditions and international prices affect this market, since the grain can be considered a standard commodity. In addition, the straw market is subjected to high uncertainty due to climate effects and can experience strong variations from year to year. Moreover, when the amount harvested is low, straw prices rise sharply due to the stable consumption of the livestock sector (where is mainly destined to animal beds).

On the contrary, when production volumes are high, the consequently low prices of the straw push the farmers to leave large amounts in the field, which could be used as biomass raw material for different purposes as previously mentioned. Therefore, the high seasonality of the supplies and the variability of the prices imply serious barriers for starting-up new biomass business lines within the grain chain sector industries that need to be taken into consideration. Perhaps, a mature secondary market for biomass may help to stabilize this situation.

4.2.4 Non-technical barriers

Although the main general non-technical Spanish barriers for the implementation of the IBLC concept in the agro-industries can be found in Table 16 (Annex A of this report), there are some specific ones that only concern grain chain sector.

Analysing the dry climate of Spain, the episodes of water scarcity of the last decades have encouraged a raising tendency for the implementation of new irrigation systems, responsible with the water management (i.e., droppers). Expected future water restrictions (legislative barrier) for maize and other cereal crops could affect the dryer facilities. This can be considered both a problem and an opportunity, since the old activity could disappear in mid or long term but, at the same time, it could be replaced by a new business line related with the processing of biomass.

As it happens in the wine and olive oil sectors (see chapters 2 and 3), the maize crop residues (leaves and stalks) are usually left in the soil as nutrients or are burned on the fields margins. Though the legislation forbids the burning, sometimes public administrations allow it, and so discourage new ways of valorisation. This is also related to the lack of suitable harvesters for the collection of these type of biomass, since there is no awareness of its potential by the farmers.

Special attention has to be paid to the seasonality of the straw production, which could lead to problems in the supply of raw material for the new IBLCs. Seasonality issues could be solved using different raw materials, which could be handled relatively easy by the industries of the grain sector, since several residues are generated by them (see Section 4.2.1).

Since Spain shows a deficit in soybean crops, most of the soy has to be imported from other countries. Therefore, and since the dried stem is usually destined to animal feeding, the availability of soy straw in Spain is expected to be very low [FAO, 2003 and MAPAMA, 2017]. Something similar happens with the rape crop, though it has experienced a significant grown during past years, it remains a marginal production in Spain [MAPAMA, 2017].

The lack of equipment completely suitable for the processing of biomass in the grain chain industries leads to higher investments, which could represent in many cases a significant financial barrier for many companies in order to implement IBLC concepts.

5 FEED AND FODDER

5.1 Profile of the feed and fodder sector

5.1.1 Production

Animal feed industries final products are homogeneous mixes of several raw materials (grains, cereals, vegetable and animal by-products) and components (oil and fats, molasses, vitamins and minerals) from which a balanced and nutritious food is achieved, providing a better conversion performance in the animal feeding. Grinding is usually required in the animal feed production activities and its position in the process leads in to two main types of process flow diagrams: pre-grinding (see Figure 18) or pre-dossing processes. The difference resides in that grinding is carried out before the dosing in the first case, and instead, in the second one, raw material is coarsely mixed before being ground together formula by formula [Tesla, 2014].

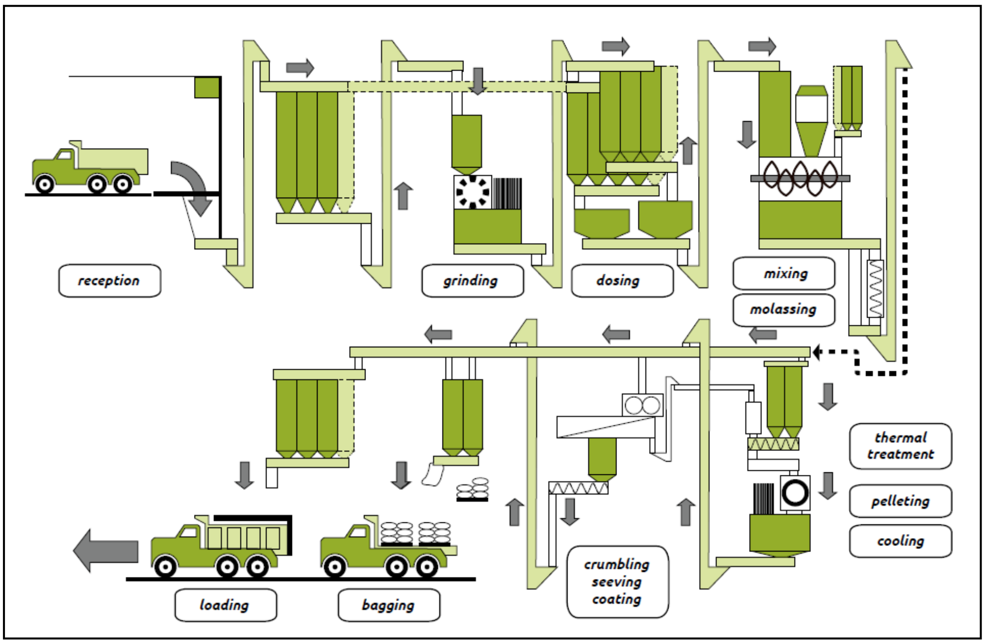

Figure 18. Pre-grinding process flow diagram of feed manufacturer industries. Source: Tesla, 2014.

Raw materials are usually transported by truck. Once in the plant, trucks are weighed and later discharged into the reception hoppers, from which feedstock is transferred by mechanical or pneumatic system to the grinding equipment. There, the particles are transformed with the aim of getting formulas with similar particle size. After particle homogenisation, the materials are carried to the dosing stage to get the right amounts of each raw material needed to prepare the formula. Having all the elements together, mixing operation distributes those in a homogeneous manner before receiving heat treatment for feed hygiene and being later pelletized and cooled. Sometimes, pellets can be broken (crumbling/sieving/coating) into smaller particles to improve the intake of small animals, or directly conditioned, loaded and delivered in bags or bulk (see Figure 18).

Fodder industries process herbaceous matter for better preservation of the nutritious elements contained on it through three different industrial processes; silage, haymaking and dehydration (see Figure 19). This last process reduces moisture from 80-90 % to near 10 %, providing a higher concentration of dry matter and a better preservation of the carotenoids and protein content. Besides, fodder dehydrator industries are targeted for the scope of the AGROinLOG Project as they use compatible equipment (see Section 5.1.4) with the processing of biomass (the regular use is for the legumes and grasses dehydration, from which 85 % corresponds to Lucerne) [INTERAL, 2013]. Final products (see Figure 19) are marketed within two formats, bales (77 %), mainly for dairy production ruminants, and granulated format or pellet (23 %), for meat production and feed industry. Dried fodder is used by the animal feed industries to produce specific formulas and supposes around 2.5 % of their raw material use [MAPAMA, 2005 and 2015 and INTERAL, 2013].

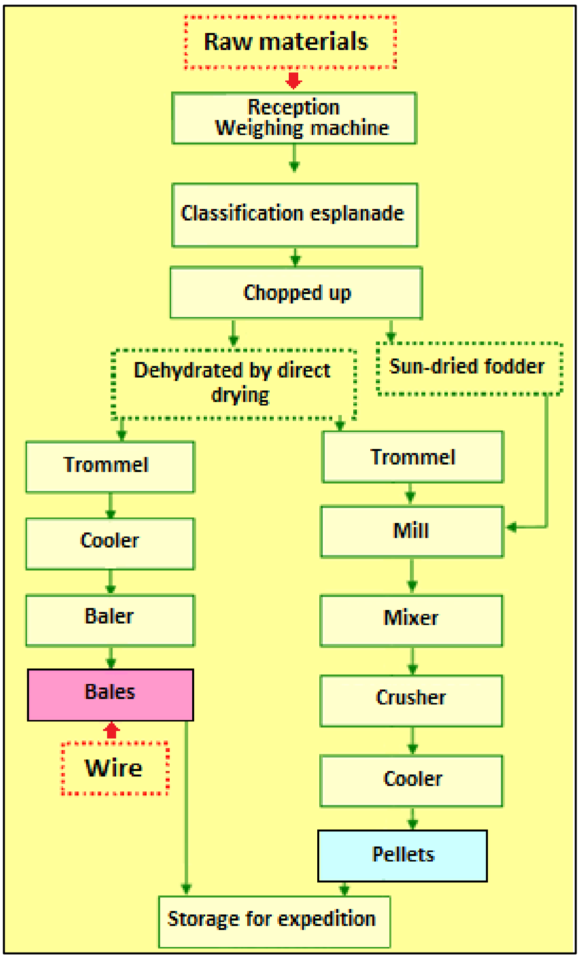

Figure 19. Process flow diagram of fodder dehydrator industries. Source: AEFA, 2013.

As it can be observed (see Figure 19), received raw materials of fodder dehydrator industries are discharged and classified in esplanades for their latter chopping and drying (for pellets manufacture it can be sun-dried or heated inside the trommel). Once dried, depending on the final product pursued, fodder can be cooled and baled or milled, mixed, crushed and cooled before being pelletized.

5.1.2 Volume of the sector

According with the FEFAC (European Feed Manufacturers' Federation) data for 2015, Spain was the second producer of the European Union (EU), behind Germany, with an increase in the production compared to 2014 of 3.7 %. It has to be remarked, that similarly than in this report, FEFAC data only considers the production of industrial manufacturers. The Spanish feedstuff production in 2016 reached 23 million tonnes, 1.67 % more than the previous year [CESFAC, 2016].

On the other hand, data provided by CESFAC (Spanish Confederation of Compound Feedstuffs Manufacturers for Animals) shows that Spanish fodder dehydrator industry was leading the EU production of dehydrated fodder in the 2012-2013 campaign with a share of over 45 % of final production [CESFAC, 2013] and a total area of fodder crops near 1,100,000 ha [AEA, 2015]. Dehydrated fodder production of 2016-2017 campaign was 1,610,000 tonnes, representing an increase of 3 % from the previous campaign [AEFA, 2017].

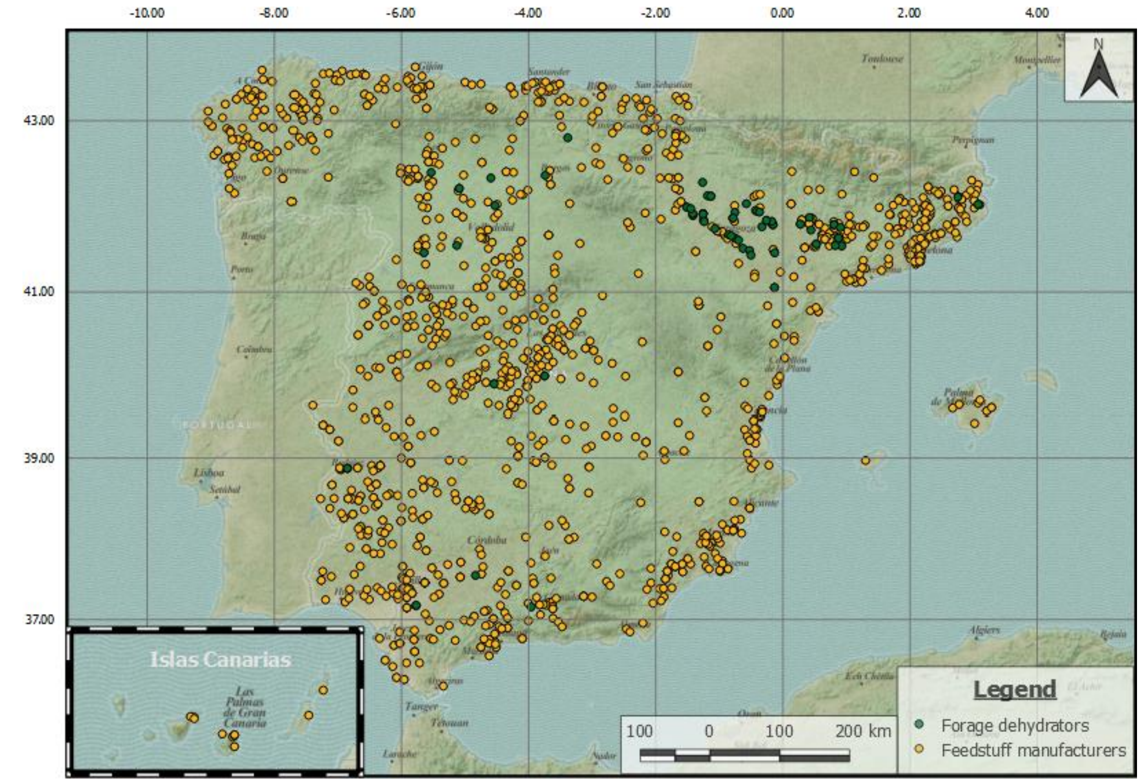

Figure 20. Location of Spanish feed and fodder sector industries. Source: SPANISH CO-OPS (elaborated from SILUM, 2017 and AEFA, 2017 data).

Feed and fodder sector counts with around 70 fodder dehydrator industries and almost 1,500 feed industrial manufacturers. Besides, there are many other industries from other related sectors (around 1,800) which manufacture animal feed for their own consumption (mainly from livestock industry) and some others that produce premixes (around 170). In addition, there are near 8,700 companies which main activity is the market of animal feedstuff or related products [SILUM, 2017].

Only the industries of which main activity is the production of feedstuff have been represented in the map (see Figure 20).

Fodder dehydrator industries are mostly agglomerated in the north-west of Spain (Aragón, Navarra, Cataluña, etc.) and, in fact, 85 % of the dehydrated fodder is manufactured in the Valle del Ebro area. Feedstuff industries have a wider spread distribution all over the country, with a higher concentration of animal feed manufacturers in Cataluña (16 %) and followed by Andalucía (15.3 %), Castilla y León (15 %) and Castilla-La Mancha (near 11 %).

5.1.3 State of the sector

According to MAPAMA data, average total product sales of animal feeding products (which include other subsectors besides the compound feedstuff and dehydrated fodder) between 2009 and 2014 was €8,360 million (see Figure 21). In addition, the average value (see Table 9) of the industrial production of compound feedstuff for animals between 2009 and 2015 was €6,820 million [CESFAC, 2013/2016] and of €300 million for the dehydrated fodder production (average from 2009 to 2016) [AEFA, 2017 and SPANISH CO-OPS, 2017]. It must be remarked that in 2013 the dehydrated fodder production only represented 35% of total fodder production in Spain [MAPAMA, 2017].

Table 9. Value of the compound feedstuff and fodder production. Source: CESFAC, 2013/2016; AEFA, 2014 and 2017; SPANISH CO-OPS and MAPAMA, 2017.

Value of the compound feedstuff and dehydrated fodder production								
	2009	2010	2011	2012	2013	2014	2015	2016
Value of the industrial production of compound feedstuff for animals (million €)*	5,564	5,914	6,903	7,409	7,346	7,323	7,289	-
Variation (%)	-	6.29 %	16.7 %	7.33 %	-0.85 %	-0.31 %	-0.46 %	-
Value of the dehydrated fodder plants production (million €)	308.3	321.2	341.8	288.3	295.4	261.6	277.59	286.6
Variation (%)	-	4.19 %	6.44 %	-15.7 %	2.46 %	-11.4 %	6.11 %	3.23 %

*Data includes premix values

Considering the number of industrial feed manufacturers (around 1,500) and the average value of the industrial production of compound feedstuff for farm animals (around €6,820 million), it can be estimated a gross income per industry and year of €4.5 million. In the same way, considering the average value of the last years for the dehydrated fodder production (near €300 million), and the number of dehydration industries (around 70), a gross income per industry and year of €4.3 million can be estimated.

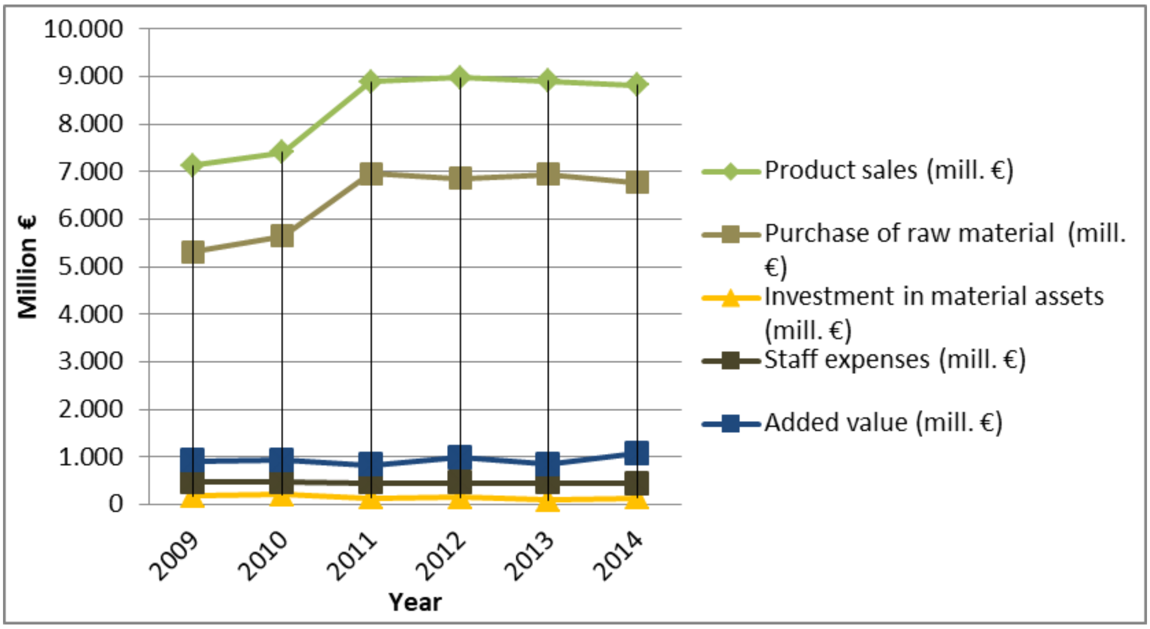

Figure 21. Animal feeding products industries financial features, period 2009-2014. Source: SPANISH CO-OPS (elaborated from MAPAMA data, 2015).

Analysing the above figure, strong growth can be noticed during the 2009-2011 period followed to an overall stability phase. This growing through a period of general economic crisis shows the strength and relevance that this sector currently has in the Spanish industry and so, the expected growth tendency for next years. A list of the main companies of the sector (those industries which could be in best position for making investments in other activities, such as developing an IBLC) is following presented (see Table 10).

Table 10. Top 10 animal feeding products industries. Source: INFORMA D&B S.A. (S.M.E.), 2016; Corporación Alimentaria Guissona S.A., 2016 y Alimarket, 2017.

Top 10 animal feedstuff sector industries			
Nº	Company	2015 sales (million €)	2016 sales (million €)
1	Nanta S.A. (Grupo)	828	806
2	Corporación Alimentaria Guissona	328	339
3	Cooperativas Orensanas S.C.G. (Coren)	231	-
4	De Heus Nutrición Animal S.A.U.	221	197
5	Cooperativa Agropienso	122	135
6	Mazana Piensos Compuestos S.L.	131	135
7	Esporc S.A.	136	129
8	Piensos Procasa S.A.	119	116
9	Skretting España S.A.	111	110
10	Aragonesa de Piensos S.A. (Arpisa)**	96	95

** data include activities in other sectors

Focusing on the fodder dehydrator sub-sector, Aldahra Fagavi S.L, Navarro Aragonesa de Forrajes S.A.U. (Nafosa) and Grupo Venso, can be considered the main companies of this sector [AEFA, 2017].

In 2015, most animal feeding products industries (around 48 %) were catalogued as micro enterprises (see Figure 22), followed by small companies (31 %) and companies with no employees (15 %). Only few of them had more than 50 employees (6 %) and none more than 500 [MAPAMA, 2016]. Therefore, around 94 % of feed industries are not expected to have enough economic strength and resources to implement an IBLC within their facilities. Despite this, the remaining 6 % (almost 100 companies) seem to reunite required conditions to start new biomass related business lines.

Information provided by AEFA in 2017 regarding fodder dehydrator subsector, stated that around 1,100 direct and 1,800 indirect employments were generated that year. This data allows to estimate an average of near 16 direct and 26 indirect employments per industry. Therefore, the size of the fodder dehydrator industries is expected to be significantly higher than the animal feedstuff manufacturers and so, have more resources at the time of facing the implementation of an IBLC (though feedstuff producers are much more numerous than the fodder industries).

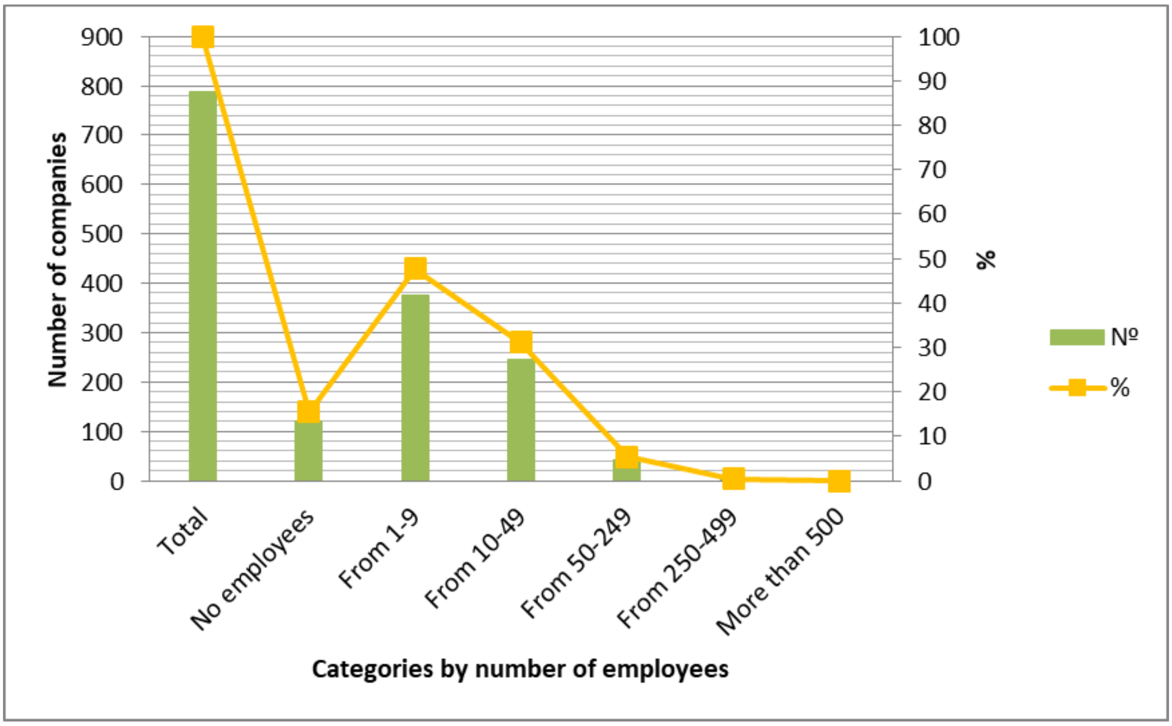

Figure 22. Typical size of animal feeding products industries (by number of employees). Source: MAPAMA, 2016.

Taking into account that the average animal feedstuff production from the 2009-2016 period was 21,690,000 tonnes/year and the average dehydrated fodder production from the 2012-2016 period was 1,580,000 tonnes/year [INTERAL, 2013; CESFAC, 2013/2016 and AEFA, 2017], an average production per feed industry of 14,500 tonnes/year and per fodder dehydrator industry of 23,000 tons/year can be estimated [AEFA, 2017].

This information and the provided in the previous section (see Section 5.1.2) seem to show an average greater size for fodder dehydrator industries than in the case of feed industries and thus, better chances at the time of becoming an IBLC.

5.1.4 Distinctive facilities of the sector

Feedstuff industries own compatible equipment with the processing of biomass such as pelletizers, silos for storage, screening and chipping machinery, besides of a high degree of staff professionalization and many other valuable assets useful for the biomass processing activities (workforce, means of transport, etc.).

Similarly than in the feed industries, fodder dehydrator industries own pelletizers, silos for storage, screening and chipping machinery compatible with the biomass handling. Besides, fodder dehydration process requires from horizontal rotary dryers to reduce the water content, completely suitable for biomass drying. Occasionally, some of these agro-industries are consumers of biomass to supply their energy demands [Sucellog, 2017].

In both cases some of the compatible equipment and facilities could require adjustments for the biomass production.

5.1.5 Degree of innovation

According to a survey performed by MAPAMA in 2009, near 10 % of animal feed industries had an operative department exclusively devoted to innovative issues. Another 19 % stated that when it was necessary, working groups were created for developing specific projects. In addition, around 27 % of the industries destined a range between 1 % and 3 % of their turnover to research and development and innovation (R&D&I).

An innovative project (LIFE) called “CLEANFEED”, was carried out between 2009 and 2013 in the Basque Country related with the prevention of the vegetal waste generation and its reuse for animal feed. Besides, some industries are implementing other innovative actions related with the energy efficiency of their facilities (such as MAZANA PIENSOS COMPUESTOS, S.L., where the old boiler of fossil fuels has been replaced for a biomass one) and the improvement of nutritious formulas [CESFAC, 2014 and IMARTEC, 2017]. According to CESFAC information (2017), animal feedstuff industries are performing two main lines of innovation research that consist, by one side, in the search of new raw materials with a higher content in nutrients and, by other side, the development of new additives that are less pollutant when ingested by the animals.

Regarding fodder dehydrator subsector, research and investment efforts in relation with innovation are currently (2017) focused in the improvement of the baler system to meet the demand presented by the export [AEFA, 2017].

When combining with the impressions that were stated in the previous sections, data seem to remark that only a residual part of the feed and fodder sector companies would be interested in being involved into innovative actions like the start-up of an IBLC.

5.1.6 Miscellaneous

Food industry by-products are potential raw materials for animal feeding which inclusion could help to reduce the carbon footprint of the animal feedstuff. Besides, the use of these by-products offers an alternative removal to many industries pressured by legislation resulting in an opportunity for feed industries to take advantage of.

In addition, feed and fodder sector industries are used to handle both raw materials and final products such as bales, pellet or other granulated format and thus, they have wide experience in the management of biomass.

The environmental impact of the feedstuff production in Galicia was studied by means of Life Cycle Assessment founding eutrophication as the most significant impact, highly associated with the cultivation of barley and cotton seed [Ciencia y Tecnología Alimentaria, 2003].

5.2 Opportunities IBLC

5.2.1 Sector related residues

Feed and fodder facilities are featured by their small or null generation of residues. Though sometimes feed industries produce little amounts of residues, those are usually disposed by an authorized manager [CESFAC, 2017]. On the other hand, fodder dehydration industries do not produce any important biomass residue, either in the agrarian or processing phase, as they are able to manufacture pellets with the remnants of the baling process [Sucellog, 2017].

Despite this, both industries usually have close relations with cereal processing industry (see Figure 23) facilitating access to their residues (i.e. corn stalks, wheat and barley straw, grain dust, etc.) and thus, to raw material from which develop new biomass related business activities.

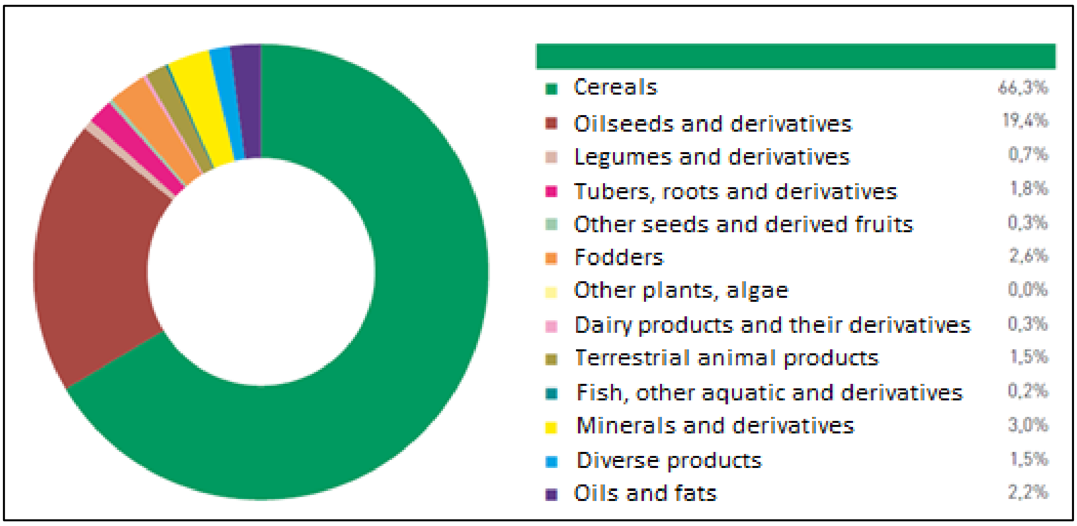

Figure 23. Raw material consumes in the animal feedstuff production, 2015. Source: CESFAC, 2016.

This great access to agricultural residues and the strong potentiality of the fodder dehydrator industries as developers of the IBLC concept lead to choose one of these industries in Spain, Agroindustrial Pascual Sanz (APS), as the developer of one of the three demonstration cases that are planned in the AGROinLOG Project (see WP2 – Tailored Business Plan and Exploitation of the Innovative Business Models). The new business line intended for this agro-industry has been conceived to take advantage of the idle period of the equipment in the plant taking place from December to March. During this time, new pellets for two different purposes will be produced: energy use and biocomposite materials. Therefore, two additional markets will be tackled with these new products: bioenergy and biocomposites. The raw material used to produce the pellets will be cereal straw, maize stalks and sudan grass to be purchased from the farmers located in the surrounding area. In order to upgrade the quality of the pellet when the goal is to satisfy the energy demands, wood chips will be also acquired.

5.2.2 Potential synergies & benefits

Feedstuff manufacturer industries keep their production ongoing during all the year and, thus, there is no idle period (see Figure 24). Instead, fodder dehydrator industries activity is usually carried out between March/April and November, having an idle period that lasts from December to the middle or end of March.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
IDLE PERIOD OF AGRO-INDUSTRIES												
Feed industries												
Fodder dehydrators	(green)	(green)	(striped)									(green)
(green)	Periods where facilities equipment or other compatible resources used to be idle											
(striped)	Differences between regions are represented in striped box											

Figure 24. Idle period of feed and fodder sector industries. Source: Sucellog, 2017 and AEFA, 2017.

Therefore, though animal feed industries own compatible equipment with the processing of biomass (see Section *5.1.4*), their continued activity through all the year implies that this equipment would not be available at any time and thus, could not be used for the IBLC purposes. Eventually, the new IBLC activities should be implemented in those production lines with occasional stops (i.e. due to fluctuations in demand) or in new ones specifically installed for this purpose [Sucellog, 2017].

Regarding fodder dehydrator industries, they present important synergies regarding the implementation of an IBLC since they have a significant idle period, own compatible equipment with the processing of biomass (see Section 5.1.4), have a relatively easy access to agrarian residues (which can be used as raw material for the production of solid biomass) and seem to have enough economic strength to carry out investments (see Section 5.1.3).

In fact, during the idle times of their regular activity and according with the information provided by AEFA (2017), there exist a fodder dehydrator industry that dries wood, some others that manufacture chipped straw bales and others that produce pellets from the lucerne hay. However, around 40 % of the industries only market and review their facilities in prevision of next campaign [AEFA, 2017].

According to the same source, 42 % of the associates use biomass in their boilers to produce electric and/or thermal energy. From these, 50 % are currently using almond shell, 21 % olive oil pomace, 18 % grape residues and the last 11 % other sources (mainly forestry biomass) [AEFA, 2017]. These examples strengthen the idea about the potentiality of fodder dehydrator industries to become IBLCs.

The start-up of IBLCs would bring up employment in the region due to the manufacture of new equipment or other related assets, the implementation of new activities, associated maintenance required and the supervision tasks. In addition, environmental benefits would be achieved through the creation of a new market of biofuels that substitutes the use of fossil fuels, saving CO_2 emissions. However, investments are also expected, as some equipment would need to be adapted or purchased.

5.2.3 Market developments

The lack of generation of residues from the feed and fodder sector industries does not generates a significant barrier due to the easy access to the agrarian residues generated in the raw material production process. From the processing of these last residues, bioenergy and bio-commodity markets could be attained.

However, in the case of animal feed industries, the lack of idle period jointly with the small size that features this type of industry (see Section 5.1.3) constitute significant barriers that must be overcome for the implementation of an IBLC.

5.2.4 Non-technical barriers

Horizontal non-technical barriers for all the sectors are presented in Table 16 (Annex A of this report). Though these barriers can be extrapolated to the majority of the sectors, there are a few specific ones for feed and fodder sector industries.

In the case of the animal feed industries, the lack of compatible equipment with the processing of biomass will require higher investments, which could suppose a significance financial barrier for many companies, as the typical size is small (see Section 4.1.4). Other legislative barrier that concerns these industries is the mandatory disposal of their residues by an authorized manager, removing any chance of using this material for any biomass purposes [CESFAC, 2017].

There are no evidence or detection of any non-technical barrier regarding the fodder industries that could impede the development of an IBLC.

6 VEGETABLE OIL

6.1 Profile of the vegetable oil sector

6.1.1 Production

Vegetable oil industries are mainly composed by the oil extractors and the refineries. However, in a preliminary phase, these last industries were not found of interest for the scope of the AGROinLOG Project. Since vegetable oil can be extracted from several crops (due to the relevance of the olive oil in Spain specific report has been dedicated to it see chapter 3) such as sunflower, rape, corn, soybean, peanut, etc., small variations from the overall oil seed extraction process (see Figure 25) can be expected depending of the used raw material.

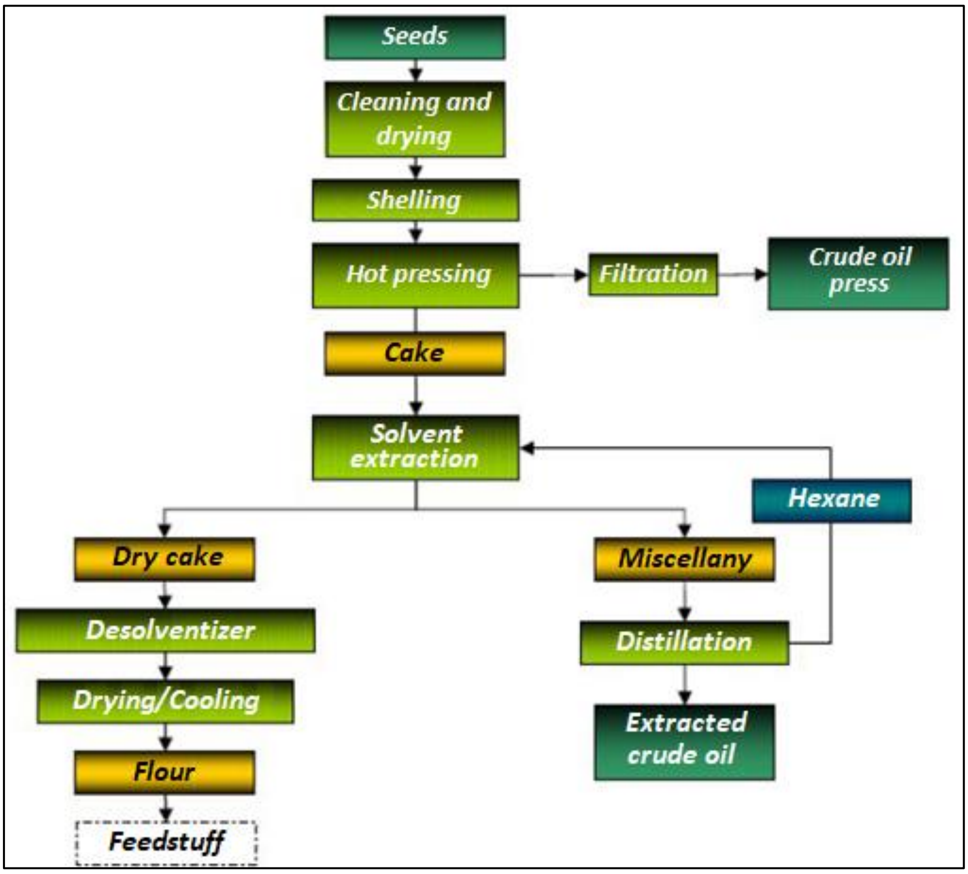

Figure 25. Process flow diagram of vegetable oil industries. Source: UPM, 2017.

After the reception of the seeds, these are commonly dried in vertical dryers and conditioned for a better preservation once stored in the silos. Vertical driers are not as suitable for the processing of biomass as the rotary horizontal ones, since they can only process granular biomass. However, there are some industries where horizontal rotary driers are used for the drying of the oil seeds, such as the case of the Cooperative Santa Ana (Carrascosa del Campo), where they dry sunflower seeds.

When performing the extraction, husks are removed (shelling) to improve the protein content of the final products. Later, seeds are pressed to obtain the crude oil. In this process (pressing) cake is generated and subjected to solvent extraction (usually with hexane, which is later recovered) producing both dry cake and miscellany (oil with solvent). From the distillation of this miscellany crude oil is obtained (must be later refined to be suitable for consumption). Once the solvent has been removed from the dry cake, this last is dried and cooled for flour obtainment.

6.1.2 Volume of the sector

Vegetable oil seed crop area was of around 800,000 hectares in 2015, some 1.6 % of total Spanish area [MAPAMA, 2016]. Besides, in the 2016-2017 campaign Spanish oil seeds production represented 4 % from the total EU production, with a share of 10 % of sunflower seeds and 0.4 % of rape seeds [Oleoprecisión 4.0, 2017]. The average vegetable oil production (olive oil excluded) for the 2012-2016 period was 1,167,000 tonnes, with an estimated value of €1,200 million. In 2016, 52 % of the production corresponded to soybean oil, 40 % to sunflower oil, 5 % to rapeseed oil and the rest to other minor oils such as the grape seed oil, cotton oil or maize germ [Fediol, 2017]. However, it must be highlighted that nearly 39 % from the sunflower seed was imported to maintain a continued production during the whole year and that, since soybean production is almost non-existent in Spain, 99.9 % of it had to be imported. Only 9.9 % of rapeseeds had to be imported in the same year [Fediol, 2017].

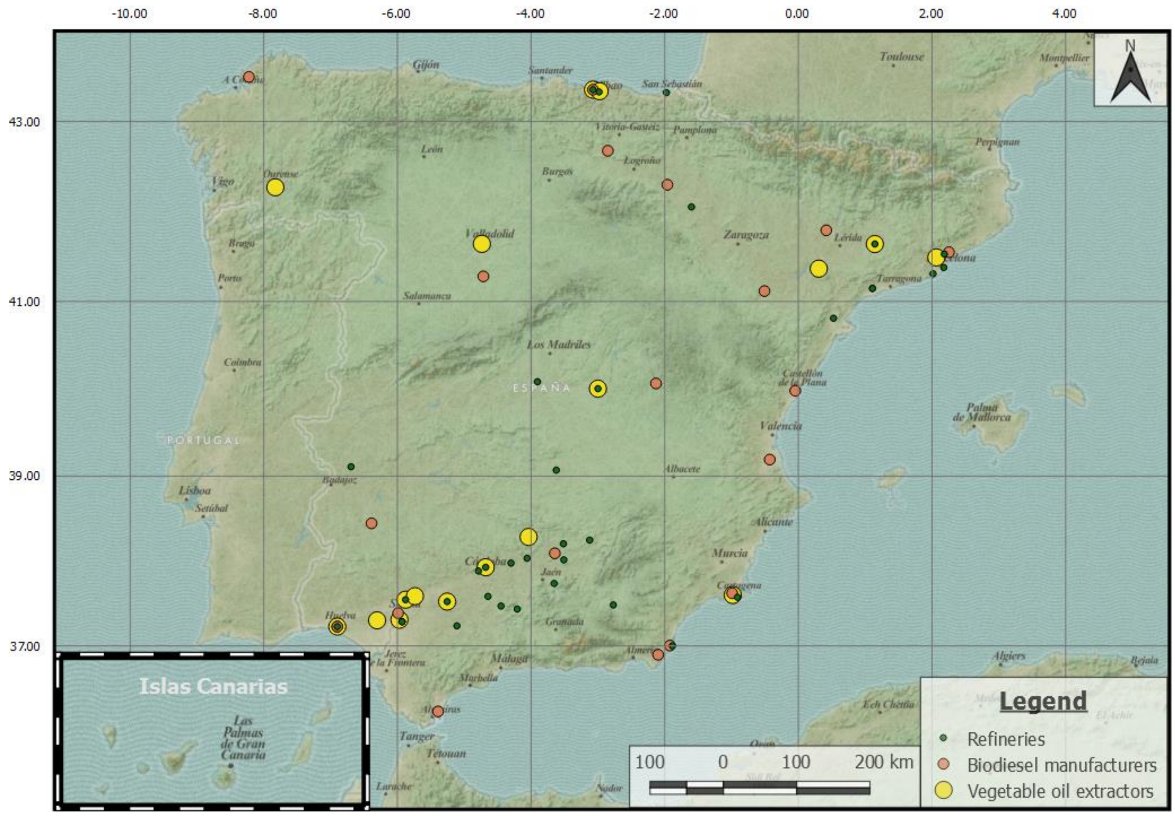

Figure 26. Location of Spanish oilseed sector and related industries. Source: SPANISH CO-OPS (elaborated from AECOSAN, 2017; APPA, 2011/2017 and AEFA, 2017 data).

Though there are around 40 vegetable oil extractor industries registered in the archive of the Spanish Agency of Consumption, Food Security and Nutrition (AECOSAN), only 13 of them have a continued activity and some other 5 carry out occasional extraction activities (the rest seem not to be currently producing) [ACOR, 2018]. Although the refineries are not the direct target of this project, it is worth to remark that around 36 refineries are also registered in the same archive. Moreover, according to the information provided by APPA, in 2017 there were 20 biodiesel plants in Spain producing biodiesel from vegetable oil, mostly from palm oil and residual oils (see Figure 26). Nevertheless, it must be pointed that some of these biodiesel plants might not have any current activity, such is the case of the plant owned by Sociedad Cooperativa General Agropecuaria (cooperative) in Valladolid [ACOR, 2018].

It can be noticed (see Figure 26) that most vegetable oil extractor industries are settled in Andalucía (47 %), Cataluña (12 %) and Castilla-La Mancha (12 %) [AFOEX, 2017 and ACOR, 2018], in consequence, near 50 % of the vegetable oil production was produced in Andalucía on 2016. Regarding the crop production, in the 2016-2017 campaign Castilla y León was the Autonomous Community with higher production of sunflower (over 40 % of total production), followed by Andalucía and Castilla-La Mancha [Oleoprecisión 4.0, 2017].

6.1.3 State of the sector

Sunflower oil was the second most consumed oil in Spain in 2015 (just behind olive oil) with a 25 % share of the market [MAPAMA, 2015]. The estimated value of the vegetable oil production for 2016 did not overcome €1,200 million [FEDIOL, 2018 and ACOR, 2018], far from the €3,471 million estimated for the olive oil market value (see Section 3.1.3). This huge difference is explained through a three times bigger area for the olive oil crop and over four times higher price in the olive oil market than in the vegetable one.

Main vegetable oil extractors industries (soybean oil extraction not included) are presented (see Figure 27) according to their milling performance (2017) in the following figure:

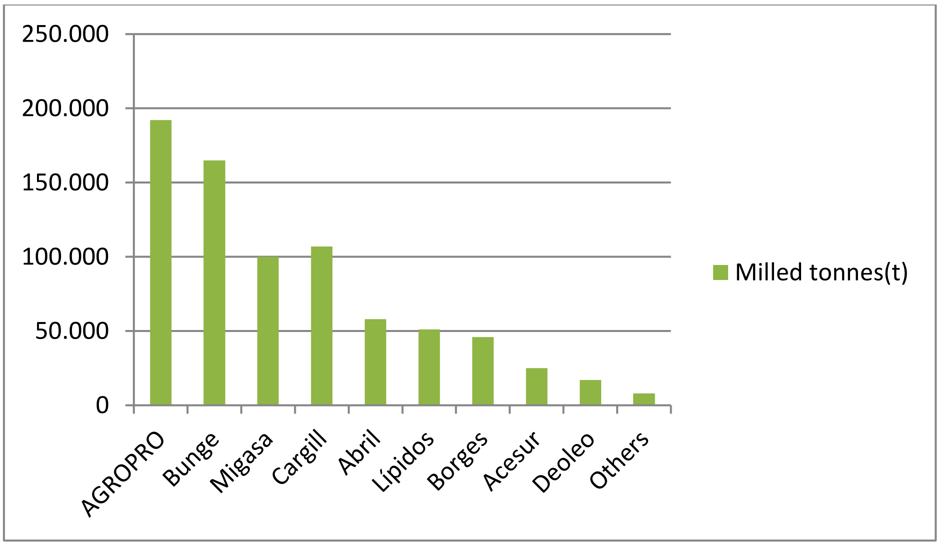

Figure 27. Main vegetable oil extractors (soy oil not included), 2017. Source: Interviews with sector professionals, 2017.

The high and unstable prices of olive oil against the stability of the sunflower market favoured that, in the first semester of 2017, sales of sunflower oil exceeded for the first time those of olive oil, with 45.34 % of the market compared to 44.87 %. The sunflower, with an average price of 1 € per litre compared to 4.5 € for the olive, grew as consumers' choice for home and catering. On the horizon of the sunflower oil market there is no glimpse of a reduction in prices due both to supply forecasts and to the upward trend in world demand [Anierac, 2017].

AGROPRO is a joint venture shared at 50 % by Sovena and Acor, which buys from these companies the necessary oil seeds to produce vegetable oil at bulk. At the same time, this vegetable oil is later sold to Sovena, where it is finally packaged and marketed. However, since the previous chart (see Figure 27) does not include soybean oil extraction and, taking into account that the companies Bunge, Cargill and Dreyfus are the main soybeans extractors, and that this oil represents the biggest vegetable oil production in Spain, it is expected that Bunge will be the main company of the vegetable oil sector [SPANISH SCO-OPS, 2018].

6.1.4 Typical size of the companies

From the number of vegetable oil extractors (18) and the estimated average production (1,167,000 tonnes) and value (€1,200 million) for the 2012-2016 period, an average production per vegetable oil extractor industry and year of 65 Kt and around €67 million of income can be estimated [AFOEX, 2017; ACOR, 2018; FEDIOL, 2018 and SPANISH CO-OPS, 2018]. In addition, the average size by number of employees is estimated in some 50 workers per company, though there is a range between 20 and 100, approximately [ACOR, 2018].

When comparing these figures with other sector industries, vegetable oil industries seem to be high sized (in general) and with available economic assets. Thus, expected investing capacity would also be high, encouraging the implementation of IBLCs in most vegetable oil industry facilities.

6.1.5 Distinctive facilities of the sector

Although vegetable oil extractor industries do not usually have any specific equipment completely compatible with the processing of biomass, they have other valuable resources such as the access to workforce, laboratories, means of transport, silos to store the seeds, etc., which could be very useful at the time to implement an IBLC in their facilities. It is important to highlight that the system used for reducing the water content, previous to the storage of the seeds in the silos (in the vegetable oil extractors), which is usually performed in a vertical dryer (there are exceptions, see Section 6.1.1), not as suitable for biomass as the rotary horizontal ones since not so many biomass formats are compatible with these dryers (only granulate material but no straw or chip).

By other hand, these industries usually produce a residue (though sometimes it is added to the cake), the seed husks, that could be used in the implementation of the new biomass business line (see Section 6.2.1). Moreover, they have access to the agrarian residues, providing them of another raw material for the start-up of an IBLC.

Regarding biodiesel production plants, since most of them use palm oil as raw material, it is expected that some technical modifications would be required at the time of implementing the production with different raw materials (detailed in Annex IX of Directive 2015/1513) [APPA and BOE, 2018].

6.1.6 Degree of innovation

Although vegetable oil sector has not shown a significance interest about innovation during past years, recently (September 2017) the PNDR has granted a fund of 84,000 € for the creation of a supra-autonomic group called Oleoprecisión 4.0 focusing on the innovation regarding the vegetable oil sector cultivation, the related agricultural productivity and sustainability issues. Main aim of this group is to elaborate an innovative project which provides solutions to modernize the vegetable oil crop, improving its profitability, traceability and sustainability and facing the environmental challenges. Though it does not directly concern the industry, it can be considered as an important first step of the vegetable oil sector towards the innovation.

It is important to highlight that this group is led by one of the main companies of the sector, Sovena S.A., which joined to the grouping of cooperatives. ACOR, Manzanilla Olive and ACOPAEX make up the operative group. Besides, those companies are supported by several national research centres such as the Institute of Agriculture and Fisheries Research and Training (IFAPA), the Agricultural Technology Institute of Castilla y León (ITACyL), Center for Scientific and Technological Research of Extremadura (CICYTEX), etc.

As stated by AFOEX (National Association of companies for the Promotion of Oilseeds and their Extraction), greater innovative efforts have been addressed to remove the pollutants coming from the refine and, generally, pursuing a better implantation of technologies. Furthermore, the cultivation of the high oleic is being encouraged.

These efforts, joined to the above mentioned (see Section 6.1.3) high and unstable prices of olive oil, have created an opportunity of growth and profitability that the vegetable oil sector is trying to take advantage of through innovation.

6.1.7 Miscellaneous

Vegetable oil sector industries are very used to deal with the biomass through all the process stages, since the reception, processing and generation of the final products (oil seed and flour), as well as their own biomass residues (seed husk). This experience with the biomass handling is an advantage at the time of implementing new IBLC's that must be considered.

Besides, there exist an opportunity provided by the access to the seed husks and plant stalks (see Section 6.2.1) which could be valorised both for bioenergy purposes and for the manufacture of biocommodities such as waxes, phenolic compounds paper pulp or textile fibre [FAO, 2000 and Journal of Cleaner Production, 2016]. In addition, another great opportunity arises from the recycling of the used vegetable oil and its conversion into biodiesel, as well as from residual fatty acids (see Section 6.2.1).

6.2 Opportunities IBLC

6.2.1 Sector related residues

Despite a more complex refinery process is required when the husk (between 10-12 % of the seed weight) of the seeds (mainly sunflower in Spain) is not removed in the vegetable oil extraction process, most of the vegetable oil extractors do not separate it due to the high investment that the specific machine requires and so, it is later added to the cake [ACOR, 2018]. In addition, due to its high content in lignin, the husk leads to a worst digestion of the flours destined to animal feeding, decreasing their price [CONICET, 2014 and ACOR, 2018].

To the contrary, the separation of the husk would lead to a less complex refine process, higher flour prices and provide a useful raw material for the bioenergy production (LHV of 3,400 kcal/kg) [ASAGA, 2015] as well as for the extraction of waxes and phenolic compounds (biocommodities) [CONICET, 2014]. One of the vegetable oil extractor that has work on the removal of the husk is Sovena España S.A., which self-consume the energy produced from its combustion in their Andújar facilities. Furthermore, they also manufacture and market pellets produced from the husk [ACOR, 2018].

On the other hand, as mentioned before (see Sections 6.1.5 and 6.1.7), vegetable oil sector industries have access to the agrarian residues. Given the fact that sunflower oil represents most part of the crop production (see Sections 6.1.1 and 6.1.3), sunflower stalk is expected to be a more accessible residue. However, according to the ACOR cooperative, the stalks are usually chopped and incorporated into the soil, as these do not present any agronomical issue. Besides, since in some Spanish regions the sunflower crop is considered a “refuge crop” (only cultivated when there are no other feasible options) and its yield is low, there would not be a great potential available [ACOR, 2018].

From the production of vegetable oils, on average, 20 kg of pastes or waxes are obtained per tonne of milled oilseeds. Those are normally used for cleaning products and have a price of 100 €/tonne. On the other hand, lecithin’s are also generated in the same process, although in smaller quantities, reaching yields of 1.81 kg per tonne of milled oilseeds. The price of lecithin’s is higher, selling at 2,100 € per tonne and are normally used for emulsions in the food industry [ACOR, 2018].

Apart from pastes or waxes and lecithin, which are by-products already allocated to certain markets, fatty acids are also generated (2 kg of fatty acids per tonne of milled oilseeds) in the vegetable oil production process. These fatty acids have a price of 400 €/t and can be used to produce biodiesel [ACOR, 2018]. In a similar way, there are several companies in Spain (Ecoqueremos, Grupo Ecológico Natural S.L., etc.) that are currently manufacturing biodiesel from residual vegetable oil [El Mundo, 2010 and Ecoqueremos, 2017]. Thus, vegetable oil industries could collect their own final products, once used by other companies, both to produce biodiesel for the self-consumption or marketing.

However, it must be noticed that this residue (recycled vegetable oil) is not directly generated in the agrarian field but, as it has a strong relation with the vegetable oil sector, it has been detected as an interesting opportunity.

Furthermore, researchers from the Cádiz University (UCA) obtained in 2015 natural compounds from the leaves of the sunflower plant for the manufacture of organic herbicides. With the development of this bioproduct, the researchers aim to valorize the leaves, a residue which has large productions and is usually burned or left to dry [UCA, 2015].

In the same line, the BIOMAT research group (from the UPV, Universidad del País Vasco) developed in 2014 a single-layer biodegradable packaging for both liquid and solid fatty products from agro-industrial by-products, specifically, from soy protein obtained as a by-product from soy oil industry. [Journal of Cleaner Production, 2014].

6.2.2 Potential synergies & benefits

Though the production of vegetable oil raw materials such as the sunflower presents deficit in Spain, thus an important part is imported to allow continued activity and, the vegetable oil extractors do not have any idle period. Some of them only stop their production three weeks per year to perform maintenance operations and supervision tasks [AFOEX, 2017 and ACOR, 2018].

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
IDLE PERIOD OF AGRO-INDUSTRIES												
Vegetable oil extractors												
RESIDUES AVAILABILITY												
Husks and other residues from oil seeds	■	■	■	■	■	■	■	■	■	■	■	■
(green)	Periods where facilities equipment or other compatible resources used to be idle											
(brown)	Periods when the biomass is produced by harvest or processing activities											

Figure 28. Synergies between agro-industries idle period and residues availability. Source: Sucellog, 2017 and SPANISH CO-OPS, 2017.

Since vegetable oil extractors usually own equipment specifically compatible with the processing of granulated biomass (see Section 6.1.5), and do not present any idle period to perform biomass related activities, the start-up of the new business line is expected to require hiring of new employees and high investments in additional equipment. However, given the high size that features vegetable oil extractors (see Section 6.1.4) and the expected availability of resources, this could be feasible. In fact, an interesting opportunity arises from the valorisation of the seed husk, which would require the acquisition of the proper machine to perform the separation as well as an adaption to a biomass fed boiler (self-consumption) and/or the purchase of a pelletiser (marketing). Similar than in the other sectors, the start-up of IBLCs would bring up employment in the region due to the new activities generated (manufacture of equipment, maintenance tasks, etc.). In addition, environmental benefits would be achieved through the saving of CO_2 emissions that the bioenergy production would provide.

6.2.3 Market developments

As it has been mentioned before (see Sections 6.1.7 and 6.2.1), new markets can be attained through the processing of the own agro-industry residues and from the crop ones. Despite of this, the absence of idle period and the high investments consequently expected could generate important barriers to face at the time of implementing an IBLC.

6.2.4 Non-technical barriers

Main general non-technical Spanish barriers of agro-industries for implementing the IBLC concept are summarized in Table 16 (Annex A of this report). Similar than wine cellars, oil mills or the animal feed industries, vegetable oil crushers do not own any fully compatible equipment with the processing of biomass, and thus, higher investments would be required for the start-up of a new IBLC. This could suppose a significant financial barrier for some companies [AFOEX, 2017].

On the other hand, as it also happens in other sectors, the residues from the main vegetable oil crop in Spain, the sunflower, are usually crushed and left in the soil or later burned (lack of awareness) due to the consent of some public administrations (lack of proper regulation).

As stated by AFOEX, there is a feasible scenario in which, in the midterm, the implementation of new and stricter regulations could require tighter controls for imported raw materials, limiting the entry of required products for the vegetable oil extractors, and therefore, negatively affect the vegetable oil industry and, by extension, the implementation of IBLCs.

Furthermore, since there seem to be an agreement for prohibiting the marketing of the palm oil destined to the production of biodiesel in the European Union from 2022, this will predictably bring a sharp rise of the availability of palm oil in the market, threatening the production of other vegetable oils such as sunflower or rapeseed oils, since prices will surely decrease [ACOR, 2018].

7 Summary analysis of the country

Table 11. Summary of the wine sector.

Wine sector	
	Profile
Production	• Crops production residues: pruning. • Industry processing residues: grape stalks, lees, vinasses, leaves, grape pomace, exhausted grape pomace and grape seeds.
Volume of the sector	• Average production of wine around 38 million hectolitres. • Spain has around 4,000 wine cellars and some 20 distilleries.
State of the sector	• Average sector industries total net sales: €5,460 million. • Expected growth tendency for next years.
Typical size of the companies	• Most sector industries are micro and small enterprises. • Average turnover per company: €1.35 million. • Production per industry: 1,475 tonnes/y (grape) & 10,600 hl/y (wine).
Distinctive facilities of the sector	• Cellars do not posess compatible equipment with IBLC concept. • Distilleries own compatible equipment with IBLCs activities.
Degree of innovation	• Sector investment in the last five years: €170-180 million per year. • Only a residual part of the companies interested in innovation issues.
Miscellaneous	• Wide experience in the management and transport of residues. • Implementation of IBLC's could reduce industries footprint.
	Opportunities for IBLCs
Sector related residues	• Vineyard pruning: 1,250,000 - 2,500,000 tonnes/year (fresh matter). • Grape pomace: 830,000 tonnes/year (fresh matter). • Exhausted grape pomace: 310,000 tonnes/year (dry matter). • Grape stalks: 295,000 tonnes/year (fresh matter).
Potential synergies & benefits	• Idle period of wine cellars usually lasts from January till August and shorter in the case of distilleries (from June to October). • Association of a number of wine cellars of the area is advisable, as they will collect more residues and thus, solve the size problem. • IBLC's would increase employed people and improve conditions.
Market developments	• Opportunity to extract several biocompounds with a wide range of benefits applied to different fields. • Bioenergy market can also be addressed with the production of biogas, biofuels or solid biomass.
Non-technical barriers	• Authorities allow burning practices (regulatory barrier), stimulating farmers to keep doing so (knowledge and awareness barriers). • Wine sector is not properly mechanised to undertake the collection and processing of biomass (organisational barrier). • Higher financial barriers in the case of wine cellars.

Table 12. Summary of the olive oil sector.

Olive oil sector	
	Profile
Production	• Crops production residues: pruning. • Industry processing residues: leaves, TPOMW, exhausted olive pomace, olive pits and wastewater.
Volume of the sector	• Average production of olive oil around 1,080,000 tonnes/year. • Olive oil sector has around 1,780 oil mills, 67 olive pomace oil industries and 26 refineries (see Figure 9).
State of the sector	• Oil mills average market value: €3,270 million. • Olive pomace oil industries market value: €150 million. • Expected growth tendency for next years.
Typical size of the companies	• Most part of olive sector industries are micro and small enterprises. • Average turnover per oil mill: €1.8 million. • Average turnover per olive pomace oil industry: €2.24 million. • Average production per oil mill: 600 tonnes/year (olive oil).
Distinctive facilities of the sector	• Oil mills do not posess any compatible equipment. • Olive pomace oil industries own compatible equipment.
Degree of innovation	• Olive oil sector surpasses other sectors regarding innovative actions. • Innovative products derived from the olive are being developed.
Miscellaneous	• Two-phases systems have been widely implemented. • Large experience in biomass handling.
	Opportunities for IBLCs
Sector related residues	• Olive pruning: 2,600,000-10,400,000 tonnes/year (fresh matter). • Exhausted olive pomace: 700,000-3,000,000 tonnes/y (dry matter). • Olive pits: 200,000-700,000 tonnes/year (dry matter).
Potential synergies & benefits	• Oil mills have longer idle periods than olive pomace oil industries.
Market developments	• Opportunity to extract several biocompounds. • Both bioenergy and biocommodities markets can be addressed.
Non-technical barriers	• High seasonality compromise the supply for the IBLCs. • Authorities allow burning practices (regulatory barrier), stimulating farmers to keep doing so (knowledge and awareness barriers). • Olive oil sector is not properly mechanised to undertake the collection and processing of biomass (organisational barrier). • Important market barriers for biocommodities (low demand and difficulties at the time of create new ones). • Knowledge barrier due to the ignorance of bioenergy and biocommodities technical issues.

Table 13. Summary of the grain chain sector.

Grain chain sector	
	Profile
Production	• Residues potentially suitable as biomass feedstock are generated during grain crop as well as in the processing of grain stages. • Crops production residues: maize stalks and leaves, cereal straw. • Industry processing residues: bagasse, corn cobs and rice husks.
Volume of the sector	• Value of grain produced in Spain (rice included) reaches figures above €3,500 million. • 2014 flour milling and starch sector total sales: €2,930 million. • 2014 bakery and pastry sector total sales: €6,570 million. • 300 flour and semolina industries, 500 breweries, 70 warehouses, 10 bioenergy and bioethanol producers and 150 dryers.
State of the sector	• Sector absolutely dependant of international markets. • It is expected that industrial sector linked to cereals remains stable as there is a high demand of their products.
Typical size of the companies	• Over 90 % of grain chain sector industries have micro or small size. • Only few companies will have resources to implement an IBLC.
Distinctive facilities of the sector	• Most of the industrial grain dryers are vertical dryers, not as suitable for biomass as the rotary horizontal ones. • Cereal drying industries have interesting potential to become IBLCs.
Degree of innovation	• Innovation willingness varies with the size of the companies. • 16.6 % of milling and starch industries allocate over 4 % of the budget.
Miscellaneous	• Grain sector industries are very used to manage biomass resources. • LCAs studies on cereal crops for the production of bioethanol.
	Opportunities for IBLCs
Sector related residues	• Potential biomass is about 20 % of the total agricultural residues produced per year for winter cereals and 70 % for maize. • Rice husk and corn cobs are unexploited residues.
Potential synergies & benefits	• Exploitation of straw for biomass purposes, most feasible option. • Several long idle times coincident with residues availability periods.
Market developments	• Several grain chain sector residues could be used for attaining bioenergy markets through the production of solid biofuels. • High supply seasonality and prices variability supposes great barriers that difficult the start-up of new biomass.
Non-technical barriers	• Expected future water restrictions for maize and other crops could affect the activity of dryer facilities (legislative barrier). • Seasonality of straw production compromise the supply of IBLCs. • Low suitability of grain industries equipment's with the processing of biomass will require higher investments (financial barrier).

Table 14. Summary of the feed and fodder sector.

Feed and fodder sector	
	Profile
Production	• Feedstuff production process require several raw materials (access). • 85 % of the raw materials used by fodder industries is lucerne.
Volume of the sector	• 2016 feedstuff production overcame 23,050,000 tonnes/year. • 2016 dehydrated fodder production was 1,610.000 tonnes/year. • 70 fodder dehydrator industries and 1,500 feedstuff producers.
State of the sector	• Compound feedstuff value (industrial production): €6,820 million. • Fodder production value: €300 million.
Typical size of the companies	• 94 % of feed and fodder sector industries are not expected to have economic strength and resources to implement an IBLC. • Greater size for fodder dehydrator industries.
Distinctive facilities of the sector	• Feedstuff and fodder dehydrator industries own compatible equipment with the processing of biomass. • In both cases some of the compatible equipment and facilities could require adjusts for the biomass production.
Degree of innovation	• Around 27 % of the industries destined a range between 1 % and 3 % of their turnover to research, development and innovation. • Only a residual part of the wine sector companies are interested in innovative actions like the start-up of an IBLC.
Miscellaneous	• Food industry by-products are potential raw materials for animal feeding which inclusion could help to reduce the carbon footprint. • Feed and fodder sector industries are used to handle both raw materials (wide experience in the management of biomass).
	Opportunities for IBLCs
Sector related residues	• Feed and fodder industries do not have any available biomass waste but they have a relatively easy access to other agrarian residues.
Potential synergies & benefits	• Feed industries work during all the year (no idle period). • Fodder dehydrator industries have an idle period that lasts from November to March/April. • IBLCs start-up would bring up employment and related benefits.
Market developments	• The small size that features animal feed industries together with the lack of idle period constitute significant barriers for the IBLC concept implementation.
Non-technical barriers	• Mandatory disposal of the feed animal residues by an authorized manager (legislative barrier). • Feed industries will require higher investments (financial barrier).

Table 15. Summary of the vegetable oil sector.

Vegetable oil sector	
	Profile
Production	• Crop production residues: stalks and leaves. • Industry processing residues: seed husks.
Volume of the sector	• Vegetable oil production (2012-2016 average): 1,167 kt. • 18 vegetable oil extractor industries, 36 refineries and 20 biodiesel plants in Spain.
State of the sector	• Vegetable oil production value (2016/2017): €820-1.200 million. • First semester of 2017 sunflower oil sales exceeded olive oil ones.
Typical size of the companies	• Production per vegetable oil industry and year: 43-62 kt. • Incomes per vegetable oil industry and year: €45-67 million. • High investing capacity in most vegetable oil industries.
Distinctive facilities of the sector	• Vertical driers are suitable for granulate biomass only. • Valuable resources such as workforce, means of transport, etc.
Degree of innovation	• No significance interest about innovation in the sector. • High and unstable prices of olive oil have created an opportunity of growth that has to be exploited through innovation.
Miscellaneous	• Vegetable oil sector industries are very used to deal with biomass. • Seed husks and plant stalks could be valorised both for bioenergy and biocommodities manufacture purposes.
	Opportunities for IBLCs
Sector related residues	• Seed husks can be used for bioenergy production as well as for the extraction of waxes and phenolic compounds. • Available sunflower crop residues: 640,000 -1,830,000 tonnes/year.
Potential synergies & benefits	• Vegetable oil extractors do not have any idle period. • The start-up of the new business line is expected to require the hiring of new employees and high investments in new equipment.
Market developments	• Bioenergy and biocommodities markets can be attained through the processing of the own agro-industry/crop residues. • Absence of idle period and expected high investments are important barriers to face at the time of implementing an IBLC.
Non-technical barriers	• Lack of equipment compatible with biomass management demands higher investments (financial barrier). • Authorities allow burning practices (regulatory barrier), stimulating farmers to keep doing so (knowledge and awareness barriers). • Vegetable oil sector is not properly mechanised to undertake the collection and processing of biomass (organisational barrier).

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V.P. Pago de Calzadilla - www.pagocalzadilla.com

V.P. Pago Florentino - www.pagoflorentino.com

V.P. Pago de Otazu - www.otazu.com

V.P. Prado de Irache – www.irache.com

9 ANNEX A

Table 16. Main Spanish non-technical barriers to implement IBLC's. Source: Own elaboration, 2017.

Main Spanish non-technical barriers to implement IBLC's	
	Barriers
Bioenergy	• Current low fossil fuels prices (market barrier) and ease of use (organisational barrier). • Lack of political commitment with agricultural biomass at the time of addressing sustainable energy issues (policy barrier). • Lack of standardization of agriculture biomass (regulatory barrier) creates uncertainty and issues of social acceptance (people are used to forestry biomass) related with the spread of misinformation (knowledge and awareness barrier). • Self-consumption of agro-fuels by agro-industries requires higher investment and maintenance costs in comparison with fossil fuels (financial barrier). • Additional cost could be imposed by the need of fulfil emission thresholds (financial barrier) set by regulation for specific equipment (i.e. acquisition of electrostatic filters, Venturi washers, separation chambers, etc.). • Agricultural solid biofuels increase specific costs (financial barrier) due to their low heating value (when compared to forestry biofuels). • Public funding addressed to bioenergy projects are required by stakeholders (funding barrier).
Biocommodities	• Low market activity and incentives (market barrier). • Lack of technologies at affordable prices (market barrier).
Both	• Fluctuating, seasonal raw material supply (organisational barrier). • Complex logistical organisation (both in the collection and processing of residues) makes the implementation of an IBLC less feasible (organisational barrier). • Manage of foreign residues (coming from different companies to the one that is going to process them) could imply in occasions the need of a waste manager certificate (organisational barrier).