AGROinLOG

INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors – Cover report

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ABBREVIATIONS

DM	Dry matter
FM	Fresh matter
GWh	gigawatt hour
Ha	hectare
IBLC	Integrated Biomass Logistic Centre
kt	kilotonne
kWh	kilowatt hour
Ml	million litres
Mt	million tonnes
OMWW	Olive Mill Waste Water
OOWW	Olive Oil Waste Water
R&D	Research and Development
t	tonne
TPOMW	Two-phase 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

This report contains the results of the research into the potential and possibilities of establishing Integrated Biomass Logistics Centres (IBLCs) in a number of specific agricultural sectors and industries in Europe. The research was conducted within the framework of the AGROinLOG project, demonstration of innovative integrated biomass logistics centres for agro-industry sector in Europe, that is funded from the European Union's Horizon 2020 research and innovation programme. Part of the research and innovation project AGROinLOG concerns the development of generic strategies for the development of future IBCLs in the EU (Work Package 6).

This study contains an in depth-description of selected agro-industrial sectors in Greece, Serbia, Spain, Sweden and Ukraine and a review of the sectors' potential as basis for IBLC activities and benefits. In addition to the analysis for the mentioned countries, a broad review of the sectors for the EU-28 countries was conducted with the objective to inventory potential footholds in other EU countries as well.

The study is a follow-up of the report "Updated conceptual description of an Integrated Biomass Logistics Centre (IBLC)" (Annevelink et al., 2017). In the report the following sectors have been reviewed for the respective countries:

Table I. Sectors chosen to be addressed per country and one extra for EU.

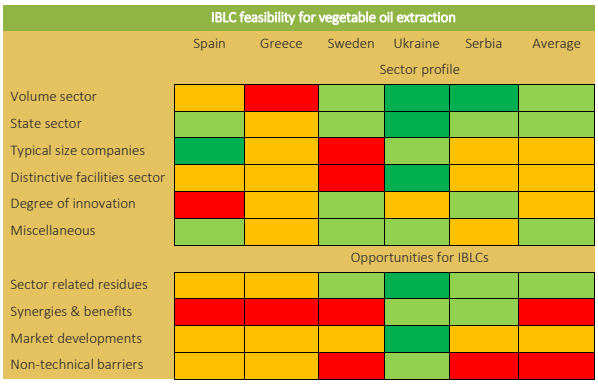
Chosen sectors per country						
Sector	Spain	Greece	Sweden	Ukraine	Serbia	Europe
1. Vegetable oil extraction	X	X	X	X	X	X
2. Olive oil chain	X	X	-	-	-	X
3. Feed and fodder	X	-	X	X	X	X
4. Wine sector (cellars & distilleries)	X	X	-	-	X	X
5. Grain chain (incl. straw until final product biofuel)	X	X	X	X	X	X
6. Sugar industry	-	X	X	X	X	X

Based on literature research, expert knowledge, inventory and analysis of data, and stakeholder interviews / feedback sessions (in Task 7.3), the report gives an accurate impression of the current potential and possibilities of establishing IBLCs in the investigated sectors and countries.

The result is the description and analysis of the 6 sectors / agro-industries that are of varying significance in each of the assessed countries. Given the fact that differences between countries are to be considered, the report contains in-depth analyses for the respective countries. These country reports are included as individual deliverables in Annex A of the report, and form the basis for the overall sector analyses in the main report.

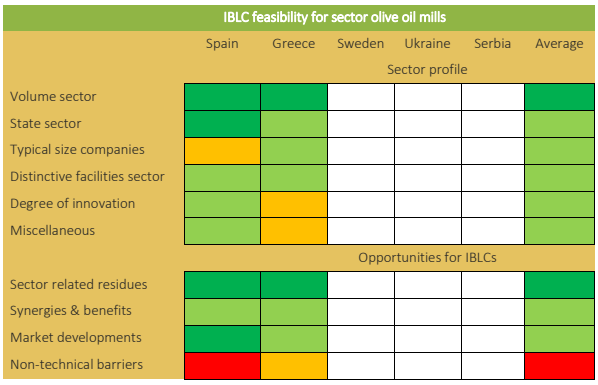
The researchers applied a so-called "traffic-light tool", which was developed to enable the evaluation of the quantitative and qualitative data in the report and to present the outcomes in a clear and concise manner. The following Table II provides an overview of the traffic light analysis for each of the 6 sectors, along with the main conclusions regarding the potential for establishing IBLCs (see section 2.1.6 for the legend of the colours).

Table II. Overview of sector traffic-lights and main conclusions



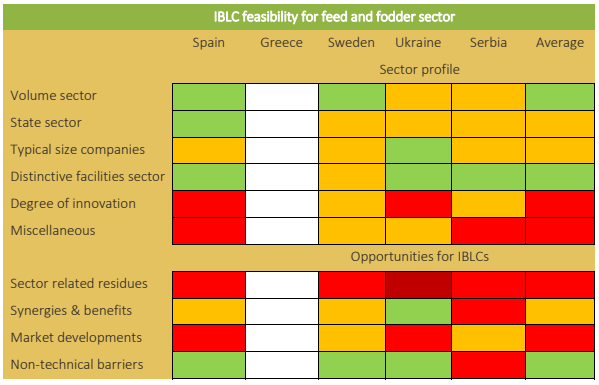
Vegetable oil

For all assessment categories the values for the vegetable oil extraction sector vary a lot between the countries. The analysis indicates that the vegetable oil extraction sector in general does not have many opportunities for establishing IBLCs. Although the sector has large volumes of residues, it only has a few synergies & benefits, only some market opportunities but rather uncertain and serious non-technical barriers with limited perspective to overcome.



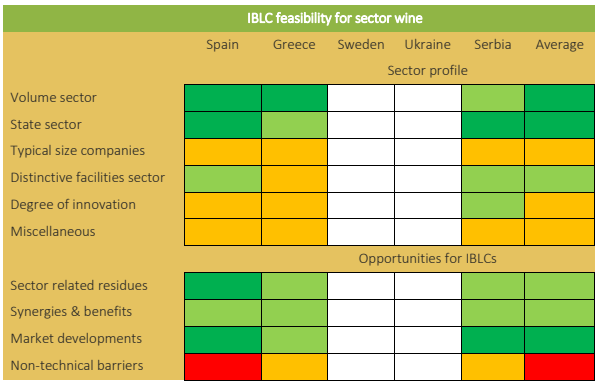
Olive oil mills

For all assessment categories the values for the olive oil mills sector vary only a bit between the two countries (Spain and Greece). The analysis indicates that the olive oil mills sector has many opportunities for establishing IBLCs since it has a very large volume of residues, many synergies & benefits and good market opportunities with promising perspective. The only problem is that there are serious non-technical barriers with limited perspective to overcome.



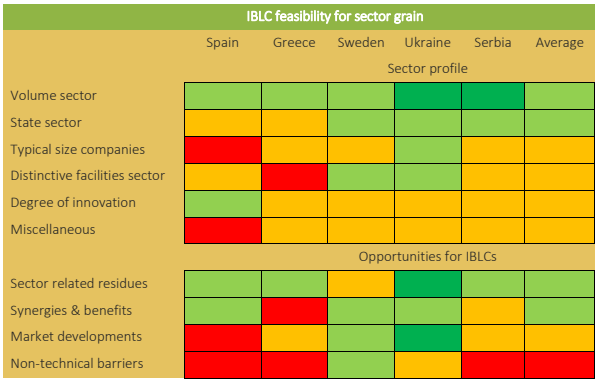
Feed & fodder

For all assessment categories the values for the feed and fodder sector vary between the four countries, but not very much. The assessment indicates that the feed and fodder sector has some but limited opportunities for establishing IBLCs, since it has only a low volume of residues (unless it uses residues from other sectors), some synergies & benefits and only a few good market opportunities that are rather uncertain. A positive point is that there are only small non-technical barriers that can be overcome.



Wine

Although some of the major wine producing countries such as France and Italy are not included in the sector review, it is fair to state that the conclusions from this study apply to some extent to most of the wine producing countries in the EU. Based on the different aspects on which the sector's overall suitability has been inventoried and evaluated by the researchers, the wine sector is considered to have sufficient basis for further research into the feasibility of establishing IBLCs. Most importantly this will include research into feasible solutions to overcome the logistical bottleneck, as well as into the proposition of a market portfolio that will provide a balance between low – and high value added products from the IBLC.



Grain

Based on the sector analysis the grain sector does not seem to provide a convincing basis for the establishing of IBLCs. However, the analysis also showed that there are large differences between countries of the sector's suitability. The analysis of the grain sector in Ukraine and Sweden indicated a good basis for setting up IBLC activities both from production and market point of view, while the analysis of the grain sectors in Spain and Greece showed less favourable conditions. Given the fact that the grain sector is an important contributing sector in European (and global) agriculture, it is advisable to investigate the feasibility of establishing IBLCs in connection with the grain sector in those countries that have a sufficient starting point (amongst which the availability of feedstock and facilities, market perspective, business awareness, governmental support, etc.).

IBLC feasibility for sector sugar	Spain	Greece	Sweden	Ukraine	Serbia	Average
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Sugar

In some European countries, the sugar industry is considered as one of the more innovating agro-industries in the field of bio-refinery and biobased products. The analysis of the sector that was done for 4 countries in this study shows, however, an outcome that the sector's suitability is characterised as medium to poor. An aspect that cannot be ignored is the recent change in the EU quota regime that has raised uncertainty within the sector of market prices and revenues within the sugar chain (for both sugar beet growers and processing industries). This may perhaps have changed once the transition to a market regime will be completed by the industries and their suppliers. But given its potential as an important European large scale agro-industry and its innovating potential in bio-refinery it is worthwhile to further investigate the feasibility of IBLCs in the sugar sector on a case-by-case basis.

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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 bio-based industry (also including biofuels and bio-energy).

Deliverable 6.2 'Basic analysis of targeted agricultural sectors' of the AGROinLOG project studies several pre-identified priority agricultural sectors (per participant country and the overall EU-28) that are considered to have synergies for establishing an IBLC. The sectors include a first transformation of agrarian products being: vegetable oil extraction, olive oil chain, feed and fodder, wine sector (cellars & distilleries), grain chain (incl. straw until final product biofuel) and sugar industry.

The purpose of this study is to gain insight in the potential and possibilities to combine core production activities within the specific sectors with the processing of biomass and biomass residues as feedstock for bio-based industries. The sectors have been reviewed by consortium partners from Greece, Serbia, Spain, Sweden and Ukraine. The review included, amongst others, the availability of idle capacity for biomass handling and processing, and the availability of biomass residues.

This Deliverable 6.2 consists of a cover report and six country reports in the annex of this cover report. These annex reports contain five in-depth country studies for selected sectors that are especially relevant for these specific countries (Greece, Serbia, Spain, Sweden and Ukraine). The sixth annex report is a general sector review for all EU-28 countries.

2 METHOD

2.1.1 Introduction

The study was initiated by formulating clear and defined steps in order to converge the research efforts by each of the contributing research partners. This process was recorded in a set of workflow schemes (further elaborated in section 2.1.3) and agreed upon by the partners as blueprint for the study. For each participating country a number of sectors were described and analysed from the perspective of the potential implementation of the IBLC concept. The basic analysis of targeted agricultural sectors in Task 6.2 was organized by country at first and not by sector.

2.1.2 Responsible partners

For the three countries where the AGROinLOG project develops IBLC demo's the national partners (i.e. research partner and company demo partner) have operated as teams to research and elaborate on selected sectors that may qualify for developing an IBLC in these countries:

- Spain: CIRCE & Spanish Co-ops
- Greece:CERTH & INASO-PASEGES
- Sweden: RISE & LANTMÄNNEN

For the Ukraine and for Serbia the selected sectors were researched by UCAB and UBFME, respectively. The remaining EU-countries were the topic for a sector analysis by AESA. The overall co-ordination of this study was done by WFBR, who was also responsible for the drafting of the combined analysis report and for the review of the national and European analyses. The final review was performed by CIRCE.

2.1.3 Planning the work flow in Task 6.2

The first sub-process was the final selection of the sectors (a) that had to be described by the country teams. Then a decision was made on the common procedure and lay-out of the country reports (b). The main part of the work was the detailed analysis of the sectors per country (c) and the general sector review of the EU-28 countries (d). The results of (c) and (d) were then used as input in a combined analysis of the sectors' suitability/feasibility for the IBLC concept (e) which resulted in this cover report (f).

The main process flow chart of the whole Task 6.2 is given in Figure 1.

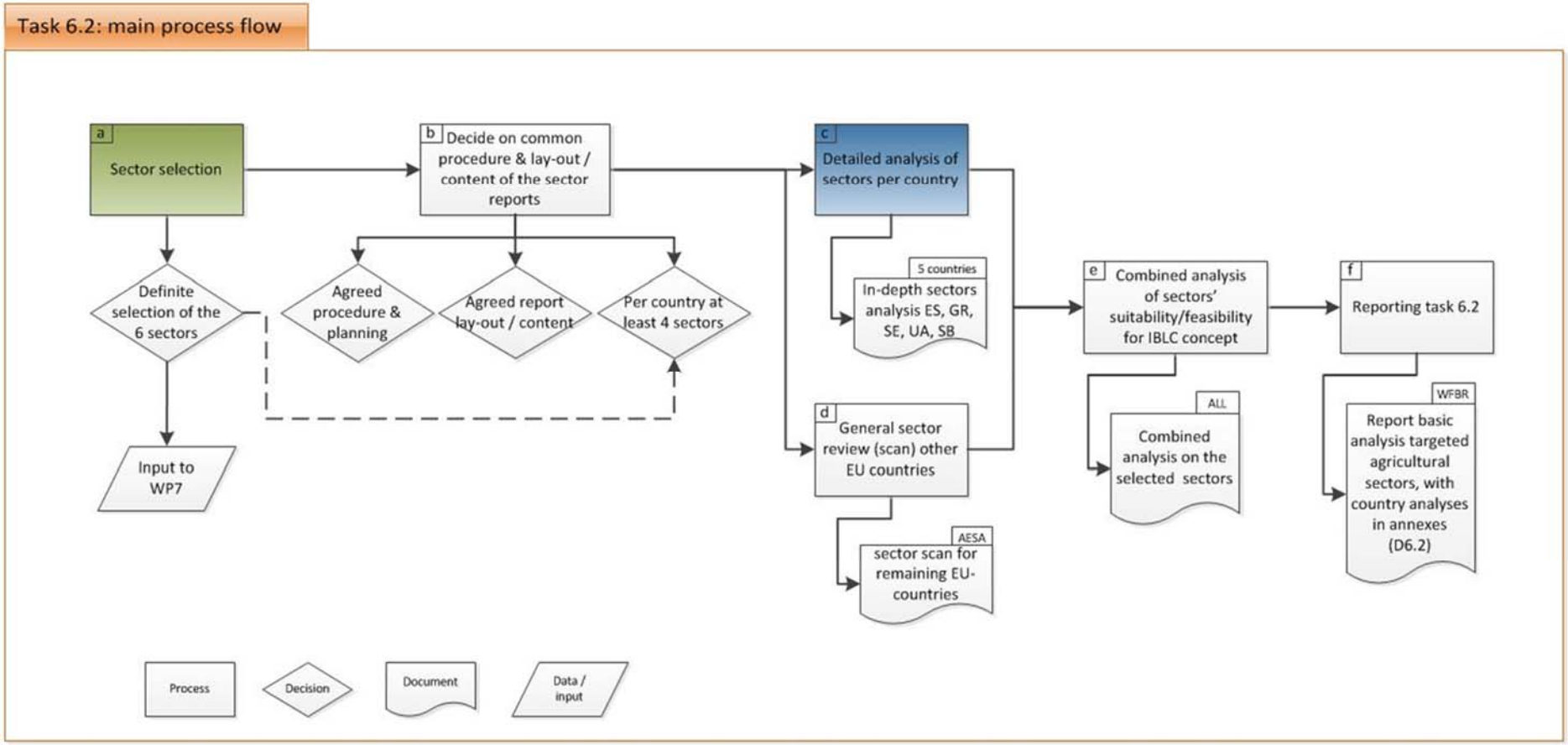

Figure 1. Main process flow chart of Task 6.2

The flow chart of the second part of Task 6.2 is given in Figure 2.

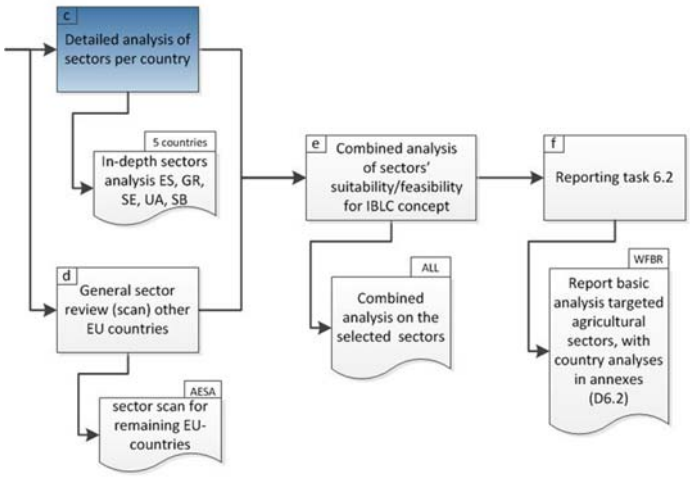

Figure 2. Process flow chart of second part of Task 6.2

Finally, the procedure for the detailed analysis per country (sub-process c) is given in Figure 3.

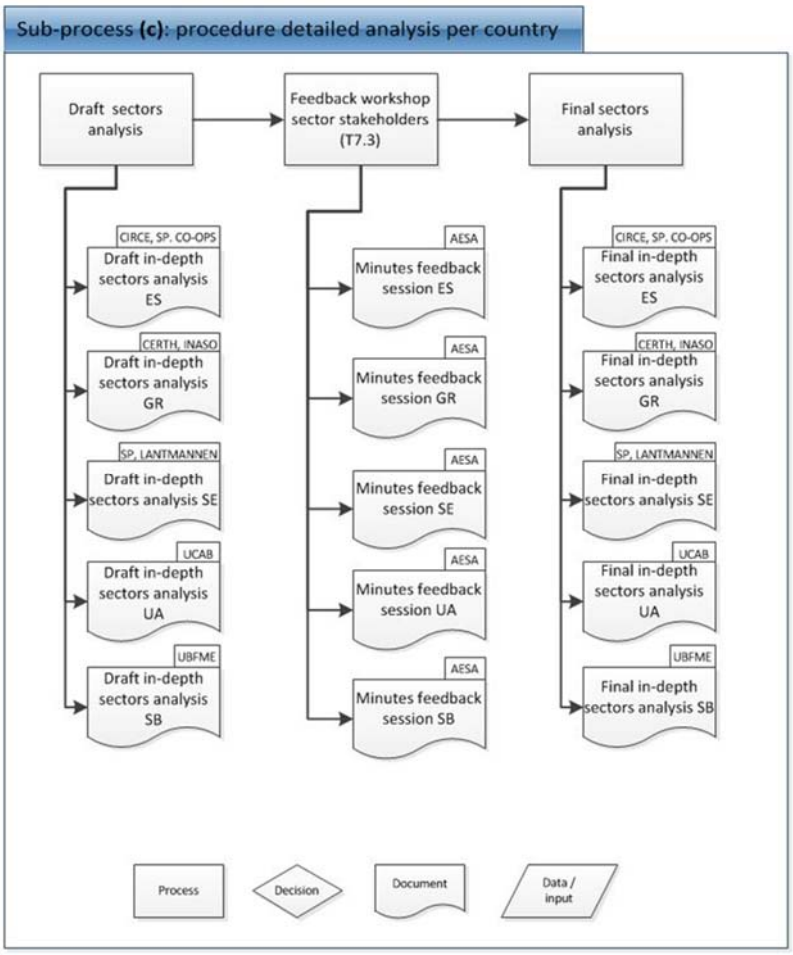

Figure 3. Process flow chart of detailed analysis per country.

2.1.4 Selection of the sectors

First a selection was made of the sectors that were going to be analysed. The food processing industry (with their residues) could also have a potential for establishing an IBLC. However, it was decided that this will not be studied by the individual countries, but that this would be addressed by AESA in the general sector review of the European countries. Given the scope of the research looking more at the primary agricultural sectors, the food processing industry was not studied in great depth.

The input from the partners resulted in the selection of six sectors for the in-depth sector analysis per country (see Table 1).

Table 1. Sectors chosen to be addressed per country and one extra for EU.

Chosen sectors per country						
Sector	Spain	Greece	Sweden	Ukraine	Serbia	Europe
1. Vegetable oil extraction	X	X	X	X	X	X
2. Olive oil chain	X	X	-	-	-	X
3. Feed and fodder	X	-	X	X	X	X
4. Wine sector (cellars & distilleries)	X	X	-	-	X	X
5. Grain chain (incl. straw until final product biofuel)	X	X	X	X	X	X
6. Sugar industry	-	X	X	X	X	X
7. Food processing industry	-	-	-	-	-	X

2.1.5 Country reports describing relevant sectors

In the country reports, the emphasis was put on the profile of the sector and the opportunities for an IBLC. The profile of the sector was described by addressing the following categories:

- Production - a brief impression of the steps/phases in the current production chain;
- Volume of sector - what is the overall size of the sector? Will it be large enough to play a role in the development of future IBLCs?
- State of sector - is the sector economically strong enough (capable) to invest in future IBLCs?
- Typical size of companies - are there enough companies of a certain size that could develop an IBLC? (please note that it is not always clear yet what that optimal size will be because that is part of the further research)
- Distinctive facilities of the sector - are there facilities that possibly have idle time and could be used for other (biobased) purposes and/or are there facilities that could be easily combined with new facilities for biobased purposes?
- Degree of innovation - does the sector have a history of looking at and investing in innovations, so that they will also be interested in developing an IBLC?
- Miscellaneous – description of various other items that could influence the development of future IBLCs in the sector

The opportunities for establishing an IBLC were described by the following categories:

- Availability of sector related residues - what residues from the sector could be available for processing in future IBLCs?
- Potential synergies & benefits - what synergies & benefits do we and/or the sector see for establishing future IBLCs in the sector?
- Market developments - does the sector already have any ideas about entering new markets for their residues?
- Non-technical barriers - what other non-technical aspects influence the establishment of future IBLCs in this sector?

Complementing remarks and suggestions for extra topics (underlined) in the country reports were:

- From the project Sucellog it was learned that market barriers were experienced as the most important factor in the process of establishing successful business cases for the processing of biomass residues to supply the bio-energy market (Sucellog, 2017).
- Similar reasons apply to legal barriers.
- Technical barriers can also be an important aspect. E.g. in the Sucellog project the quality of the agropellets gave unexpected problems in relation to the availability of suitable boilers.
- The contribution of biomass residues in the ecological cycle is also an aspect to be taken into consideration as specific topic of sustainability.
- A brief reference to the current technologies used in the respective sectors.
- Previous experience with biomass handling in the sector.
- The perspective from biomass residues only is rather narrow. It was therefore suggested to choose a somewhat altered approach for the IBLC concept by focusing on both primary and secondary feedstock.

The analysis was made, based on databases, available literature sources and input from local stakeholders through bilateral contacts. Draft versions of the country reports were reviewed and commented by WFBR. During the research and reporting process, two consultation rounds with stakeholders have taken place (in Task 7.3):

1. consultation for data collection when writing the draft report, and
2. consultation to validate the information in the final draft report.

The consultations were done by the country teams. The details about the consulted stakeholders can be found in the various country reports in Annex 6.2.1 until 6.2.6. The interviews were used to validate the information that was written in the country reports, specifically the qualitative data (e.g. the future of the sector, market opportunities). This kind of information gained value because it was cross-checked with sector stakeholders. Therefore, the final draft (95 % ready) was submitted to a selected number of stakeholders per country. Their comments have been processed in the final country reports. The final country reports and the European review report are included in the annex to this cover report (see the list in Annex A).

2.1.6 Combined analysis

The combined analysis report serves as a cover-report for the country reports. The combined analysis contains a high-level analysis of the different sectors concerning the possibility/feasibility of applying IBLC-like concepts in these sectors.

In this cover report, first of all, a general profile description of the sector is given based on the country reports. The sector review contains a map (when available), which shows the geographic importance of the respective sector in the European countries. A standardized flow diagram of the sector's supply chain processes was developed by using the standardised IEA Bioenergy Task 42 methodology for process mapping (see an example in Figure 4).

The summary tables of the various sectors in the individual country reports were an important starting point for the combined analysis. Per sector, the results of the analyses in the various countries were combined into an overall sector analysis summary.

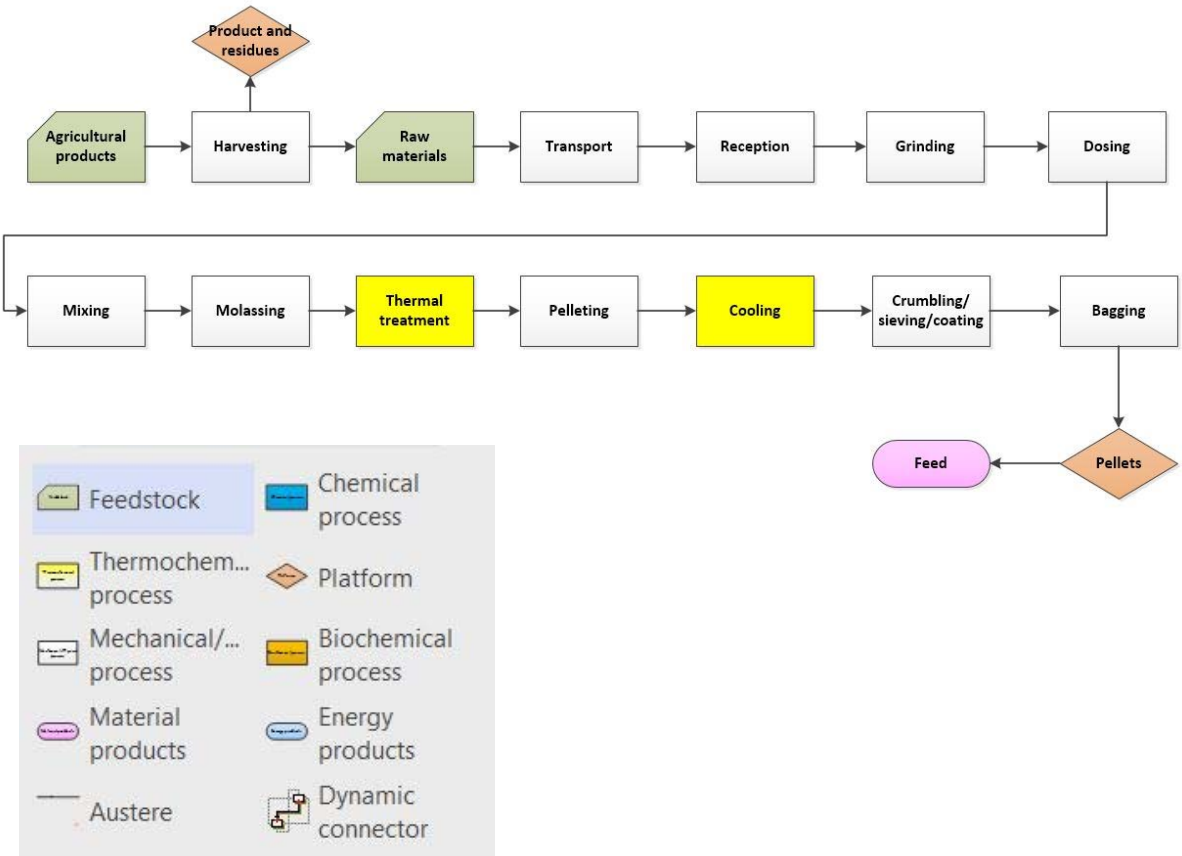

Figure 4. Example of a process flow diagram of the feed sector.

Finally, for each sector an indication for IBLC potential/feasibility is presented by means of a traffic light analysis (see example in Table 2). In this traffic light, the colour-spectrum from light green to dark red (see explanation of the colours in Table 3) presents this feasibility and enables the reader to get a quick overview of the sectors' possibilities. The scores were first filled in for the individual countries and then an 'average' was determined. This is of course a very rough estimate and therefor the traffic light analysis can only be used to get a quick general impression of the IBLC potential of a sector, and not to give a final verdict on the feasibility. For that purpose, the specific details of a certain case will always have to be studied in much more detail.

Table 2. Example traffic light analysis for the vegetable oil extraction sector.

IBLC feasibility for vegetable oil extraction						
	Spain	Greece	Sweden	Ukraine	Serbia	Average
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 3. Explanation colour traffic lights.

Category - Assumption of the influence on establishing IBLCs					
Volume of the sector - A larger sector has more possibilities for setting up an IBLC	Very large sector	Large sector	Medium sector	Small sector	Very small sector
State of the sector – An economically healthy sector has more opportunities to build IBLCs	Very healthy sector	Healthy sector	Medium healthy sector	Unhealthy sector	Very unhealthy sector
Typical size of the companies – The number of companies with a suitable size determines the number of IBLCS that can be developed. The suitable size depends on the sector of course, but on the average one can assume that medium sized and larger companies will have more opportunities.	Very many suitably sized companies	Many suitably sized companies	Some suitably sized companies	Few suitably sized companies	No suitably sized companies
Distinctive facilities of the sector – If there are more facilities that can be shared then there are more opportunities to set up an IBLC	Almost all of the facilities to be shared (more than 5)	Many facilities to be shared (4-5)	Only a few facilities to be shared (2-3)	Only one facility to be shared (1)	No facilities to be shared
Degree of innovation – If a sector is more innovative it will be more likely to invest in innovative IBLCs	Very high innovation level	High innovation level	Medium innovation level	Low innovation level	Very low innovation level

Miscellaneous – Presence of other factors that might stimulate the choice for setting up an IBLC	Very many stimulating factors	Many stimulating factors	Some stimulating factors	Only few stimulating factors	No stimulating factors
Sector related residues – If the sector itself has residues this will stimulate setting up IBLCs	Very large volume of residues in sector	Large volume of residues in sector	Medium volume of residues in sector	Low volume of residues in sector	Very low volume of residues in sector
Potential synergies & benefits – If the sector sees synergies & benefits then this will stimulate setting up IBLCs	Very many synergies & benefits	Many synergies & benefits	Some synergies & benefits	Few synergies & benefits	No synergies & benefits
Market developments – If there are promising local (national) market opportunities for biomass/biocommodities then there are more opportunities for setting up IBLCs	Excellent market opportunities with promising perspective	Good market opportunities with promising perspective	Some good market opportunities but rather uncertain	Few good market opportunities and rather uncertain	No market opportunities at all
Non-technical barriers – These will hinder setting up IBLCs	No or minor barriers	Some small barriers that can be overcome	Barriers that require serious attention but can be overcome	Serious barriers with limited perspective to overcome	Serious barriers and no possibility to overcome

3 COMBINED ANALYSIS

3.1.1 Vegetable oil extraction

Vegetable oil can be extracted from several crops such as sunflower (Figure 5), rape, corn, soybean, peanut, etc. Small variations from the overall oil seed extraction process (see Figure 6) can be expected depending of the used raw material. After the reception of the seeds, the seeds are dried and conditioned for a better preservation during storage in the silos. The drying of the seeds is commonly done in vertical dryers. Compared with the rotary horizontal ones, these dryers are less suitable for the drying of biomass, as not so many biomass formats are compatible with these dryers (only granulate material but no straw and chips). At the time of performing the extraction, the husks are removed (shelling) to improve protein content in the final products and then the seeds are pressed to obtain the crude oil (NOTE: in Spain the process of separation of the husks is not a common practice and is done by only one vegetable oil extraction industry; see Annex D6.2.1). In this process (pressing), the cake is generated and subjected to solvent extraction (usually with hexane, which is later recovered) producing dry cake and miscellany (oil with solvent). From the distillation of this miscellany crude oil is obtained (that must be later refined to be suitable for consumption). In addition, after solvent removal of the dry cake, it is later dried and cooled for flour obtaining.

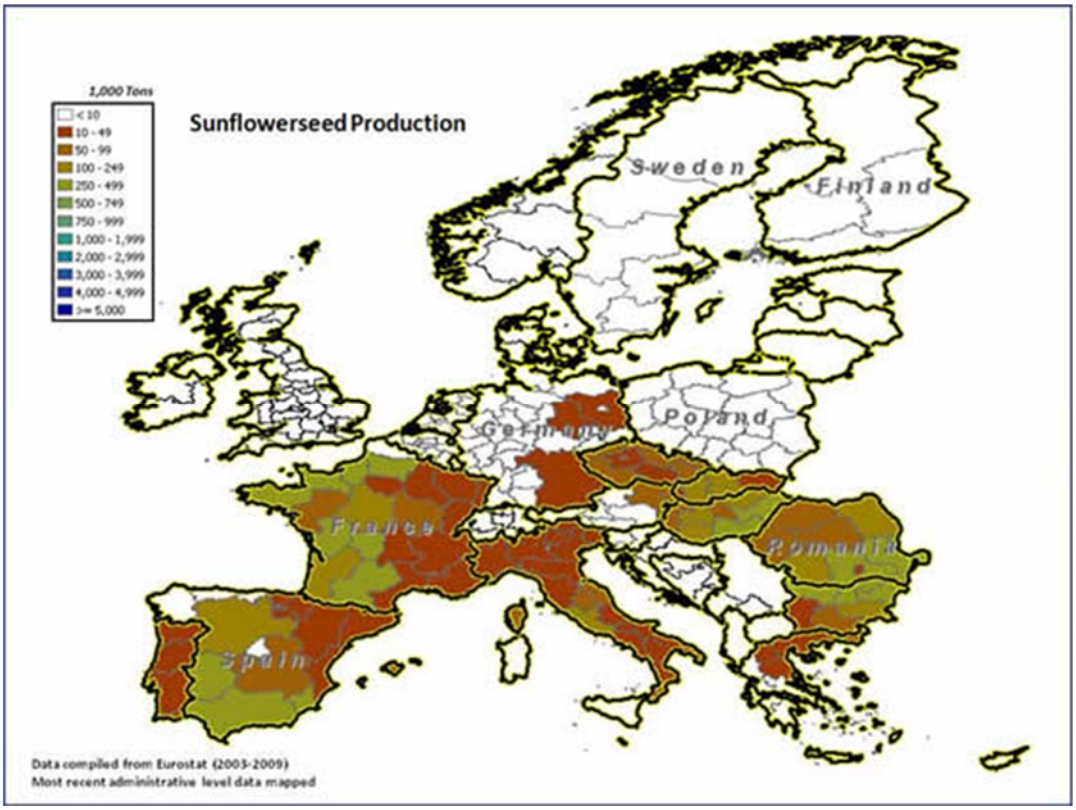

Figure 5. Sunflower production in Europe (source: USDA World Agricultural Production).

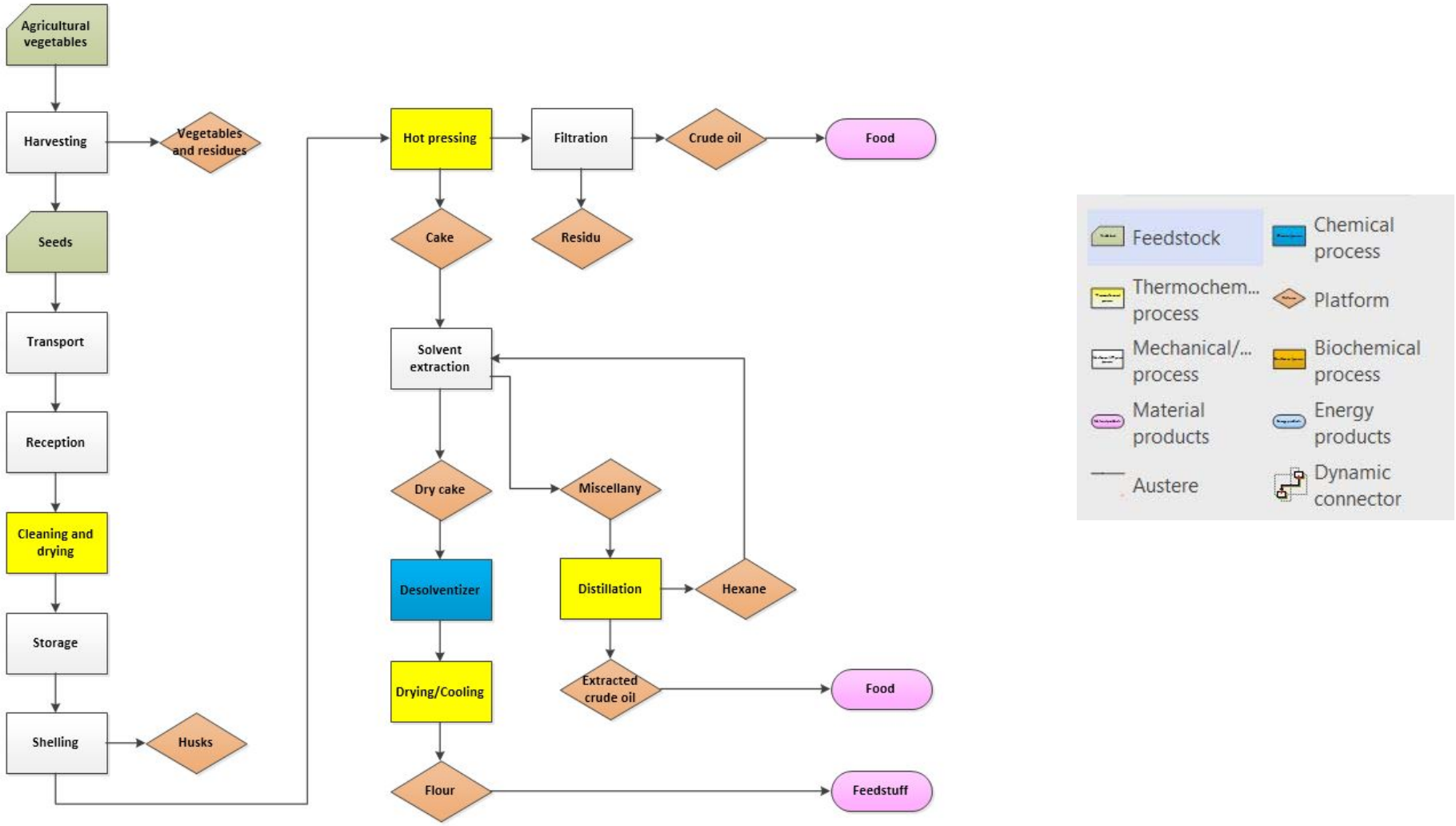

Figure 6. Process flow diagram of the vegetable oil extraction sector

Table 4 provides a cross-country analysis for the vegetable oil extraction sector in view of its potential for integration with IBLC concepts.

Table 4. Summary vegetable oil extraction sector.

Sector vegetable oil extraction	
	Profile
Production	• Seed crops are cottonseeds, soybeans, sunflower seeds and rapeseed. • The main primary residues during the crop production are stems and leaves • Products are vegetable oil, fat and seeds. • Secondary residues are seed husks and press cake.
Volume of the sector	• Cultivated area in 2015: o Spain 0.80 million ha o Greece 0.11 million ha o Sweden 0.10 million ha o Ukraine 0.33 million ha o Serbia 0.33 million ha o Other important countries are France (2.27 million ha), Poland (0.99 million ha) and Hungary (0.93 million ha) o EU 11.5 million ha • Volume vegetable oil production 2016: o Spain 1,112 kt o Greece 136 kt o Sweden 136 kt o Ukraine 5,200 kt o Serbia 1,200 kt o EU 34,000 kt • Number of large scale vegetable oil extraction industries: o Spain 18 o Greece 3 o Sweden 1 o Ukraine 15 o Serbia 6 o EU 180
State of the sector	• Average yields of sunflower have been fluctuating in the recent years. Sunflower yields have seen a sharp rise since 2015 (in Ukraine and Serbia). • Soybean and rapeseed yields have been steadily increasing (in Ukraine and Serbia). • Rapeseed crops in Sweden are in a sharp rise.

	• In several countries vegetable oil extraction industry has a high profitability (e.g. in Sweden). • It is considered to be a stable sector in Greece for the last three years. • The sector is stimulated in the EU by biodiesel and renewable energy demand.
Typical size of the companies	• Size of the vegetable oil companies strongly varies between EU-countries: o For Spain the estimated production per vegetable oil industry and year is between 43 and 62 kt, generating an income of between 45 and 67 million euros. o A Greek company that produces cottonseed oil has an annual production of 2,000 tonnes. A typical vegetable oil company can operate 300-400 tonnes of seeds/day. o In Sweden AAK (the only industry) had an economic turnover of approximately 650,000 euros in 2016 (including imported seeds). o In the Ukraine the processing industries are primarily large companies. • In Spain most vegetable oil industries have a high investing capacity.
Distinctive facilities of the sector	• In some countries no idle equipment (Sweden) is available and in some other countries the industry still has available idle capacity (Spain, Serbia). • Facilities that could be shared are: workforce, logistical network, separators, storage (silos), centrifuges, storage facilities and crushers. • Vertical driers are suitable for granulate biomass only. • Vegetable oil industry in Serbia has a large experience with sunflower husks utilization. • Possibilities for IBLCs implementation exist e.g. in Serbia.
Degree of innovation	• In Spain there is no significant interest about innovation. However, high and unstable prices of olive oil have created an opportunity of growth that has to be exploited through innovation. • The vegetable oil extraction units use a simple technology, compared to pomace mills. No special R&D activities are performed on the vegetable oil sector in Greece. • The rapeseed oil and rapeseed meal industry is a mature industry in Sweden. • In comparison to other sectors analysed in this report, the vegetable oil sector in the Ukraine and Serbia may be considered as the most innovative.

Miscellaneous	• The vegetable oils are an agricultural product that is chemically most similar to mineral oils and therefore have a great potential as biological raw materials to replace the mineral oils in industries such as for biomaterials and chemicals.
	• The sector already has experience of handling biomass, mostly in form of producing solid biofuel – pellets – from sunflower husk for bioenergy. • Opportunities exist for the production of biocommodities.
	Opportunities for IBLCs
Sector related residues	• The main residues types are straw of crops, seed husks and oil waste. • Residues are currently used as animal feed or energy pellets. • When not used for animal feeding seed husks can be used for bio-energy production as well as for the extraction of waxes and phenolic compounds.
Potential synergies & benefits	• It is year-round production so vegetable oil extractors in Spain and Sweden do not have any idle period. • Some countries have no great opportunities for an IBLC (e.g. Sweden). • Although variating from year to year some countries have a capacity surplus that offers opportunities for IBLCs. (e.g. 40 % for the industry in the Ukraine, and in Serbian in soybean processing industry up to 70 %).
Market developments	• New markets can be attained (bio-energy and bio-commodities) through the processing of the own agro-industry residues and from the crop ones. • The absence of idle periods and the high investments consequently expected due to the lack of compatible equipment with the processing of biomass constitute important barriers to face at the time of implementing an IBLC. • There are research projects in Sweden investigating rapeseed straw used as raw materials in the manufacturing of renewable plastic materials and to convert the press-cake from rapeseed to human food. • The vegetable oil sector is in good shape in the Ukraine and Serbia. The market for sunflower oil, and respectively for sunflower seed, is likely to continue to grow in the future.
Non-technical barriers	• Lack of equipment compatible with biomass management in Spain demands higher investments (financial barrier). • Authorities in Spain allow burning practices (regulatory barrier), stimulating farmers to keep doing so (knowledge and awareness barriers).

- The vegetable oil sector in Spain is not properly mechanised to undertake the collection and processing of biomass (organisational barrier).
- Current low prices for fossil fuels (market barrier) and ease of use when compared with biomass (organisational barrier).
- Low acceptability of consumers and citizens.
- The attitude of the Swedish industry is that they are not interested in becoming a supplier of biocommodities.
- When generating energy by burning sunflower biomass (e.g. pellets) one should consider the emissions issue.
- Small farms in Serbia with insufficiently high capital reserves and with relatively small capacities for operation according to modern standards.
- Variability of prices in Serbia, especially for farmers since they have fewer possibilities to manage risk.
- Uncertainty related to agricultural policy measures in Serbia which support the production of oil crops.
- Transport problems for biomass delivery in Serbia - bad road infrastructure, bad conditions in railway sector and insufficient use of river transport.

Table 5. Traffic light analysis for the vegetable oil extraction sector.

IBLC feasibility for vegetable oil extraction						
	Spain	Greece	Sweden	Ukraine	Serbia	Average
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 5 presents the traffic light analysis expressing the suitability of the vegetable oil extraction sector for establishing an IBLC, either as contributor of (sector related) agro-residues and/or of capacities for processing biomass. Based on the traffic light analysis the following observations were summarised:

- In Greece and Sweden the volume of the sector is small (both 136 kt vegetable oil production in 2016), in Spain and Serbia medium (1,112 kt and 1,200 kt) and in Ukraine it is very large (5,200 kt). So there is much difference between the studied countries but on the average the volume is large.
- The state of the sector ranges from very healthy (Ukraine and Serbia) and healthy (Spain and Sweden) to medium healthy (Greece). Remember that many of the judgments in the traffic light analysis (e.g. healthy/unhealthy) are qualitative and thus no exact figures can be given here. On the average the vegetable oil extraction sector is generally considered to be healthy, which is positive for investing in IBLCs.
- The typical size of the companies in the vegetable oil extraction sector also varies between the countries. A considerable amount of suitably sized companies (for an IBLC) can be found in Spain, as well as in Ukraine. Two countries only have some suitably sized companies (Greece and Serbia). Finally, Sweden has only few suitably sized companies. On the average some suitably sized can be found per country, which could invest in an IBLC.
- Only in the Ukraine almost all of the distinctive facilities can be shared. In three of the countries only few facilities can be shared (Spain, Greece and Serbia). And in Sweden only one facility can be shared. On the average only a few facilities can be shared, which is less favourable for establishing an IBLC, because it means that some of the needed equipment will have to be bought new.
- The degree of innovation varies from high in Sweden and Serbia to low in Spain. Greece and the Ukraine have a medium innovation level. On the average there is a medium level of innovation in the sector, which should be sufficient to at least consider IBLCs.
- Three countries have many stimulating miscellaneous factors (Spain, Sweden and the Ukraine) and two have some (Greece & Serbia). A stimulating fact is e.g. experience of handling biomass, mostly in form of producing solid biofuel – pellets – from sunflower husks for bioenergy. So on the average there are many stimulating miscellaneous factors, which is again favourable for the establishment of IBLCs.
- Some countries have more residues than others. In the Ukraine a very large volume of residues is available in the sector. The sector in Sweden and Serbia has a large volume of residues and in Spain and Greece only a medium volume of residues from the sector exist. On the average there are large volumes of residues (like straw of crops, seed husks and oil waste) in the sector that could potentially be processed at an IBLC.
- Unfortunately, only few synergies and benefits can be found in the sector in Spain, Greece and Sweden because there is a year-round production and thus no idle time occurs. On the other hand, many synergies and benefits can be found in the Ukraine and Serbia because there is a surplus of processing capacity. So on the average only few synergies and benefits can be found, but some countries have more opportunities than others.

- Most countries have some good market opportunities but they are rather uncertain, which is then also considered to be the average. Only the Ukraine has good market opportunities with promising perspective.
- In two countries (Sweden and Serbia) serious non-technical barriers with limited perspective to overcome are present (e.g. the industry does not seem to be interested in IBLCs in Sweden). In two others (Spain and Greece) non-technical barriers exist that require serious attention but can be overcome (e.g. a lack of equipment to collect the biomass). And only in Ukraine some small non-technical barriers exist that can be overcome. On the average the sector has serious non-technical barriers with limited perspective to overcome, which could constitute a major problem when implementing IBLCs.

General conclusions: For all assessment categories the values for the vegetable oil extraction sector vary significantly a lot between the countries. The analysis indicates that the vegetable oil extraction sector in general only has limited opportunities for establishing IBLCs. Although the sector has large volumes of residues, it only has a few synergies & benefits, only some market opportunities, but rather uncertain and serious non-technical barriers with limited perspective to overcome.

3.1.2 Olive oil mills

After the harvest, the olives (see Figure 7 for production areas) are transported to the olive oil mill where oil is produced by cold or hot pressing of the olive fruit. The mills carry out the first phase of olive oil production, which is then either directly available for consumption in bulk or promoted to commercial enterprises for resale, or it is supplied to processing and/or standardization companies.

In general, there are three main types of olive oil mills depending on the production process:

- traditional olive mills, where hydraulic presses are used;
- three-phase centrifugal mills, where the extraction process produces olive oil, pomace and olive mill waste water (OMWW); and
- two-phase centrifugal mills, which are the most advanced, producing olive oil and wet pomace.

Between the two types of centrifugal extraction, two-phase mills are both more productive (in terms of the amount of extracted olive oil) and more environmentally friendly. The main difference is that they require less water during the extraction process, leading to lower energy costs, less water waste during the process and a higher extraction rate of olive oil (output/input ratio). Analytically, the whole process of olive oil production is generally the following (see Figure 8):

- Receiving the fruit: After harvest, the olives are transported to the mill, where they are temporarily stored until they are processed.
- Defoliation – Washing: Placement in a picking hopper of olives, transport by conveyor or endless screw to a leaf removal, where leaves and other foreign bodies are removed and then washed to remove other impurities.
- Crack-milling of olives: Extrusion of the fruit and formation of olive oil (or olive paste).
- Malaxation: the olive oil is blended in softeners to achieve the merging of the oil traps into larger drops of oil.
- Extraction of olive oil: In the traditional process (hydraulic press), a liquid/water mixture is first extracted, which is separated in a subsequent phase by centrifugation to obtain the olive oil. As explained before, there are three possible ways:
    - Three-phase centrifugation: In this step a significantly amount of hot water is used to wash the oil. Separation of solid residue (olive cake) from the other two liquid phases is done in the decanter.
    - Vertical Centrifugation: The final separation of olive oil from the vegetation water.
    - Two-phase centrifugation: Same process as in three-phase centrifugation but the horizontal centrifugation is performed without the addition of water. Two output streams as it separates olive oil from solid phase (TPOMW- wet olive cake).

The olive mill wastes are sent to pomace mills where further processing occurs for retrieving edible pomace oil. Pomace mills are necessary steps in the olive oil value chain. They use as raw material the crude olive cake produced from the olive mills, dry it and extract the residual oil (usually using chemical solvents, such as hexane), known as pomace oil. Moreover, they produce one or more solid

biofuels originated from the stone, flesh and skin of the olive fruit (along with some small quantity of residual oil). Depending on the process adopted, they can produce olive stones (mostly the pit part of the olive fruit), exhausted olive cake (mostly the flesh part of the olive fruit) or "combined" fractions.

Concerning the pomace oil mills, there are two main stages of pomace oil production:

- Drying process: During the drying process, the olive pomace is propelled into large cylindrical dryers, heated and rotated. With this procedure the large amount of water is reduced and the oil is easier to be separated.
- Extraction process: pure hexane (C_6H_{14}) is used for the extraction process of the olive pomace, which literally "rinses" the oil from it. The oil-hexane mixture is then propelled into special distillation tanks where the two components are completely separated. After this stage the pomace oil is ready for storage.

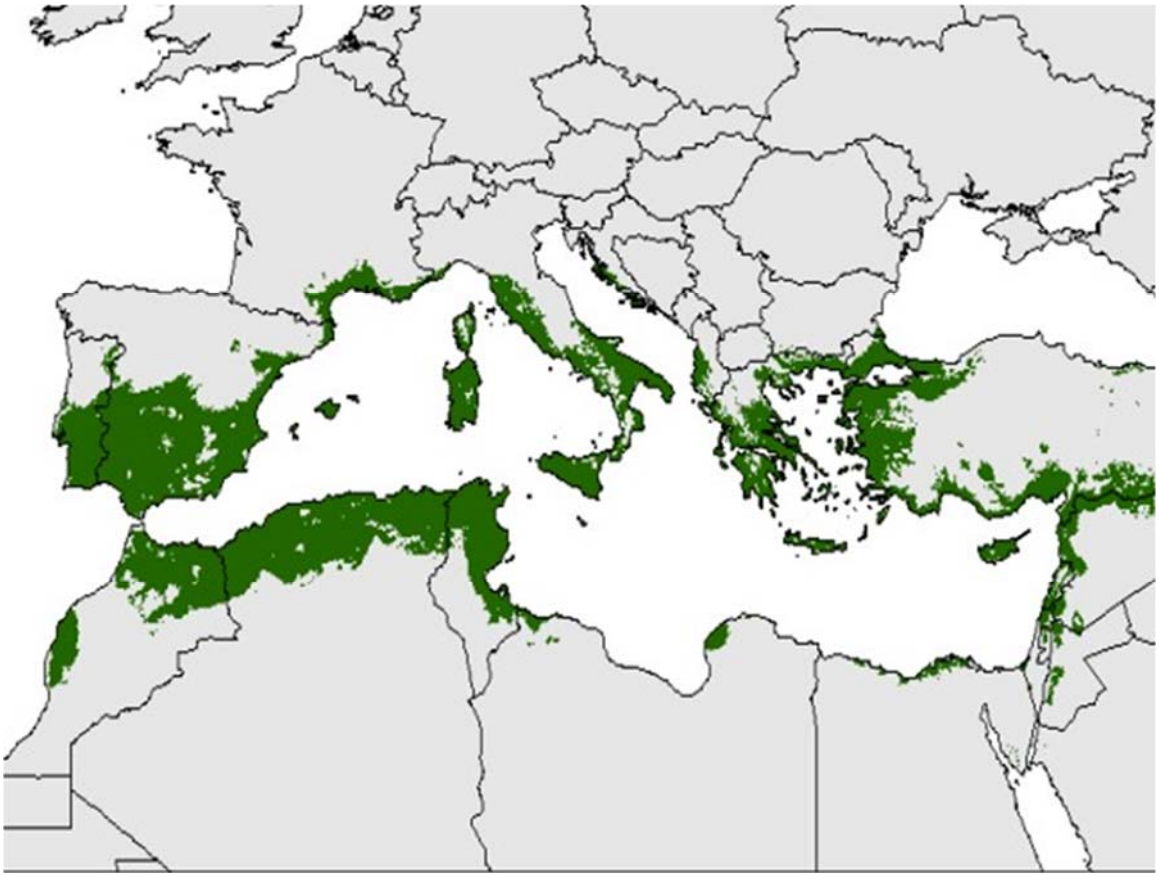

Figure 7. Distribution areas of Olea europaea (Source: J. Oteros, Phd thesis, University of Cordoba - Spain, 2014).

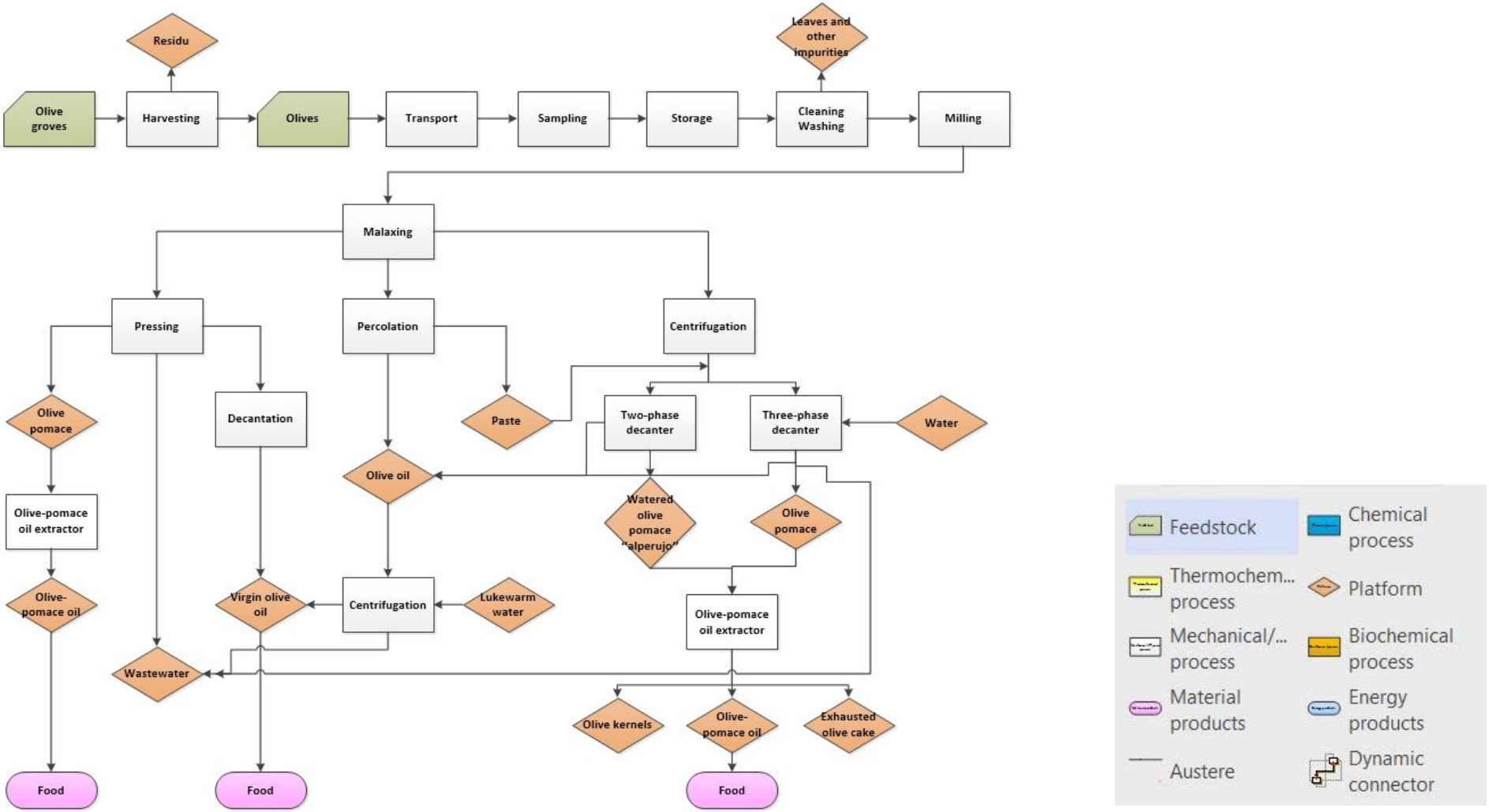

Figure 8. Process flow diagram of the olive oil mills sector

Table 6 provides a cross-country analysis for the olive oil mills sector in view of its potential for integration with IBLC concepts.

Table 6. Summary olive oil mills sector.

Sector olive oil mills	
	Profile
Production	• Crop: Olives • Crop production residues: prunings • Products: olive oil • Industry processing residues: leaves, TPOMW, exhausted olive pomace, olive stones and wastewater • Two main types of olive oil mills: o two-phase centrifugal mills and o three-phase centrifugal mills • Olive mills' residues (pomace) are sent to pomace mills for pomace oil extraction and other by-products.
Volume of the sector	• More than 5.0 million hectares (70 % of the world production) is concentrated in the Mediterranean area. • Cultivated area: o Spain 2.6 million ha o Greece 0.8 million ha o Italy 1.1 million ha o Portugal 0.4 million ha o EU 5.0 million ha • Volume olive oil production 2016: o Spain 1,080 kt o Greece 300-400 kt o Italy 475 kt o Portugal 109 kt o EU 2,322 kt • Number of olive oil mills: o Spain 1,780 o Greece 2,500 o Italy 5,000 • Number of pomace mills: o Spain 67 o Greece 35 • Number of refineries: o Spain 26 o Greece 10

State of the sector	• Olive growing is a perennial Mediterranean crop, meaning that there is rigidity in farm adaptation to economic trends. A plantation takes between five to seven years to become fully productive. • There are few alternatives to olive trees in marginal regions with poor productivity (mountainous or hilly areas); they can grow in poor, stony soil which it would be difficult to put to other crop uses. Consequently, they play an important environmental role (fixing soils, biodiversity, landscape and contribution to rural development). • In the EU, olive trees are grown in Spain, Italy, Greece, Portugal, France, Cyprus, Slovenia and Malta. • The oil mills average market value for the last seven campaigns was 3,270 million euros in Spain. The olive pomace oil industries market value in Spain was €150 million. The total sales for economic year 2014 in Greece amounted to 832.7 million euros, 16.2 million euros lower than the previous year. • Only the 27 % of the Greek olive oil is consumed domestically and the rest (70 %) is exported (100,000 to 135,000 tonnes). • The sector has a tendency to grow in Spain. In Greece its size is fluctuating: after the historical low productivity and sales of olive oil in the years 2011-2014 the productions and sales have increased again in 2017.
Typical size of the companies	• The structure of production is typically very fragmented (small holdings) and olive growing is a major feature of the heritage and socio-cultural life of Mediterranean regions. • Around half the olive oil operations in the EU producer countries specialise in olive oil production. However, there are major disparities among EU regions: in Andalusia and Apulia, between 65 % and 80 % of farms are specialised. In contrast, in Portugal, Cyprus and Slovenia, the majority of holdings do not specialise in olive growing. • In small farms, olive oil production may be a secondary, traditional and family activity: oil is produced for personal consumption and only a small amount may be marketed for direct sale. • Most part of Spanish olive sector industries are micro and small enterprises with small production and low investment capacity. The average production per oil mill and year in Spain is about 600 tonnes of olive oil. • In Greece, olive mills are characterised by a co-operative structure and high involvement of farmers in the processing of olives. For a typical Greek olive oil mill the average capacity is 200-230 tonnes of olive oil per year. A typical pomace mill has a capacity to treat 450-500 t of pomace/day. Around 15,000 seasonal workers are employed in olive

	mills. Around 210 permanent workers and 875 seasonal workers are employed in pomace mills. Around 140,000 seasonal workers in farming and harvesting activities of olives.
Distinctive facilities of the sector	• The peak in activity occurs in winter, which makes it compatible with other agricultural and non-agricultural activities. With traditional growing methods, labour represents over half of production costs; and therefore, olive growing plays an important role in society. • In Spain oil mills do not possess any compatible equipment with the processing of biomass. However, these industries have many other assets useful at the time of implementing an IBLC such as labour, transport, warehouses, conveyor belts and other machinery for biomass management (scales, tractors with spades, etc.). • Olive pomace oil industries in Spain own equipment ((horizontal) dryers) compatible with the processing of solid biomass and the extraction of bioactive compounds. They also could use warehouses, labour and transport. • In Greece the operation lasts from September (can also start earlier, climate dependent) to March. The off-season potential for using idle agro-industrial capacities is April-September. • Pomace mills in Greece are larger than olive mills and more sophisticated. Therefore, they are better candidates for IBLC implementation. Several facilities are available for implementing the IBLC concept such as dryers, separators and storage areas. These facilities could be exploited in idle times with other raw material as alfalfa, clover etc. However, also additional equipment is needed.
Degree of innovation	• Small producers and primary processors lack the means to adapt supply to demand and therefore the ability to invest in innovative technologies. As a result of this they are unable to benefit properly from the full value of their production. • In Spain new innovative products (hydroxytyrosol, oleuropein, and triterpenes) derived from the olive are being developed and produced at very competitive prices by olive oil sector industries. • In Greece the sector has the ambition to modernise with the state-of-art technologies. However, with limited resources only little R&D is possible for a minority of the companies. Pomace mills are absent in national development and funding schemes.
Miscellaneous	• Spain, Italy and Greece account for around 80 % of EU consumption. It seems to be stable in the producer countries, whereas it is increasing in France and in the non-producing EU member states. • In Spain both oil mills and olive pomace oil industries have a large experience in biomass handling.

	• However, extrapolating these data to olive oil sector target industries, the fact should not be neglected that only around 40 companies (2.2 %) in Spain seem to have optimal conditions for developing a new business line for biomass processing (considering their size and associated financial assets). • In Greece last years there is a tendency to change the three-phase to two-phase centrifugation as it is more eco-friendly and due to national legislation. The two-phase system has already been widely implemented by most Spanish oil mills to avoid the sustainability problems that the wastewater implies. • In Greece, some pomace mills have other activities during their low season period. One pomace mill used to dry and package alfalfa that has a similar moisture content with the olive pomace (70-80 %). Some pomace mills extract pomace oil from expired table olives in summer. • Taking into account the low margins and incomes, it is expected that most olive oil sector industries are not able to afford extra investments for developing an IBLC.
	Opportunities for IBLCs

Sector related residues	• Olive pruning total amount:
	  o Spain: 2.6-10.4 Mt per year (fresh matter)
	  o Greece: 1.13-1.72 Mt per year (dry matter)
	• Exhausted olive pomace two-phase:
	  o Spain: 0.7-3.0 Mt per year
	  o Greece: 0.754 Mt per year
	• Exhausted olive pomace three-phase:
	  o Greece: 0.314 Mt per year
	• Olive Oil Waste Water (OOWW) in Greece:
	  o Three-phase: 345-440 Ml per year (year 2014 estimations)
	  o Two-phase: 0 Ml per year (year 2014 estimations)
	• Olive pits in Spain: 0.2-0.7 Mt per year
	• Olive stones and leaves in Greece

Potential synergies & benefits	• The equipment of olive pomace oil industries is more compatible than the equipment of oil mills but the idle periods are shorter. Nonetheless, the advantages provide great synergies to these industries for developing an IBLC. • Several agro-industries of this type in Spain have already developed business activities related with the valorisation of the biomass residues coming from oil mills, both for bio-energy and for biocommodities. This fact supports the hypothesis of a greater IBLC feasibility for these industries.

	• Several treatment options are proposed in Greece in order to improve the decontamination efficiency of the Olive Mill Waste Water (OMWW). • Processing residues such as olive tree prunings and exhausted olive cake is a possible synergy. • The capacity to store biomass is another possible synergy.
Market developments	• The bio-energy market (domestic heating, industrial power generation) can be addressed with the production of biogas, bio-fuels or solid biomass (exhausted olive cake and olive stones). • Olive sector residues (like exhausted olive cake and leaves) offer the opportunity to extract several bio-compounds (phenols, hydroxytyrosol, oleuropein, triterpenes and methanolic extracts) with a wide range of benefits for the pharmaceutical industry and food industry. • Exhausted olive cake can be used in animal feed industries as well as the biogas industry. • Phenols from exhausted olive cake (and leaves) can be used in pharmaceutics industry, food industry. • OMMW can be reused as fertiliser due to the organic matter and nutrients contained that could improve the quality of arid soils. • Olive prunings can find various applications such as production of pellets, particle boards or as fuel in power plants.
Non-technical barriers	• The law in Spain forbids the burning of olive pruning. However, despite of this, in some cases authorities allow these practices in determined periods (regulatory barrier), which stimulates farmers to keep doing so (knowledge and awareness barriers). In Greece, burning of prunings is not allowed from 1 May to 31 October. • The olive oil sector is not properly mechanised to undertake the collection and processing of biomass (organisational barrier). • Logistic problems with olive pruning collection are expected since most part is performed manually and transport costs are high (low density and added value from some feedstocks). Thus, mechanization and optimisation of logistic is needed to ensure profitability. • Fluctuations in the production of olive oil (climate dependent) and the processing of yields create uncertainty with regard to the expected volume of olive oil sector residues for potential valorisation industries. • There is an unwillingness of Greek citizens to have the pomace mills continue their operations during their idle times. This is because they are unhappy with the existing pomace facilities when operating due to odours and smoke (optical disturbance). • Olive oil mills and pomace mills are absent of national funding schemes in Greece, thus they lack funds for implementing new business concepts.

- It is difficult for the solid fuel market to absorb exhausted olive cake as a fuel for residential heating due to intense odours.
- The production of olives and pomace as well, is climate-dependent. As a result, technologies for exploiting by-products and residues of the oil production process have not been yet developed.

Table 7. Traffic light analysis for olive oil mills sector.

IBLC feasibility for sector olive oil mills						
	Spain	Greece	Sweden	Ukraine	Serbia	Average
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 7 presents the traffic light analysis expressing the suitability of the olive oil mills sector for establishing an IBLC, either as contributor of (sector related) agro-residues and/or of capacities for processing biomass. Based on the traffic light analysis the following observations were summarised:

- In Spain the volume of the olive oils mills sector is very large (1,080 kt olive oil production in 2016). In Greece it is also very large but smaller than Spain (300-400 kt). Italy that was not analysed in a country report also has a very large volume (475 kt). So on the average there are several countries with a very large volume, where IBLCs could be positioned.
- The state of the sector ranges from very healthy (Spain) to healthy (Greece). Remember that many of the judgments in the traffic light analysis (e.g. healthy/unhealthy) are qualitative and thus no exact figures can be given here. On the average the sector is healthy, which is positive for investing in IBLCs.

- Some suitably sized companies (for an IBLC) can be found in Spain, while Greece has many suitably sized companies. On the average many suitably sized companies can be found per country.
- Both in Spain and Greece many of the distinctive facilities can be shared, which is favourable for considering the establishment of IBLCs. Pomace mills are probably better candidates for an IBLC than oil mills.
- The degree of innovation varies from high in Spain to medium in Greece. On the average there is a high level of innovation in the sector, which is good for considering IBLCs.
- Spain has many stimulating miscellaneous factors and Greece has some. An example of such a factor is that both oil mills and olive pomace oil industries have a large experience in biomass handling. So on the average there are many stimulating miscellaneous factors, which is again favourable for the establishment of IBLCs.
- Both Spain and Greece have very large volume of residues are available in the sector. So on average, there are very large volume of residues (like olive prunings, exhausted olive pomace, olive oil waste water, olive pits, stones and leaves) in the sector that could be processed at an IBLC.
- Also, many synergies and benefits can be found in the sector in Spain and Greece, which is also good for establishing IBLCs. The equipment of olive pomace oil industries is more compatible than the equipment of oil mills but the idle periods are shorter. The capacity to store biomass is another possible synergy.
- Spain has excellent market opportunities with promising perspective. Greece has good market opportunities with promising perspective, which is the average.
- In Spain serious non-technical barriers with limited perspective to overcome are present. In Greece non-technical barriers exist that require serious attention but can be overcome. On the average, the sector has serious non-technical barriers with limited perspective to overcome, which could constitute a major problem when implementing IBLCs. An organisational barrier is that the olive oil sector is not properly mechanised to undertake the collection and processing of biomass. Furthermore, there is uncertainty about the expected volume of processing residues due to fluctuations in the production of olive oil. Also there is a social barrier of citizens living near pomace facilities who dislike odours and smoke. Finally, lacking funds are an example of an investment barrier.

General conclusions: For all assessment categories the values for the olive oil mills sector vary only a bit between the two countries. The analysis indicates that the olive oil mills sector has many opportunities for establishing IBLCs since it has a very large volume of residues, many synergies & benefits and good market opportunities with promising perspective. The only problem is that there are serious non-technical barriers with limited perspective to overcome.

3.1.3 Feed and fodder

Feed industries (see map in Figure 9) 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 to two main types of process flow diagrams: pre-grinding (see Figure 10) or pre-dosing processes. The difference resides in that grinding is carried out previous to the dosing in the first case but instead, in the second case, raw material is coarsely mixed before being round together by formula (Tesla, 2014).

Raw materials are usually transported by truck. Once in the plant, trucks are weighed and the load is discharged into the reception hoppers, from which feedstock are 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, those 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 10).

Fodder industries process herbaceous matter in order to achieve a better preservation of the nutritious elements contained in it through three different industrial processes; silage, haymaking and dehydration (see Figure 11). This last 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. Final products (see Figure 11) are marketed within two formats, bales, mainly for dairy production ruminants, and granulated format or pellets, for meat production and feed industry.

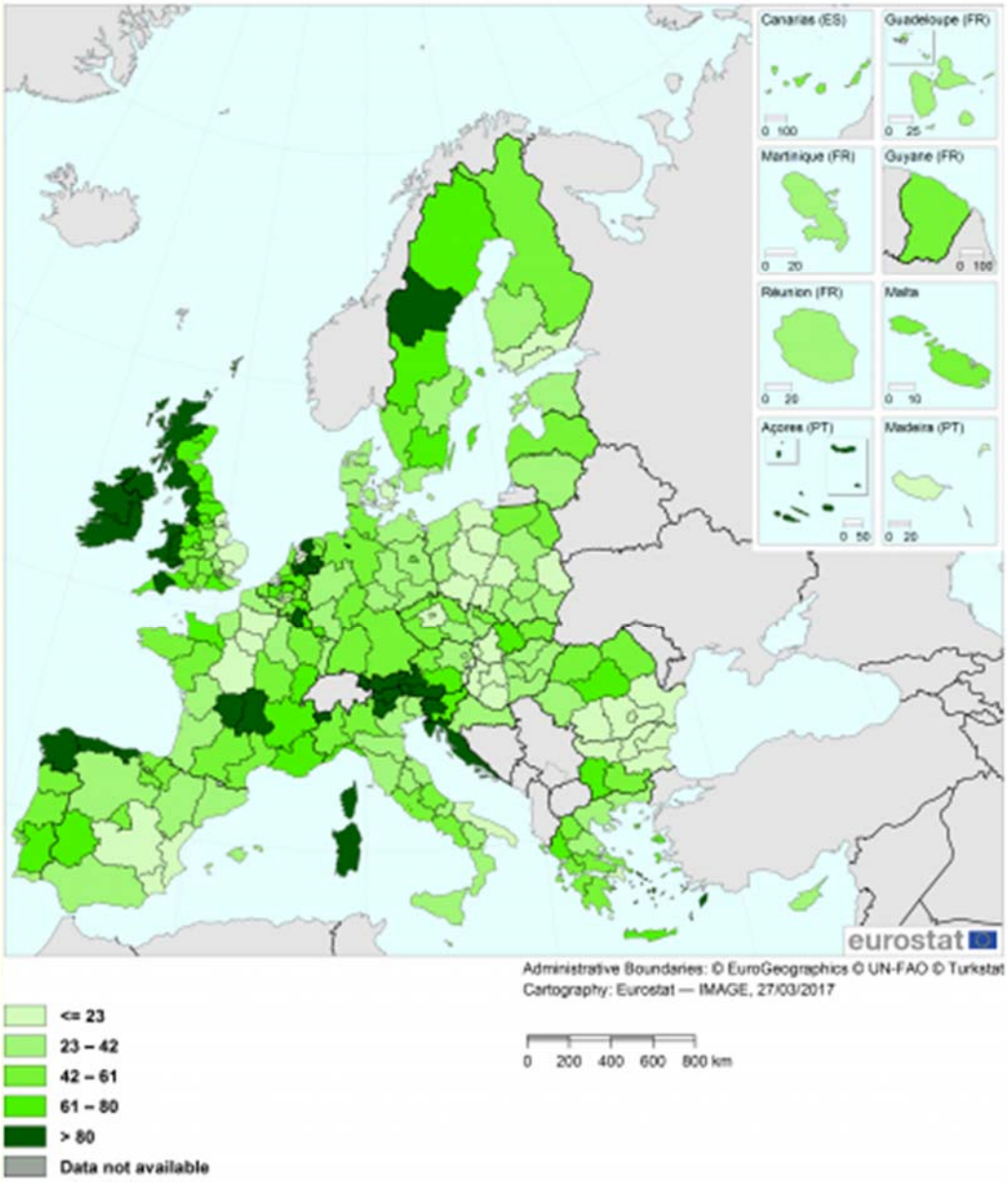

Figure 9. Map of the feed & fodder sector. Share of fodder area in Utilized Agricultural Area (UAA) by NUTS 2 regions for the EU-28 (Eurostat, 2017)

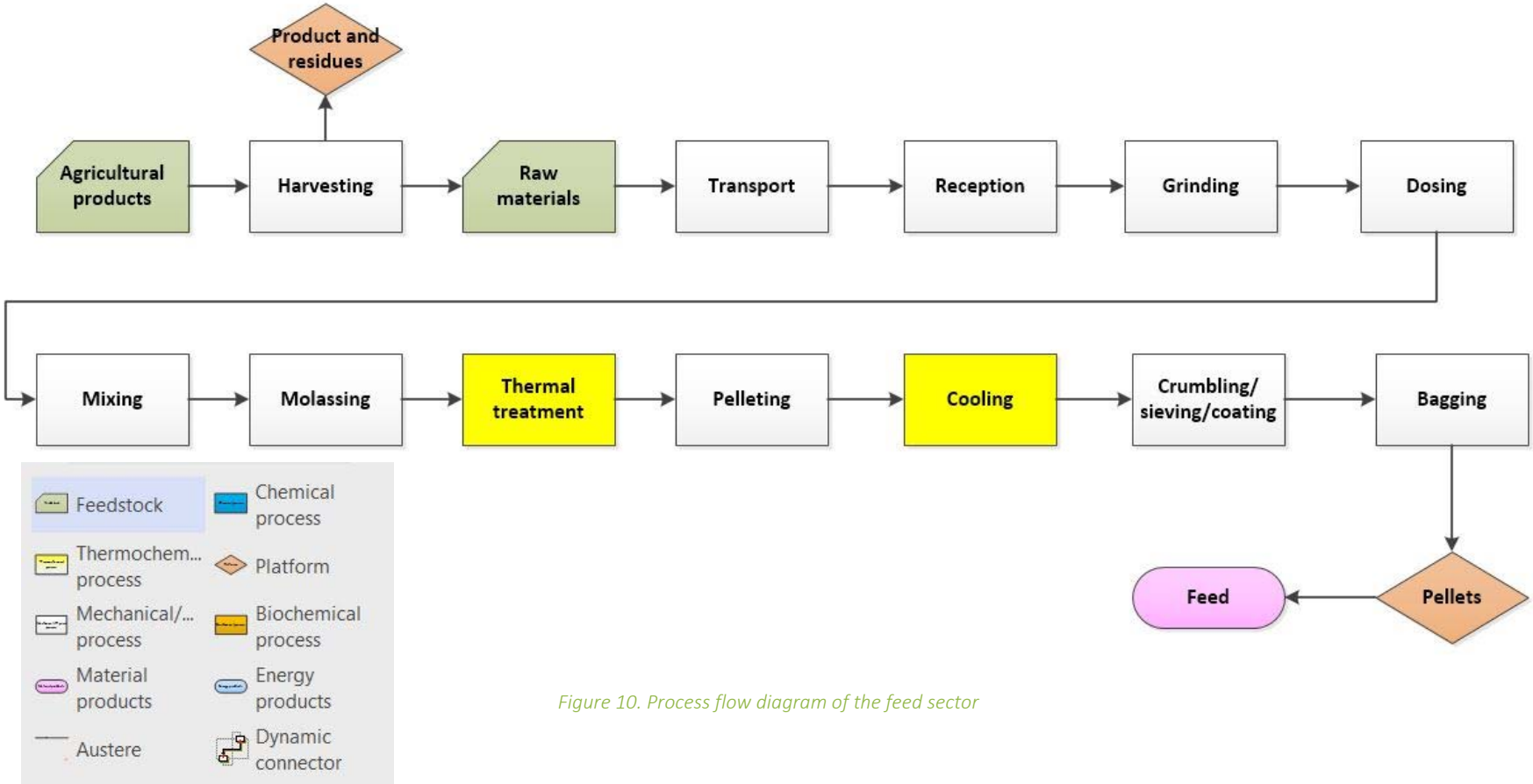

Figure 10. Process flow diagram of the feed sector

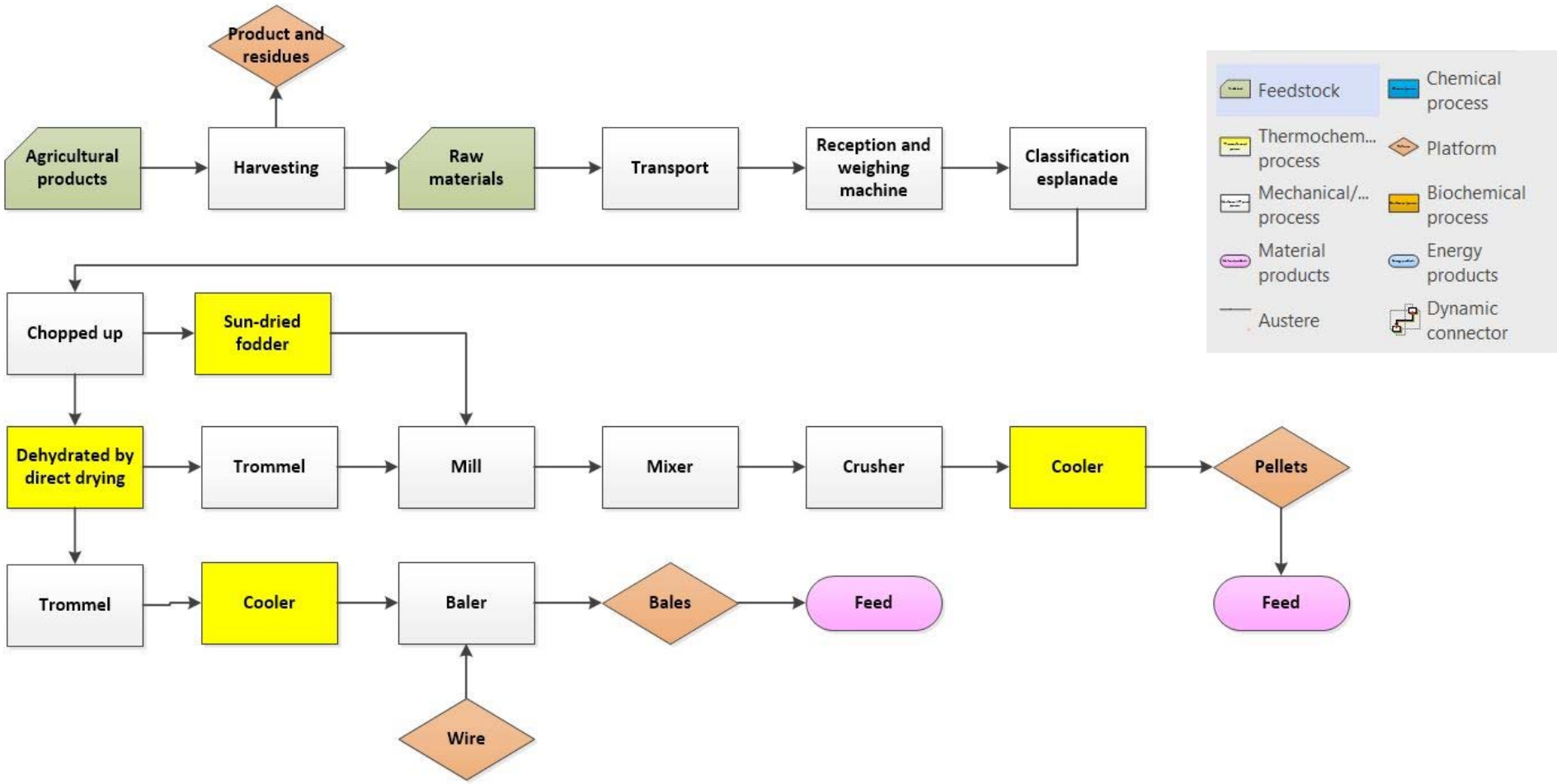

Figure 11. Process flow diagram of the fodder sector

Table 8 provides a cross-country analysis for the feed and fodder sector in view of its potential for integration with IBLC concepts.

Table 8. Summary feed and fodder sector.

Sector feed and fodder	
	Profile
Production	• Production of animal feedstuff requires several raw materials in order to prepare specific formulas (access to their residues). • Feed and fodder can consist of mixes of different crops such as: barley, wheat and oats, whole crop silages, protein crops like rape seed, peas and broad beans, grass as roughages, maize for forage, clover and alfalfa (Lucerne). • In Spain 85 % of the raw materials for dehydrated fodder industries corresponds to Lucerne. • Animal feed production can also use residues and by-products of other agricultural processes.
Volume of the sector	• Cultivated area: o Spain (2014): forage crops almost 1.1 million ha. o Sweden: leys and green crops grown on 1.1 million ha. o Ukraine (2016): specialized cultures 1.932 million ha. o Serbia (2016): 0.215 million ha. • Size: o Spain (2015): feedstuff production 23.3 million tonnes; (2016-2017) dehydrated fodder production 1.61 million tonnes. o Sweden (2016): temporary grasses 4.9 million tonnes per year in average; leys and green crops grown on 1.1 million ha. o Ukraine (2016): 6.23 million tonnes of combined and concentrated feed. o Serbia (2016): 1,555 million tonnes (note: this concerns data of the raw material that is used for production of feed and fodder; there is no exact data of the capacity of final products from the industry because there are many small processing facilities that are not monitored for their production data). • Number: o Spain: 70 fodder dehydrator industries and almost 1,500 feed industrial manufacturers. o Sweden: 7 feed mills of Lantmännen and 4 of Svenska foder. o Ukraine: 440 producers of combined and mixed feeds. o Serbia: approximately 100 producers of animal feed.
State of the sector	• The compound feed production in the EU 28 slightly increased by 0.4 % in 2016 to 155 million tonnes.

	• The share of rapeseed meal significantly increased with the development of the biodiesel sector (FEFAC, 2017). • The average value of the industrial production of compound feedstuff for farm animals in Spain was 6,820 million euros and 300 million euros in the case of fodder plants production. • If the animal sector in Sweden will decrease as predicted, then this will also affect the size and capacities of the feed and fodder industry. It also raises questions and thus opportunities for alternative use of available processing facilities and land. • The sector is not doing well in the Ukraine: the production of combined and concentrated feeds has been declining for the few recent years in a row. That is most likely due to the fact that the number of big farm animals (cattle, pigs, sheep and goats) has been declining as well. • Since livestock production occupies an important place in agricultural production in Serbia, the feed and fodder sector is important in the country's rural economy. Production facilities in the feed and fodder sector of Serbia are relatively well distributed in the country regions. Nevertheless, this branch of agriculture has been recording for the third decade negative trends. Only during the last ten years, the number of conditional heads per hectare agricultural land it was reduced from 0.34 to 0.27.
Typical size of the companies	• In Spain most animal feeding products industries are micro enterprises with 1-9 employees (around 48 %), followed by small companies with 1--49 employees (31 %) and companies with no employees (15 %). Only few of them had more than 50 employees (6 %) and none more than 500. • In Sweden Lantmännen produces 900,000 tonnes of feed yearly where about half is from grains. Svenska Foder produces 500,000 tonnes of feed. • Some 440 producers of combined and mixed feeds for farm animals operate in the Ukraine. Some 350 of them have a maximum production capacity of less than 75 tonnes of final product per day, and 90 have a production capacity above this – up to 1,150 tonnes per day. • In Serbia no data are available related to company size and production capacities.
Distinctive facilities of the sector	• In Spain 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.).

	• Fodder dehydrator industries in Spain 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 Spanish agro-industries are consumers of biomass to supply their energy demands. • In Sweden the fodder factories seem to be in production all year round with little down time. • About 70 % of all mixed and combined feeds are produced in the Ukraine by the big integrated companies. • In Serbia all existing capacities are oriented only for feed and fodder production.
Degree of innovation	• In Spain around 94 % of feed and fodder sector industries are not expected to have economic strength and resources to implement an IBLC within their facilities. In spite of this, the remaining 6 % seem to reunite required conditions to start new biomass related business lines. The fodder dehydrator industries have a greater size than the feed industries and thus, have better chances of becoming an IBLC. • In Sweden there seems to be a focus on research in using domestically grown protein crops to decrease the need of import. There is also a focus on increased grass proportion for dairy cows to decrease the need of grains and other crops as supplement. • In the Ukraine the degree of innovation is rather low. Most of feeds and fodders produced are for own needs and are not being brought to the market. • In Serbia the entire technological process of animal feed production in all factories is automated. For the purpose of efficiency of production, the factories have modernized their production in order to meet the needs of its customers by investing in machinery and equipment, as well as by building a larger production and warehouse space.
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. • 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. • In Sweden there is a potential capacity for biomass growing in low utilised agricultural production fields (dedicated crops for bio-energy/ biobased production).

	• In Serbia there are no possibilities for future IBLC development in this sector, because producers use all by-products for further production.
	Opportunities for IBLCs
Sector related residues	• The EU debate on food waste in the context of circular economy has delivered a clear recognition that the feed industry is part of the solution. • The small amounts of residues from feed industries in Spain are not available for IBLC purposes since legislation obliges to remove them (CESFAC, 2017). • Fodder dehydration industries in Spain do not produce any important biomass residue, either in the agrarian or processing phase. Instead, those industries could have a relatively easy access to agrarian residues, which can be used as raw material for the production of solid biomass. • There are no biomass residues from feed production from grains in Sweden as the by-products are being reused in feed industry. • Grass production residues in Sweden are losses during harvest and transportation between storage and feeding place. Losses in dry matter varies between 3-30 %. • In the Ukraine and Serbia the feed and fodder sector generates no biomass related residues.
Potential synergies & benefits	• Feedstuff manufacturer industries in Spain keep their production ongoing during all the year (no idle period). • Fodder dehydrator industries in Spain have an idle period that lasts from November to March/April. • The start-up of IBLCs in Spain would bring up employment in the region as a social benefit and also environmental benefits. • In Sweden using grass as break crop in grain dominant production may benefit grain production and profitability on farm level in the long run. • In the situation that the number of animals and animal producers will decrease in Sweden, there is potential of using grass and feed crops for other applications, for example in the bioenergy industry. • In the Ukraine there is a processing capacity surplus (physical processing - grinding, granulating etc.) in the sector. The current underuse of processing facilities is estimated to be at the level of 20-40 %. Due to the fact, that the production of concentrated fodders shares some similar stages with the production of solid biomass (e.g. dehydration and granulation), this surplus capacity may be potentially of interest for an IBLC. • There are no available residues from feed and fodder sector in Serbia so there are no potential synergies and benefits, which could be obtained.

Market developments	• Despite the huge variations in feed material prices over the last years, the proportion of feed materials per category remained relatively stable (50 % for cereals, 27 % for oilseed meals) (FEFAC, 2017). • In the case of animal feed industries in Spain, the lack of idle period joined to the small size that features them constitute significant barriers that must be overcome for implementing an IBLC. • Studies in Sweden are showing that grasses have potential of being used in production of biogas, ethanol and other bio applications (Prade et al., 2015). • The market in the Ukraine has been shrinking during the recent year due to decline in livestock numbers. • Business plans of companies from this sector in Serbia have shown the intention for increase the production and export to other markets.
Non-technical barriers	• Low market activity and incentives (market barrier). • A complex logistic organisation (both the collection and the processing of the residues) makes the implementation of an IBLC less feasible (organisational barrier). • Mandatory disposal of the feed animal residues by an authorized manager (legislative barrier). • Feed industries will require higher investments (financial barrier). • The non-technical barriers of feed grains are the same as mentioned in the food grain sector. • There may be competition from feed industry using feed products in the bioenergy production, but biomass availability may increase if the need for feed to animals decreases. • Feed manufacturers have been able to help managing financial risks and to buffer price fluctuations of agricultural raw materials thanks to their market arbitration and hedging possibilities for key raw materials. However, livestock farmers will need better access to financial risk tools to improve the protection of their own income (FEFAC, 2017). • Dependency of production/yield to weather conditions.

Table 9. Traffic light analysis for feed and fodder sector.

IBLC feasibility for feed and fodder sector						
	Spain	Greece	Sweden	Ukraine	Serbia	Average
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 9 presents the traffic light analysis expressing the suitability of the feed and fodder sector for establishing an IBLC, either as contributor of (sector related) agro-residues and/or of capacities for processing biomass. Based on the traffic light analysis the following observations were summarised:

- Both in Spain (32.3 million tonnes feed & 1.6 million tonnes fodder), Sweden (4.9 & 1.1 million tonnes) and the Ukraine (6.2 million tonnes combined) the volume of the feed & fodder sector is large, while it is medium sized in Serbia (1.5 million tonnes combined). On the average the volume the feed and fodder is large.
- In most countries (Sweden, the Ukraine and Serbia) it is a medium healthy sector. It is only in Spain where the sector is healthy. Remember that many of the judgments in the traffic light analysis (e.g. healthy/unhealthy) are qualitative and thus no exact figures can be given here. On average, the sector is medium healthy, which is rather positive for investing in IBLCs, but it could perhaps become a problem.
- Some suitably sized companies (for an IBLC) can be found in Spain, Sweden and Serbia, while the Ukraine has many suitably sized companies. On average, some suitably sized companies can be found per country, which could invest in an IBLC.
- In three countries (Serbia, Spain and Ukraine), many of the distinctive facilities can be shared. E.g. in Spain 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.). Fodder dehydrator

industries in Spain 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. In Sweden only a few facilities can be shared because the fodder factories seem to be in production all year round with little down time. So on the average many of the distinctive facilities can be shared, which is favourable for establishing an IBLC.

- The degree of innovation varies from medium in Sweden and Serbia to low in Spain and the Ukraine. On the average there is a low level of innovation in the sector, which could be a problem because an innovative concept like an IBLC will be less likely considered then.
- Sweden and the Ukraine have some stimulating miscellaneous factors, but Spain and Serbia only have a few. An example is that the industry is used to handle both raw materials and final products such as bales, pellet or other granulated format. So on the average there are few stimulating miscellaneous factors, which is again not favourable for establishing IBLCs.
- Spain, Sweden and Serbia all have a low volume of residues available in the sector. Ukraine even has a very low volume of residues available. So, on average, only a low volume of residues is available. This makes the feed and fodder sector less suitable as a supplier of biomass to IBLCs. However, the feed and fodder sector could also process residues of other sectors.
- Only in Ukraine many synergies & benefits can be found in the sector, because there is a processing capacity surplus (physical processing - grinding, granulating etc.) in the sector. In Spain and Sweden, the sector could have some synergies & benefits. E.g the fodder dehydrator industries in Spain have an idle period that lasts from November to March/April. In Serbia only few synergies & benefits apply. So on average the sector could utilize some synergies and benefits.
- Sweden and Serbia see some good market opportunities in the sector that are rather uncertain. While Spain and Ukraine only have few good market opportunities that are rather uncertain. So the average is a few good market opportunities that are rather uncertain.
- Only in Serbia serious non-technical barriers with limited perspective to overcome are present such as financial, legislative and organisational barriers (see Table 8). In the other three countries only small non-technical barriers are present that can be overcome. On average the sector has small non-technical barriers are present that can be overcome so this should not constitute much difficulties for establishing IBLCs.

General conclusions: For all assessment categories the values for the feed and fodder sector vary between the four countries, but not very much. The assessment indicates that the feed and fodder sector has some but limited opportunities for establishing IBLCs, since the sector has only a low volume of residues (unless it uses residues from other sectors), some synergies & benefits and only a few good market opportunities that are rather uncertain. A positive point is that there are only small non-technical barriers that can be overcome.

3.1.4 Wine sector (cellars & distilleries)

The EU wine sector contains 50 percent of the global area that is dedicated to vineyards. With 65 percent of the global wine production, wine producing countries in the EU play a dominant role with Spain, France and Italy accounting for nearly 80 percent of the EU production share (and 75 percent of the vineyard area). Figure 12 shows how the EU vineyard area is distributed over the member-countries.

Since wine contains much more sugar than its residues, it is common that a part of the final production is sold to distilleries. Part of the grape processing residues (grape pomace, lees and stalks) are also used as feedstock in distilleries for the production of alcohol. The wine sector has therefore been divided into two parts: wine cellars and distilleries.

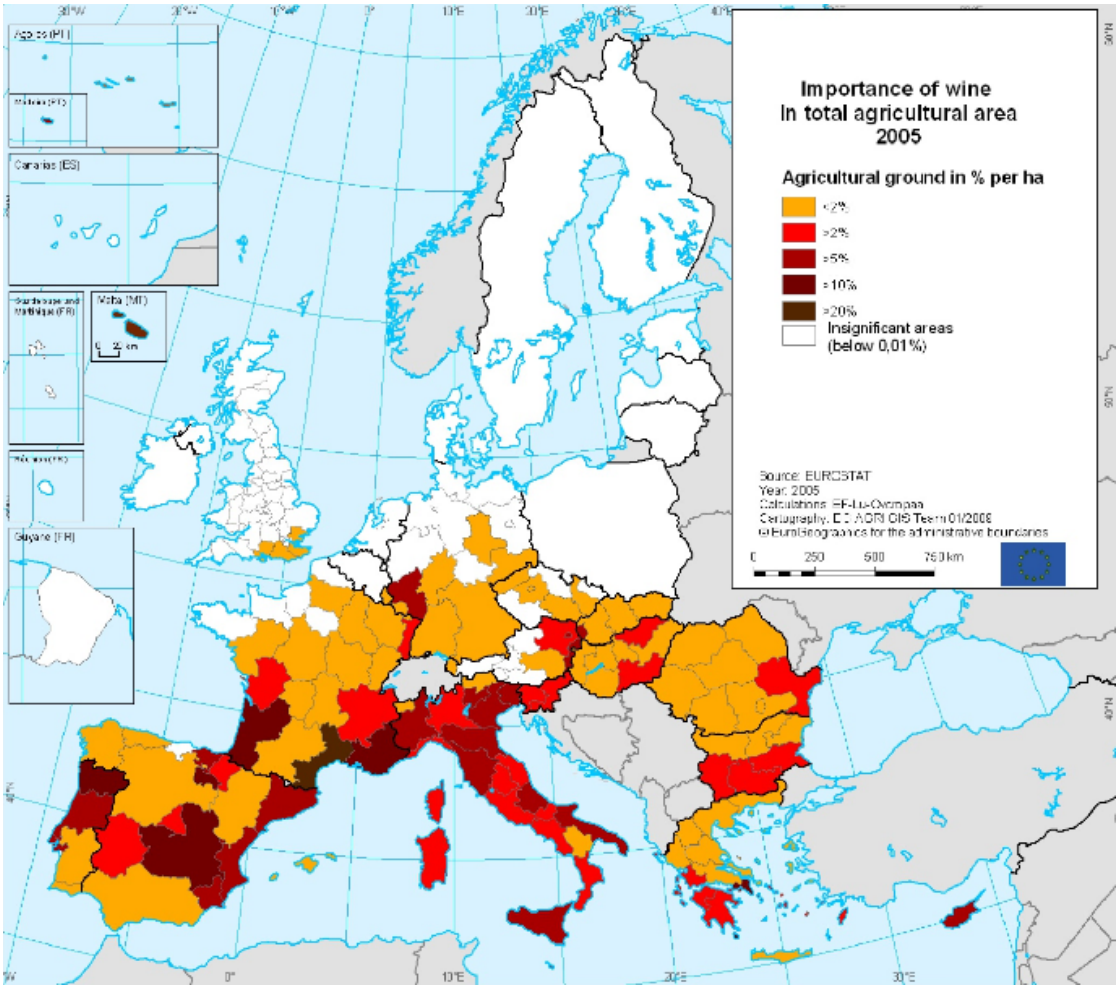

Figure 12. Wine grape surface on total agriculture area (source: Eurostat, 2005; elaborated by European Commission, 2017)

Wine cellars

The supply chain for wine is graphically presented in Figure 13. It shows the steps and processes from the harvest of the feedstock until the final product: wine. The figure also shows the various

residues that arise from the feedstock handling and processing steps in the value chain (marked by the light-brown diamond shapes).

Grapes are the main feedstock for wine cellars. The grapes are harvested by vineyard farmers in bunches, together with leaves and grape stalks, and then transported to wine cellars facilities. After reception of the bunches, grapes are separated (destemming) from leaves and stalks (the latter are usually carried to distilleries, where they are washed to recover sugar for distillation). Sometimes they are crushed all together. 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 features. At the pressing stage the main residue of wine cellars is generated, grape pomace (or grape marc), which is one of the main feedstock of distilleries for the production of alcohol.

Once ended fermentation and pressing phases, 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. 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. After finishing of the whole process, the final product (wine) is bottled, packaged, or sold in bulk.

Distilleries

The distilleries’ main activity (Figure 14) 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 (all coming from the winemaking process) that can be used for their purposes: grape pomace, grape stalks, lees and wine. These feedstocks have different (but significant) amounts of sugar, which is the basis of the distillation process.

In a first stage of the alcohol extraction process, grape pomace 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 alcohol obtaining. Each distiller is composed of 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 usual product of distilleries is the tartrate. The dealcoholized pickets and lees pass 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.

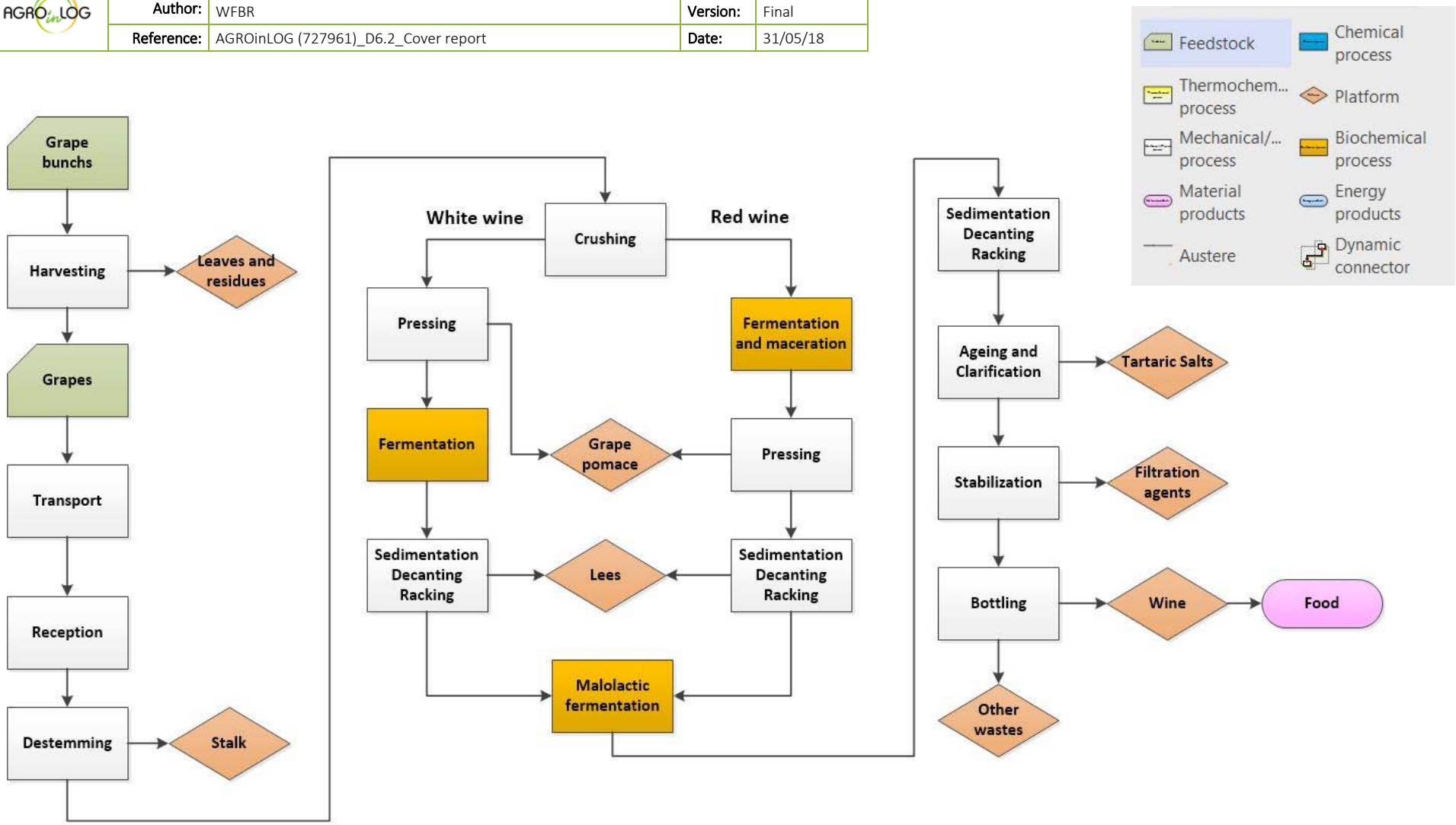

Figure 13. Process flow diagram of the wine sector

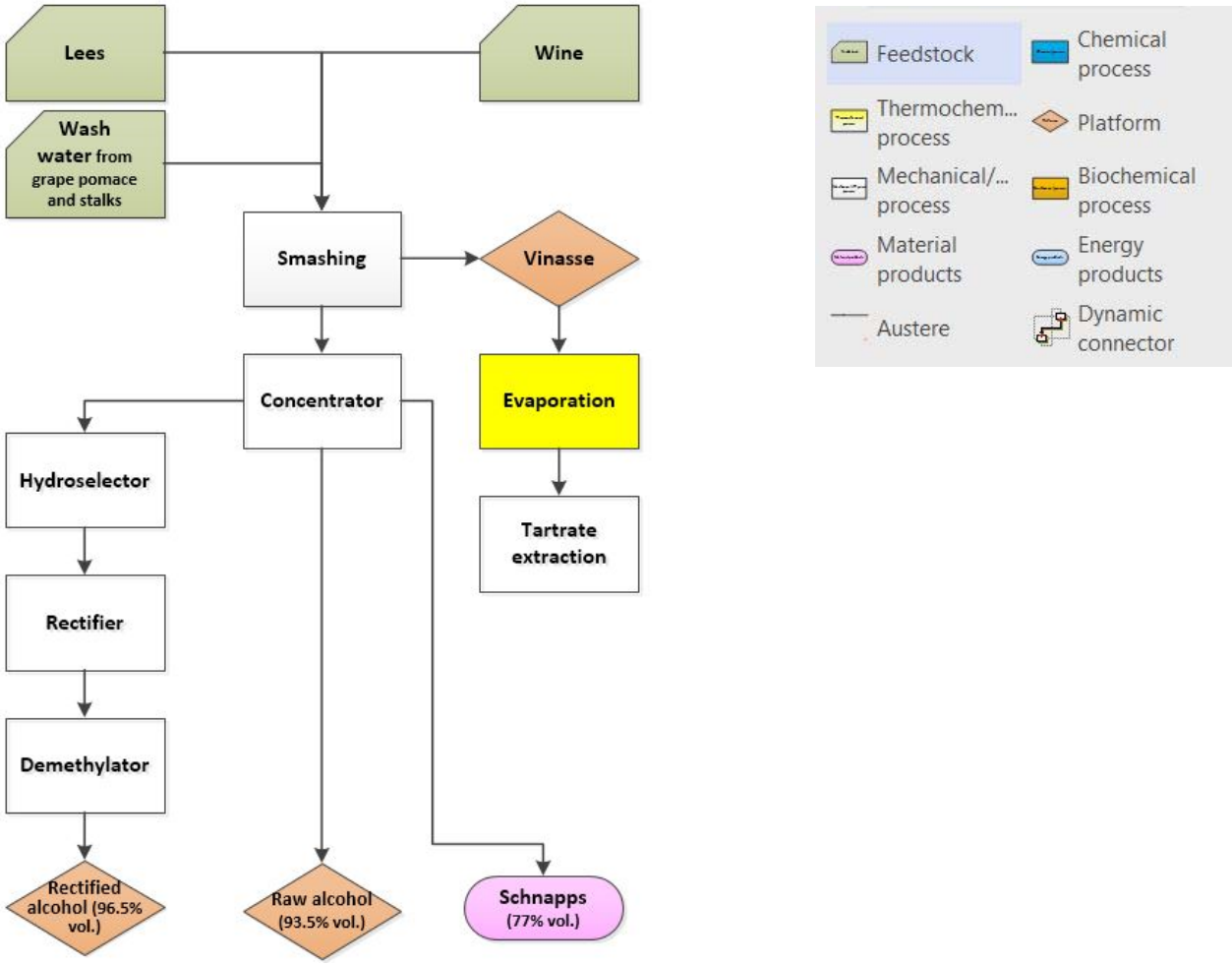

Figure 14. Process flow diagram of the wine distillery sector

Table 10 provides a cross-country analysis for the winery and distillery sector in view of its potential for integration with IBLC concepts.

Table 10. Summary wine sector.

<table>
<tr><th colspan="2">Wine sector</th></tr>
<tr><th></th><th>Profile</th></tr>
<tr><td>Production</td><td>
The main wine grape producing countries in EU (vineyard acreage / % of EU total vineyard acreage / grape production) (EUROSTAT, 2014/2015):
<table>
<tr><th></th><th>Vineyard acreage ('000 ha)</th><th>Share in total EU vineyard acreage</th><th>Share in total EU grape production</th></tr>
<tr><td>Spain</td><td>925,32</td><td>30%</td><td>23%</td></tr>
<tr><td>France</td><td>747,10</td><td>25%</td><td>26%</td></tr>
<tr><td>Italy</td><td>634,34</td><td>21%</td><td>30%</td></tr>
<tr><td>Portugal</td><td>176,87</td><td>6%</td><td>4%</td></tr>
<tr><td>Romania</td><td>169,55</td><td>6%</td><td>3%</td></tr>
<tr><td>Germany</td><td>99,91</td><td>3%</td><td>5%</td></tr>
</table>
By-products (or residues) originate from cultivation (pruning) and from feedstock processing in wineries and distilleries.
By-products from the wineries are used as input in the distillery process. Main residues from both wineries and distilleries are leaves, grape stalks, lees, vinasse, grape pomace, exhausted grape pomace, and grape seeds.
</td></tr>
<tr><td>Volume of the sector</td><td>
The production of grapes for wine processing consists of (mainly) small-scale vineyards. These are mostly small privately (family) owned orchards.
In some countries grape cultivation and wine processing are combined in large integrated firms or are organised in co-operative companies.
</td></tr>
<tr><td>State of the sector</td><td>
EU wines are exclusively produced with grapes cultivated in the diverse territories of the European Union. This wine sector is dependent on local production and it cannot rely on the international market to get its raw material. Wine production in the EU depends on the communities living in the rural areas. Here the wine sector creates value for local communities and provides the population in vulnerable rural areas with means for their daily existence where no other economic alternatives are available.
This dependence on territory is embodied in the strict EU wine legal framework, which prohibits mixing European wines with wines produced outside the European Union (CEEV, 2016).
Sector performance is largely weather dependent, with seasonal fluctuations in performance. Generally, it can be said that the sector is growing in the EU.
</td></tr>
</table>

	• A large part of the EU wine is produced for the export market (Russia).
Typical size of the companies	• The EU wine sector is composed of an overwhelming majority of small producers located in rural areas with around 2,400,000 wine producing holdings, for 3,000,000 direct fulltime jobs, most of them in rural areas. • The grape production and winery sector is generally small-scale and fragmented. A considerable share of wine production takes place in "in-house" cellars. • Economies of scale are more present in the (larger) distilleries and the larger industrial wineries. But also medium-sized (privately owned) wineries should be included as a target group of companies that may have a potential for developing IBLC concepts.
Distinctive facilities of the sector	• It is difficult to determine which specific available facilities and technologies, used in the processing and production of wine, are of interest for processing of biomass other than for grape processing. This also depends on the technological level of the specific industries and will have to be further investigated. For the wine sector at this point, there is no clear apparent match from a technological point of view. • Distillery industries may have a potential to create synergies in terms of using the available facilities for the processing of biomass residues. This was particularly recognised by the study on the Spanish wine and distillery sector. These synergies concern the use of equipment such as (horizontal) dryers that are compatible for the processing of solid biomass and the extraction of bioactive compounds. The fact that the distillery industries are in close contact with producers in the wine sector may create additional synergies, whereas it concerns the availability of residues for further processing and logistics to obtain these residues.
Degree of innovation	• The level of investment in innovations differs per country. Based on the EU review, most important innovations seem to be applied to increase efficiency in existing grape processing technology and innovations with a cost-reduction effect, rather than exploring new applications of grapes and grape residues in new products. • Innovations in the use of alternative renewable resources for own energy production and consumption may fit with the sector's need and ambition to remodel their processes towards increased overall sustainability. • Obviously, the economic sector's/ country's wellbeing has a large influence on the available means for innovation and modernisation. • The general impression is that funds for sector innovation are modest, and that innovation in the sector is partly dependent on the availability of subsidies.

Miscellaneous

- Opportunity to invest in processing biomass residues as part of the overall improvement of the sector's sustainability.
- Fragmented structure represents a serious problem to overcome when biomass residues are to be collected from the scattered vineyards. It will be a challenge to make it a feasible and sustainable operation.
- Awareness of the need or urgency for biomass residue valorisation varies per country. In Greece there is a general lack of knowledge on the potential of processing agro-residues. While in Serbia, sector stakeholders have an interest in IBLC activities, but lack the technical capacity to organise it. The Spanish wine and distillery industry can be characterised as a sector with a high awareness regarding the potential and need for the processing and valorisation of residues in order to increase the sector's overall sustainability.

Opportunities for IBLCs

Sector related residues

- Current practice is that pruning from grape vineyards are not collected for further use. Most commonly (although prohibited by law) prunings are left in the fields to be burned, or more rarely, mulched into soil. This, and given the fact that different vineyard systems (vase, espalier, etc.) produce different volumes of pruning, make it difficult to obtain data that are accurate and representative.
- For a large grape producing country such as Spain the potential yield from pruning is estimated from 1-4 ton/hectare/year (fresh matter with approximately 40 % moisture content). For a smaller producing country such as Greece the pruning yield is estimated from 1.4 to 8.6 ton/hectare/year (fresh matter with 40 % moisture content).
- Product mass balance: production and estimation of by-products from grape processing (Agriconsulting, 2017; EUROSTAT, 2014 & 2015):

	Share in feedstock	EU-28 ('000t/yr)	Spain ('000t/yr)	France ('000t/yr)	Italy ('000t/yr)
Grape processed	100 %	23,648	5,527	6,213	7,006
Must	80-85 %	19,510	4,560	5,126	5,780
Skins/peels	9-10 %	2,247	525	590	666
Seeds	3-4 %	828	193	217	245
Stalks	3-4 %	828	193	217	245
Pruning	2 t/ha	6,090	1,851	1,494	1,296

	Share in feedstock	Germany ('000t/yr)	Portugal ('000t/yr)	Romania ('000t/yr)
Grape processed	100 %	1,199	916	753
Must	80-85 %	989	755	621
Skins/peels	9-10 %	114	87	72
Seeds	3-4 %	42	32	26

Stalks	3-4 %	42	32	26
Pruning	2 t/ha	200	354	339

- The collectability of pruning (2 t/ha dry matter (Europruning, 2017)) is considered a technical barrier. In particular when considering the variability in orchard types. The ability to mechanise the collection process has a large influence on the economic feasibility.
- In Spain, the company PELETS, COMBUSTIBLE DE LA MANCHA S.L. has developed and implemented a business case for the collection and processing of vineyard pruning for the production of pellets. It seems that they have been able to organise it as an economically feasible process.
- The main by-products of wine production are untreated grape pomace and the pruning. Although pruning collection from the fields could play a key-role, grape pomace is the residue offering the best opportunities for IBLCs. Untreated grape pomace is made of:
    - skins/peels
    - grape seeds (2-3 per grape berries); they have a hard epidermis protecting them from fermentation and distillation, seeds can be separated from the pomace for oil extraction;
    - stalks, that can be present or not; they affect the storage of the grape pomace.
- Untreated grape pomace is a main feedstock for distilleries and it is therefore questionable if untreated grape pomace will be available for other processing routes (such as biobased refinery).
- Grape pomace is less eligible as feedstock for feed industry because of its odour, and is therefore applied as fertiliser (Greece).

Potential synergies & benefits

- Distilleries have sufficient economies of scale and technology available that is appropriate for IBLC concepts for the processing of solid biomass and the extraction of bioactive compounds (Spain).
- The availability of facilities during the low season period in wine production (January until August) suggests availability for the processing of biomass (residues) in an IBLC. This applies in particular to the smaller wineries whereas larger wineries stay in production for a longer period August until January). Storage yards for grape pomace may provide opportunity as IBLC for the processing of grape pomace for energy and biobased production
- Efficient collection of biomass from the vineyards is complicated because of the small-scale structure in the sector, e.g. due to small fields and many owners. Also, the different ways of vineyard cultivation (vase,

	espalier, etc.) affect the level of mechanisation in the collection of pruning from the vineyards (as is the case in the Spanish winery sector). • Fragmented sector makes it difficult to obtain sufficient facilities/capacities that are useable for other biomass processing in idle periods with sufficient economies of scale. • Collection of biomass from vineyards requires careful logistical planning to minimise transport distance to a potential biomass processing facility. • It will contribute to optimize the supply chain to liaise with grower associations rather than with individual growers. • Wine industries have wide experience in the transport, management and processing of residues (from wineries to distilleries). • Labour in vineyard and wine production is seasonable and therefore sufficiently available for employment in IBLC activities.
Market developments	• Opportunities for residues from vineyards/ wineries/ distilleries as feedstock for the production of platform chemicals, biofuels, energy, soil fertilisation, and pharmaceutical / cosmetic use. • Opportunity for extraction of polyphenols, enocyanin, and other compounds for feed industry. • Utilization of biomass residues (pruning) provide opportunity as solid biomass for energy production. This market is already advanced with good insight in potential revenues based on market prices (€85-115 /t for consumer market and €70 /t for long-term contracts with biomass power plants). Successful examples have been recorded in Spain (Pelets de la Mancha) and Italy (Settesoli). • Due to the increasing costs of fossil-based chemicals and the increasing demand for sustainable resources, the by-products from grape-processing form a challenging pathway for IBLC development. • Deeper and dedicated research is needed in order to identify operators, available volumes and cost-revenue balances.
Non-technical barriers	• Regulatory framework is required to avoid suboptimal use of available biomass, and to create economic incentives for optimal valorisation. • Efficient logistical framework and effective mechanisation should overcome organisational barriers for collection of biomass. • The sector will need an impulse for modernisation and increase of awareness to exploit the potential of agro-residues. The reuse of residues from grape-processing will enable the circularity of the sector and the strengthening of the transition to overall sector sustainability. • Infant markets for high value biocommodities are impeded by a lack of demand and require a business strategy in which a balance exists between low value added (bulk) products with a secured demand and

high value added products with low and insecure demand but potentially good prospects.

- Agro-industries may lack the knowledge and technical assets to develop the activities as proposed by the IBLC concept. New associations with expert companies may circumvent this obstacle.

Table 11. Traffic light analysis for wine sector.

IBLC feasibility for sector wine						
	Spain	Greece	Sweden	Ukraine	Serbia	Average
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 11 presents the traffic light analysis expressing the wine sector's suitability for establishing an IBLC, either as contributor of (sector related) agro-residues and/or of capacities for processing biomass. In this analysis the wineries and distillation of grapes and grape residues are taken as a combined activity within the wine sector, so no distinction was made between winery and distillation activities. Following this traffic light analyses the following conclusions can be drawn:

- According to the country studies the wine sector (grape cultivation + grape processing) the sector's volume is considered large to very large. This is not surprisingly when you take into account the European Union wine sector is the world leader (65 % of world production). Other wine producing countries that will score high on this criteria are France, Italy, Portugal, Romania and Germany (these countries combined with Spain produce 90 % of the EU's production volume).
- The sector is evaluated economically as very healthy which is expressed by a good market performance in terms of sales and a well-developed infrastructure for production and export.

Remember that many of the judgments in the traffic light analysis (e.g. healthy/unhealthy) are qualitative and thus no exact figures can be given here.

- The typical size of the companies operating in the wine sector can be phrased as 'medium'. This has largely to do with the fact that the sector is highly fragmented (many small scale grape-producers) and economies of scale are only available at the very few larger wineries and distilleries.
- A similar line of reasoning applies to the sector's innovation degree. Although innovations are implemented for increasing efficiency in grape production and harvesting, and for overall cost reduction in cultivation and processing, the perspective of innovating in alternative processing of product residues is rather limited.
- Although it was generally considered difficult to determine in which way facilities in the wine sector can be of use for alternative biomass processing, the overall potential of using the available facilities for IBLC purposes is judged as 'high' for most countries.
- According to the analysis the wine sector has the disposal of large volumes of sector related residues. This applies in particular to the availability of woody biomass from vineyard pruning, but also the grape processing yields potentially valuable residues, although the distilleries acquire a substantial share of the latter residues for the production of alcohol and spirits.
- The sector is estimated to create many synergies and benefits from facilities and technology that are available during the low-season of production, as well as of the available infrastructure and labour that can be mobilised for IBLC activities.
- Also the market is considered promising. That is, there are good market opportunities for the production and selling of various commodities and products from biomass (biobased) processing.
- The non-technical barriers to bring the potential of an IBLC into practice are evaluated as serious with a limited perspective to overcome. This has to do with the fact that the promising market outlets also contain new and relatively pioneering pathways towards industrial products based on renewables from biomass. But also the challenge of setting up cost-efficient and sustainable logistical infrastructure for the collection of biomass residues from the wine sector is considered difficult to overcome.

General conclusions: Although some of the major wine producing countries such as France and Italy are not included in the sector review, it is fair to state that the above conclusions apply to some extent to most of the wine producing countries in the EU. Based on the different aspects on which the sector's overall suitability has been inventoried and evaluated by the researchers, the wine sector is considered to have sufficient basis for further research into the feasibility of establishing IBLCs. Most importantly this will include research into feasible solutions to overcome the logistical bottleneck, as well as into the proposition of a market portfolio that will provide a balance between low – and high value added products from the IBLC.

3.1.5 Grain chain (incl. straw until final product biofuel)

In 2015, France accounted for more than one fifth (22.9 %) of the EU-28 cereal production (see map in Figure 15). Germany (15.4 %) and Poland (8.8 %) together contributed to nearly a quarter of the EU total. United Kingdom was the fourth largest cereal producer, accounting for 7.8 % of the EU-28 total.

Figure 16 presents the schematic design of the grain supply chain. Although it does not represent the chain for all types of grain, it does give a general impression of the steps that are involved in the processing of grains into its final product: flour. The figure shows the various residues that arise from the feedstock handling and processing steps in the value chain (marked by the light-brown diamond shapes).

After harvesting, both maize and rice need to reduce humidity rate, allowing better conservation along the food chain. This operation gets underway on vertical dryers. Depending on the local climate cereals need to be dried before storage as well. Once dried, feedstocks are dispatched to the different value chains. Generally, barley is used in two main industries: beer brewery and animal feed. The main destination of soft wheat is the industry of flours and bakery and durum wheat is used in pasta industry.

After reception into the bulk silos, a gas or thermal treatment to prevent infestation of grain is carried out. Before being milled, the wheat is fully cleaned from any impurities and wetted to the desired level for milling. The impurities that may be present in wheat are grains of other cereals, straw, paper, stones, sand, dust, glass, or metal.

The purpose of wetting or steaming of the grain is to allow a more efficient separation of bran from the endosperm and to achieve the appropriate degree of softness of the interior grain for the good performance during milling. Then a gradual milling process is applied consisting of the following three steps:

- The breaking system (which separates and removes the endosperm from the bran in relatively large pieces).
- The scraping system (which removes small pieces of bran and germ that are attached to the endosperm).
- The reduction system (which mills the endosperm into flour).

After the milling, the flour is mixed, enabling the creation of a large number of products, homogenising different flour and auxiliary materials at the desired ratio. Special processing consists of drying, separation of proteins, and the heat treatment of bran and milling fractions. After the mixing, the flour is transferred into storage silos or packed in bags.

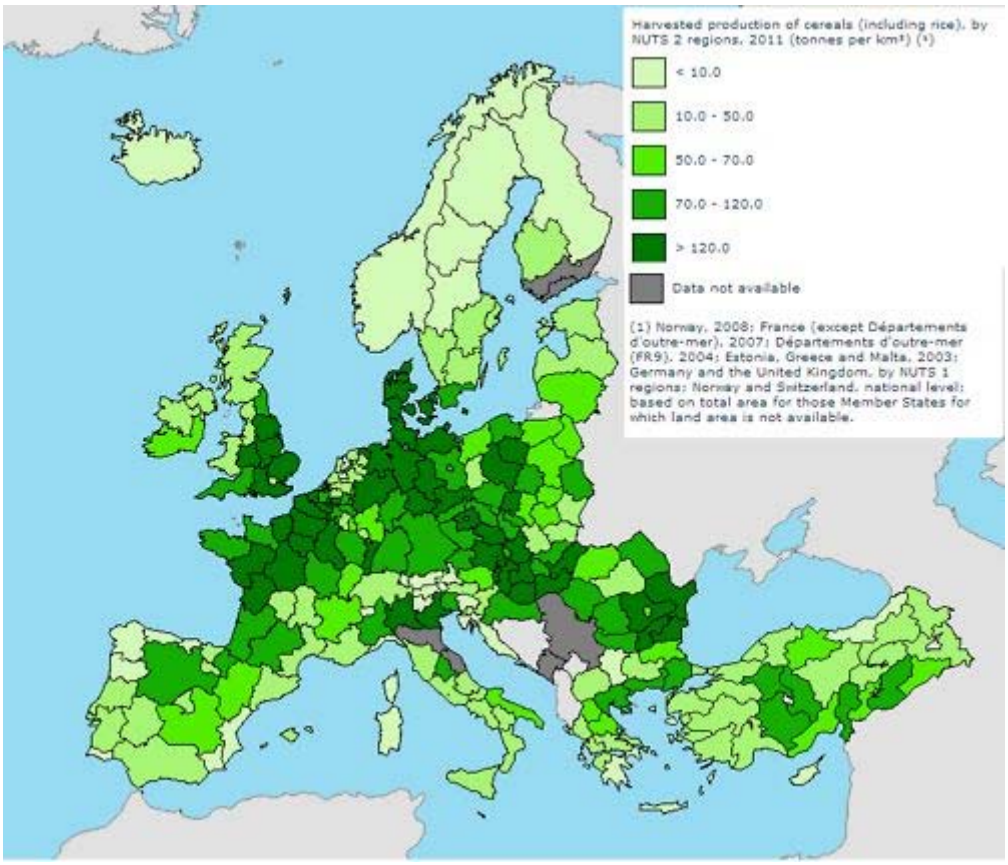

Figure 15. Map of the European grain sector (Eurostat, 2017).

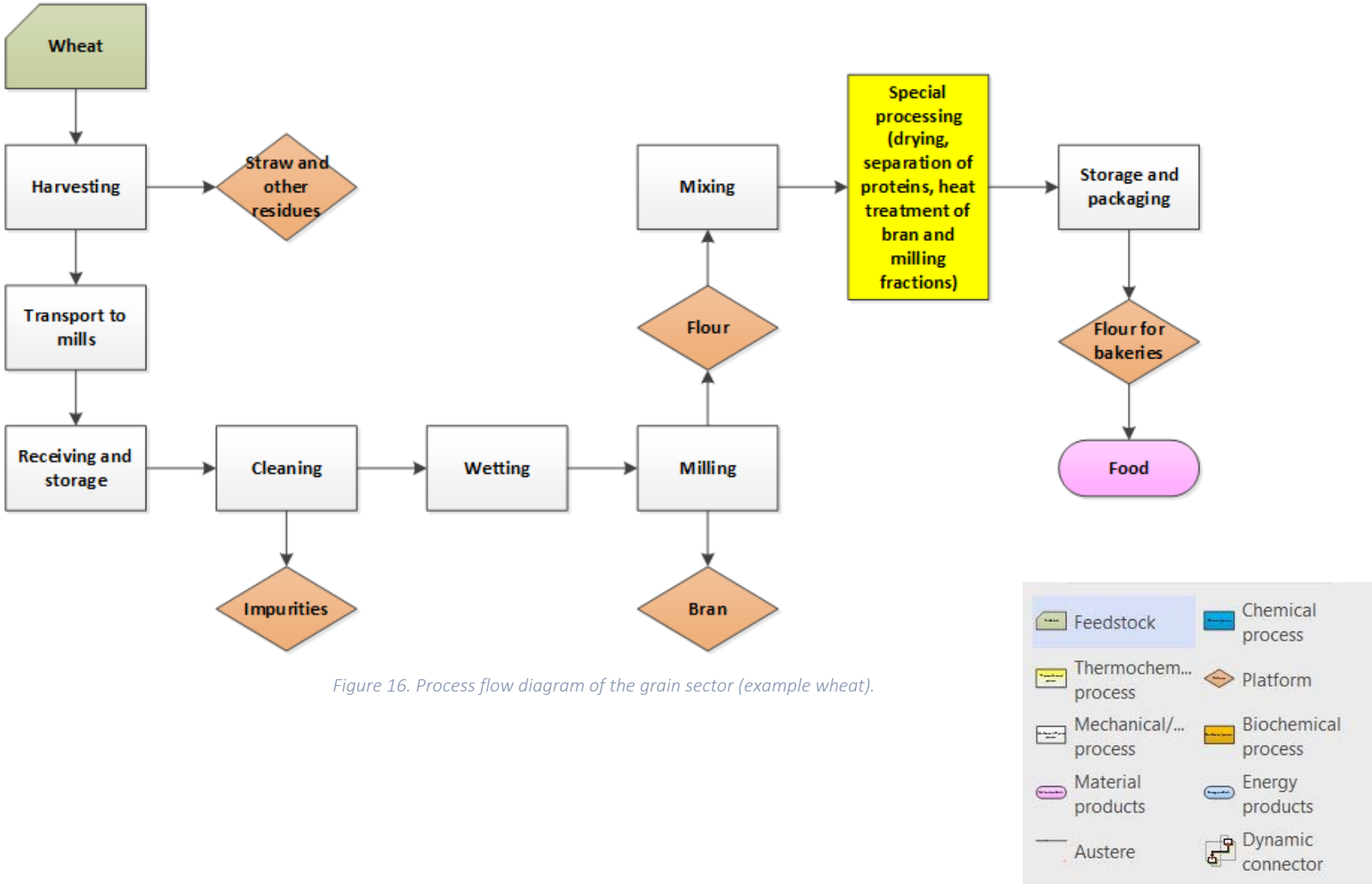

Figure 16. Process flow diagram of the grain sector (example wheat).

Table 12 provides a cross-country analysis for the grain sector in view of its potential for integration with IBLC concepts.

Table 12. Summary grain sector.

Grain Sector	
	Profile
Production	• Within the EU-28 large differences exist between countries and regions in production, yields and efficiency (both in farming and in processing). • The main feedstock from the grain sector are wheat, barley, maize, rye, and oats. Production of cereals (incl. rice) in 2015 was approximately 317 million tons. • Main cereal producing countries are France, Germany, Poland and UK. • Main rice producing countries are Italy, Spain, Greece and Portugal. • Grains are primarily processed for food (flour) and feed production.
Volume of the sector	• Cereal producing countries in EU (acreage / production, 2016) (DG Agri. 2017):

	Acreage ('000ha)	Production ('000 000t)
EU-28	56,900	295
Share in production:		
France		22.9 %
Germany		15.4 %
Poland		8.8 %
UK		7.8 %

	Acreage ('000ha)	Production ('000 000t)
EU-28	56,900	295
Of which:		
Soft wheat	24.2	134.1
Durum wheat	2.7	8.9
Barley	12.3	59.3
Maize	8.5	60.2
Rye	2.1	7.9
Oats	2.5	8.1

State of the sector	• The grain sector contains a variety of different cereal crops, each of which largely dominated by the world market. • The grain sector is an important sector in the EU with (large) regional differences in performance in terms of production yields, processing efficiency and industrial development.
Typical size of the companies	• Regional differences within the EU in both farming structure (small vs. large), and industrial processing. • Depending on the type of grain there are regional differences on scale/size of companies in production and processing:

	o Larger scale in Nordic countries (Sweden) and small scale structures in countries in the Mediterranean area. o Predominantly smaller mills in Europe operating for large brands. o Some countries with domination by a few (or one) large processing companies (Greece, Sweden) and vertical integrations (Serbia).
Distinctive facilities of the sector	• Very limited match between grain processing technology and methods for biomass processing. For example, vertical grain dryers are not suitable for drying biomass. • Availability of idle grain processing capacities is also limited to none because of year-round processing operations for the flour markets.
Degree of innovation	• Depending on the size of the processing industry there are more or less financial means available for innovation. • Technically outdated processing facilities lead to inefficiencies in industrial processing and relatively larger volumes of product residues. • Awareness of and motivation to reuse crop residues and/or residues from processing varies per country/region with a generally high awareness and motivation in the Nordic countries. Grain sectors and industries in the Eastern European countries with a low degree of innovation show inefficiencies and correlated product losses in primary production and processing (with large volume of residues).
Miscellaneous	• The potential of using crop residues for biobased applications has to be balanced with the necessity to avoid depletion of resources and to maintain the regeneration capacity of these resources (in particularly of agricultural soils). • The existence of opportunities for IBLC concepts depends on the interest of large industries and their willingness to invest in processing of biomass (residues) for biobased production. • As in some of the other sectors, the burning of crop residues (biomass) in the fields (legally or illegally) as a low cost disposal of 'waste', decreases the availability of potential feedstock for IBLCs. On the other hand, it offers opportunities to organise alternative processing through the collection of this biomass in a cost efficient way. • Interregional differences in (logistical) infrastructure and in the level of technological development influence the suitability and applicability of IBLC activities.
	Opportunities for IBLCs
Sector related residues	• The grain sector generally produces considerable volumes of biomass residues, including straw, stalks, stubble, corncobs, bran and husks (or hulls). These residues represent a lignocellulose-rich feedstock that could become available for bio-energy application in solid biofuels, gasification and for next generation biofuels.

	• Cereals delivered to the mills are mostly already cleaned from their residues. Availability of these residues will therefore require involvement from the farm sector, or an alternative approach towards the co-harvesting of these crop residues. • The use of rice husks (depending on the cultivar 17-23 % of grain weight) as biomass for bio-energy is interesting to further develop IBLC concepts, because the costs of acquiring these residues are low. Economic feasibility is, in other words, within reach. This applies to the main rice producing countries Italy (30.4 million tons), Spain (16.9 million tons), Greece (5.0 million tons) and Portugal (3.7 million tons). • The use of rice husks in fuel pallets will require attention to the problem of detrimental ashes in pellet combustion heaters. • Maize processing industries also have several unexploited residues such as corn cobs, leaves and stalks that potentially could be valorised both for bio-energy and the manufacture of bio-commodity purposes. • Straw can be considered as a potential feedstock for bioenergy although it has competing markets from the animal feed/husbandry sector.
Potential synergies & benefits	• Seasonality in grain processing may offer opportunities to combine core industrial activities with additional IBLC activities, although the potential match of equipment for rice and cereal drying and for the processing of biomass may be limited. • There are some good experiences with the use of straw for biobased processing (solid biofuel). Also the processing of chaffs is expected to offer opportunities. • Given the size of the grain sector, the sector is able to concentrate a potentially large amount of biomass residues. However, facilities are scattered over a wide territory. Large companies will cover large production areas and may have the disposal of modern agricultural mechanisation (Serbia). • It is recommended to apply IBLC activities in the first stage processing of residues close to the production areas. The involvement of the cereal processing industries seems (too) complicated. (Spain) • Complication is that substantial parts of the residues from the grain sector are consumed in the animal husbandry sector. • The fact that the grain sector is connected with a variety of industries may give some potential to combine these industries' activities with IBLC-operations (Serbia).
Market developments	• Residues from the grain sector are particularly interesting for the solid biofuel markets. • Other applications in for example biobased furniture and bioplastics are under investigation.

	• Price uncertainty (volatility) forms a considerable barrier (for grain sector industries) to invest in new biomass processing lines. Seasonality in supply and price volatility of the end-product pose barriers in the starting-up of new biomass processing activities (Spain). • Same line of reasoning holds for the investment in logistics for the collection of residues.
Non-technical barriers	• Insufficient idle periods so no capacity for the processing of biomass residues. • Also mentioned: insufficient residues / by-products (already consumed for animal feed and energy). • Uncertainties regarding the future production potential of crop production creates uncertainties concerning the bioenergy potential. • Sometimes low awareness in the sector, lack of government support, and lack of investment funds form blockades in the starting up of biomass processing activities. • Competition from low-priced fossil fuels hampers business cases for biobased equivalent products. • A significant financial barrier arises from the high costs of investing in biomass processing.

Table 13. Traffic light analysis for sector grain.

IBLC feasibility for sector grain						
	Spain	Greece	Sweden	Ukraine	Serbia	Average
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 13 presents the traffic light analysis expressing the suitability of the grain sector for establishing an IBLC, either as contributor of (sector related) agro-residues and/or of capacities for processing biomass. In this analysis, the grain chain includes also the processing of straw until the final product biofuel. Based on the traffic light analysis the following observations were summarised:

- The volume of the grain sector is evaluated as large to very large. The reason for this is of course that the grain sector forms an important backbone in the European agricultural sector for the production of food.
- The state of the sector is generally considered to be healthy. Although large differences between countries in the sector's performance and efficiency exist, the overall performance of the sector on a global market is quite good. Remember that many of the judgments in the traffic light analysis (e.g. healthy/unhealthy) are qualitative and thus no exact figures can be given here.
- The typical size of the companies involved in the grain sector shows a more ambiguous picture. Whereas South European countries have predominantly small scale processing mills, Nordic and East European countries have larger scale production facilities. Nordic countries, with larger scale production facilities, are considered better equipped for combining with IBLC activities that southern European countries.
- A similar line of reasoning applies to the availability of facilities in the grain chain that could be shared with the processing of biomass in an IBLC.
- In view of this, it is remarkable that the Spanish grain sector has a high innovation degree, whereas for other countries this is valued as medium.
- In general, the grain chain yields considerable volumes of residues during cultivation and harvesting. The availability of these residues for alternative processing may be somewhat variable between the countries. This may be a reason for the differences between the countries in the interpretation of this aspect.
- On average, the synergies and benefits between the cultivation and processing activities in the grain chain and the processing of biomass in an IBLC are considered as being many. The traffic light analysis does, however, show differences for Greece (few synergies) and to a lesser extent also for Serbia (some synergies).
- Also, the aspect of market development shows different interpretations for the countries in terms of offering opportunities for setting up IBLCs in this sector. The overall impression is that there are some good but also rather uncertain market opportunities. For Spain, these opportunities are gloomier, whereas Ukraine's grain sector is expected to offer excellent opportunities for connecting IBLCs with this sector.
- Apart from Sweden, all countries have a rather pessimistic view on the establishing of IBLCs in the grain sector based on the non-technical barriers that will have to be overcome. This has partly to do with the availability of residues for biobased processing, as in current practice these residues already of market-outlets. Mentioned also are the low awareness in the sector and the lack of governmental support and financial means for investing risk-bearing biomass processing.

General conclusions: Based on the sector analysis the grain sector does not seem to provide a convincing basis for the establishing of IBLCs. However, the analysis also showed that there are large differences between countries regarding the sector's suitability. The analysis of the grain sector in Ukraine and Sweden indicated a good basis for setting up IBLC activities both from production and market point of view, while the analysis of the grain sectors in Spain and Greece showed less favourable conditions. Given the fact that the grain sector is an important contributing sector in European (and global) agriculture it is advisable to investigate the feasibility of establishing IBLCs in connection with the grain sector in those countries that have a sufficient starting point (amongst which the availability of feedstock and facilities, market perspective, business awareness, governmental support, etc.).

3.1.6 Sugar industry

The sugar production (Figure 18 & 19) starts in the field with the sugar beets and ends with a diversity of products, including sugar products, feed products (molasses, beet pulp), sugar factory lime, stones, beet soil and water. After harvest, the farmers supply the sugar beets to the sugar industry where the beets are unloaded, washed from all soil residues and then slices into pieces. The slices, or cosettes, then enter a diffusion process in which the slices are heated and a sugared juice is collected from a pulp residue. After compression of the wet pulp, the juice fraction will enter a process of purification through liming and carbonation. Through evaporation the purified thin juice will be transformed into thick juice that is condensed in a crystallization process. The residue that remains after centrifugation and drying is crystal sugar.

Some products made in the factory are recirculated into the system as biogas, steam and water. As an example, the biogas produced at the site is combusted and the heat is utilized in the process.

Figure 17 gives an impression of the main sugar beet production areas in the EU-28, as well as of the locations of the factories where sugar beets are processed into beet sugar. Part of the residues from sugar beet processing is used as feedstock in bio-energy production, including the production of biofuels (ethanol). In the map (figure 17) are therefore also the locations of the factories indicated where ethanol is distilled from sugar beets. The map clearly shows that France and Germany are leading in the processing of sugar beet and sugar beet residues into bio-ethanol.

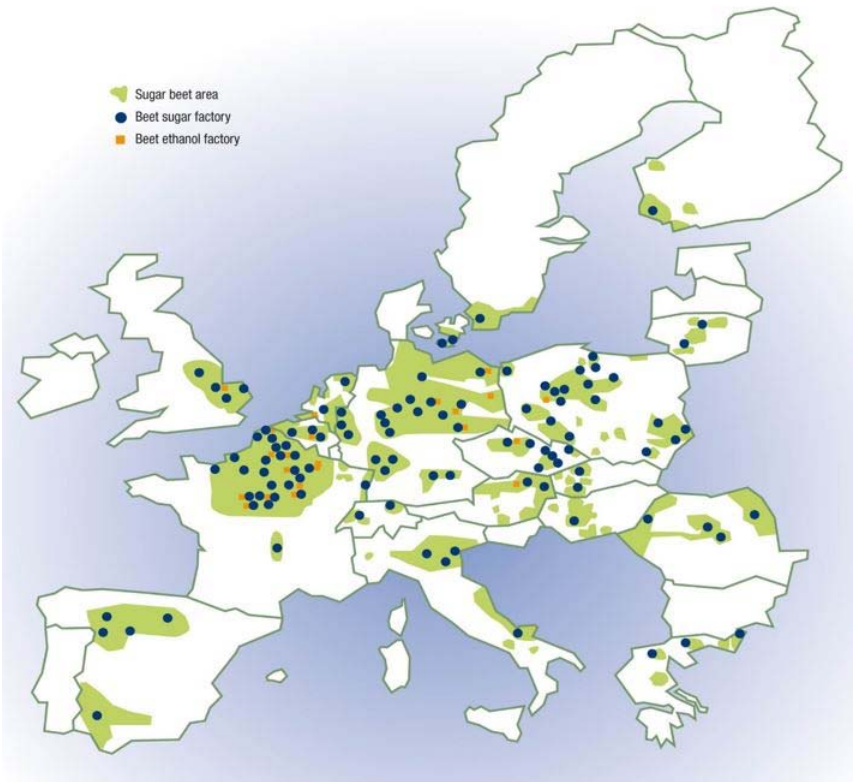

Figure 17. Sugar beet sector in the European Union (source: http://www.cibe-europe.eu).

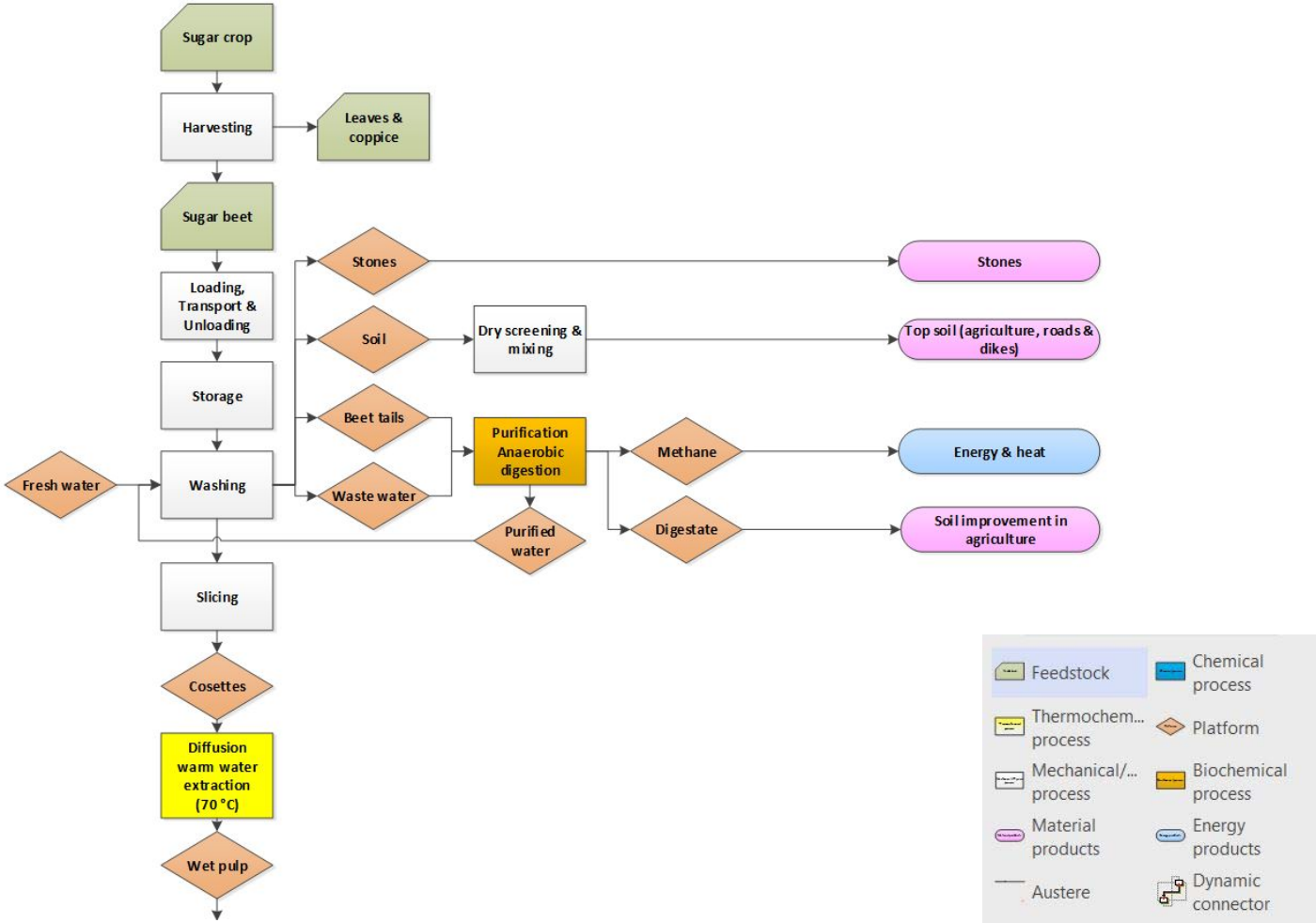

Figure 18. Process flow diagram of the first part of the sugar sector.

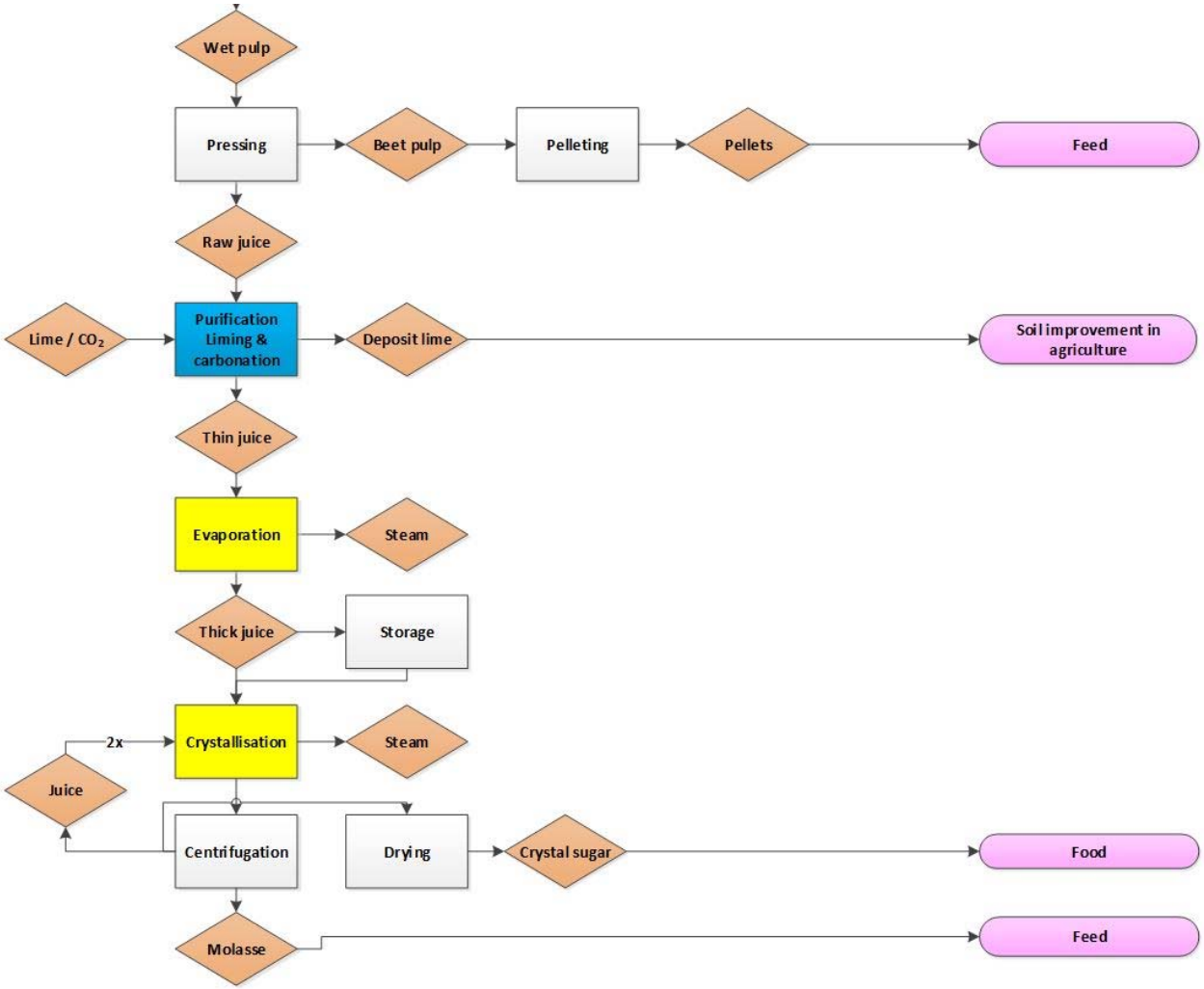

Figure 19. Process flow diagram of the second part of the sugar sector.

Table 14 provides a cross-country analysis for the sugar sector in view of its potential for integration with IBLC concepts.

Table 14. Summary sector sugar.

Sector Sugar	
	Profile
Production	• EU is the world's leading producer of sugar from sugar beet, with around 50 % of the total in yielded tons. Most of the EU's sugar beet is grown in Northern Europe where the climate is more suited to growing beet. The most competitive producing areas are in northern France, Germany, United Kingdom and Poland. • Depending on the size and the structure of the processing factory, a sugar beet processing plant is operational for 100 days per year (length of the beet campaign depends on the time between the first harvest and the first frost period). During this period, the total yield of sugar beet is processed into crystal sugar and molasses. • Sugar production starts in the field with the sugar beets and ends with a diversity of products: sugar products, feed products (molasses, beet pulp), lime, stones, soil and waste water. • A tonne of sugar beets yields 14-18 % of sugar, depending on the variety and the growing conditions.
Volume of the sector	• Sugar beet producing countries in EU, 2016 (acreage / % of EU total sugar beet acreage / sugar beet production / production white sugar) (EUROSTAT, 2017; UCAB, 2017; UBFME, 2017):

	Acreage ('000ha)	Share in EU sugar beet acreage	Sugar beet production ('000t)	Production white sugar ('000t)
EU-28	1,411	100 %	141,094	n.a.
Share in production:				
France	405	27 %	46,257	n.a.
Germany	335	22 %	34,060	n.a.
Poland	206	14 %	14,040	n.a.
UK	86	6 %	9,000	n.a.
Netherlands	71	5 %	7,959	n.a.
Ukraine	292	-	12,000	1,700
Serbia	49	-	2,684	626

State of the sector	• There is a strong interdependence between the sugar processing industry and the farming sector. Sugar factories contract farmers directly to supply sugar beets to their factory. Farm-gate prices for sugar beet and competition from other crops affect the farmers' commitment to grow sugar beet. Well performance by the sugar industry in an open global

	market is important for the overall performance and continuance of the entire sugar supply chain. • Until October 2017 the EU market for sugar beets had been regulated for 50 years with quotas and minimum prices. With the expiration of the EU regulation the sector's performance has been under pressure in the past years. Effects of the ending of the EU quota regime may have uncertain price effects on the sector and on the industry. Uncertainty about the price responses in the markets, as well as about the farming sector's response across Europe may affect the overall performance in the supply chain. • Global demand for sugar products is expected to grow, even though in some regions demand may decrease.
Typical size of the companies	• European industry for processing sugar beet is generally large scale with in some countries single large industries such as: Nordzucker, Tereos France, Hellenic Sugar Industry, Suiker Unie and British Sugar. • In Serbia the sector is dominated by medium and large sugar producers (7 sugar plants in total).
Distinctive facilities of the sector	• The sugar beet processing is a seasonal activity (3-5 months). However, for the large scale sugar industries sugar refinery is a year-round process. • Facilities and equipment that are used for sugar beet processing may be suitable and available for IBLC activities, incl. storage areas, feedstock handling, driers / evaporators, and pelletisers. • In countries where sugar beet processing facilities are idle part of the year, there are good leads to further examine the possibilities for combining sugar industries with IBLC activities.
Degree of innovation	• The sugar industry is generally a mature industry. Innovation in sugar beet processing is primarily focused on increasing energy efficiency, although research and innovation in agronomic features of sugar beet cultivation has ample attention as well. • Energy efficiency of the processing factories also concerns the clean and sustainable fuelling of the processes, as is the case in Serbia where coal is still an important (cheap) energy resource. • Sugar processing industries in the northwest European countries are open to innovation in biobased processes and products, if it will strengthen their core business activities.
Miscellaneous	• The availability and price of sugar beet, as well as the LCA-comparison between sugar beet refinery and other competing crops (such as wheat) into biobased products influences the competitiveness of sugar beets as feedstock for biobased refinery.
	Opportunities for IBLCs
Sector related residues	• A ton of sugar beet (when including the leaves and coppice an extra 490 kg would be added) yields on average 14 % of its mass in granulated sugar

	(140 kg). The remainder consists of residues and by-products, incl. beet tails, soil, stones, water, molasses, beet pulp and deposit lime (Harmsen et al., 2014) • Applications of beet pulp are in energy production (biogas, solid biofuels), animal feed and paper. • The sugar industry's biomass residues are entirely used, mainly for animal feed.
Potential synergies & benefits	• Sugar beet processing capacity is idle for considerable part of the year (6-8 months, mid January until mid-September). • It is, however, unclear in how far this equipment is suitable and available for processing of other biomass. • In addition, the large scale capacity of the sugar beet processing lines will require equal scale of flows for other biomass feedstock. Some small-scale parts of the production line may be suitable. • Residues from sugar beet processing are all used, mainly for animal feeding and in bioenergy production. • Potential to use residues in the production of bioethanol or biogas creates alternatives for higher valorisation. • Same line of reasoning for use of sugar as feedstock in bioplastics and polymers. • Creating synergies with alternative biorefinery processing routes will create less dependence on fluctuating food markets and may strengthen the business case of the sugar beet crop.
Market developments	• It is difficult to predict how the abandoning of the quota regime will affect other (larger) sugar beet producing countries. The lifting of the quota regime may very well lead to a decrease of the sugar beet acreage in countries such as Serbia. • Sugar industries have an open innovative attitude towards finding alternative processing routes for sugar beet feedstock and its residues (such as for the production of PLA in bioplastics, platform chemicals). • However, generally the sugar industry's biomass residues are entirely used, mainly for animal feed. • Volatility of the sugar price makes it difficult to develop a business case for alternative processing. On the other hand, alternative processing of sugar feedstock may lead to new markets and niches that can strengthen the overall business case. • Currently beet leaves are left in the field and are not further processed. The fact that this is a biomass resource with a substantial volume (40 t/ha, 5 t DM/ha), and because it has a potential purpose as feedstock for food (Rubsico protein), feed and energy (biogas), sugar beet leaves may be interesting for further investigation.

Non-technical barriers	• The large scale sugar processing companies and the concentration of production in only three sugar beet producing countries (France, Germany and Poland) may very well lead to a monopolistic structure. • The industry may not be very open and is rather cautious towards other stakeholders as the margins are small and are yearly fluctuating with the beet price.

Table 15. Traffic light analysis for sector sugar.

IBLC feasibility for sector sugar						
	Spain	Greece	Sweden	Ukraine	Serbia	Average
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 15 presents the traffic light analysis expressing the suitability of the sugar sector for establishing an IBLC, either as contributor of (sector related) agro-residues and/or of capacities for processing biomass. Based on the traffic light analysis the following observations were summarised:

- In the countries that were investigated, the volume of the sugar sector is evaluated from medium (7.400 ha in Greece) to large (32,000 ha in Sweden and 49,000 ha in Serbia) and very large (292,000 ha in the Ukraine). In general, the sector is valued as adequately sized as starting point for setting up IBLCs.
- The state of the sector and also the typical size of the companies give a less favourable impression, especially for the sugar sectors in Greece and Sweden. The state of the sugar sector is reflected in the price uncertainty that is the result of the abolition of the EU quota regime for sugar and sugar beets (2017). Remember that many of the judgments in the

traffic light analysis (e.g. healthy/unhealthy) are qualitative and thus no exact figures can be given here.

- In the case for both Greece and Sweden few companies of suitable size are expected to be eligible as IBLC. This is due to the fact that the sugar sector (as in many other European countries) is dominated by very few or even one sugar producing company.
- The availability of distinctive facilities is generally considered medium, in which only a few facilities in the sugar chain are available and suitable for the processing of biomass residues. This is, however, hardly the case for Sweden (only one facility) whereas Ukraine has interpreted the availability of a wider range of facilities to be available.
- The degree of innovation in the sugar sector shows a rather mixed picture for the different countries. Both Greece and Ukraine have indicated low innovation levels in the sugar sector, while Sweden and Serbia indicate high levels of innovation. For Sweden, representing one of the largest sugar industries in Northwest-Europe, this particularly applies to innovation into alternative applications of residues from sugar beet processing in biobased products.
- The availability of sector related residues is for most countries medium, except for the sugar sector in Sweden. Here large volumes are considered to be available for processing in IBLCs.
- Synergies and benefits from combining sugar beet processing activities with biomass processing activities in an IBLC are expected to be many in the cases of Sweden and Serbia. In general, these two countries have a more positive attitude when it comes to the potential of the sugar sector in combination with IBLC activities.
- This is not the case for the Greek sugar sector that sees limited market opportunities for IBLC at this moment. Although Ukrainian sugar sector sees some good market opportunities, it considers non-technical barriers to be an obstacle that is difficult to overcome, which predominantly concerns the cautious attitude of the industry and their focus on becoming self-sufficient in the manufacturing of sugar.

General conclusions: In some European countries the sugar industry is considered as one of the most innovating agro-industries in the field of bio-refinery and biobased products. The analysis of the sector that was done for the 4 countries in this study shows, however, an outcome that the sector's suitability is characterised as medium to poor. An aspect that cannot be ignored is the recent change in the EU quota regime that has raised uncertainty within the sector of market prices and revenues within the sugar chain (for both sugar beet growers and processing industries). This may perhaps have changed once the transition to a market regime will be completed by the industries and their suppliers. But given its potential as an important European large scale agro-industry and its innovating potential in bio-refinery it is worthwhile to further investigate the feasibility of IBLCs in the sugar sector on a case-by-case basis.

4 OVERALL CONCLUSIONS

The average traffic light values if the six sectors are given in Table 16. This leads to some overall conclusions per sector.

Table 16. Traffic light analysis for the six sectors.

IBLC feasibility per sector						
	Vegetable oil	Olive oil mills	Feed & fodder	Wine	Grain	Sugar
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Vegetable oil

For all assessment categories the values for the vegetable oil extraction sector vary a lot between the countries. The analysis indicates that the vegetable oil extraction sector in general does not have many opportunities for establishing IBLCs. Although the sector has large volumes of residues, it only has a few synergies & benefits, only some market opportunities but rather uncertain and serious non-technical barriers with limited perspective to overcome.

Olive oil mills

For all assessment categories the values for the olive oil mills sector vary only a bit between the two countries. The analysis indicates that the olive oil mills sector has many opportunities for establishing IBLCs since it has a very large volume of residues, many synergies & benefits and good market opportunities with promising perspective. The only problem is that there are serious non-technical barriers with limited perspective to overcome.

Feed & fodder

For all assessment categories the values for the feed and fodder sector vary between the four countries, but not very much. The assessment indicates that the feed and fodder sector has some but limited opportunities for establishing IBLCs, since it has only a low volume of residues (unless it uses residues from other sectors), some synergies & benefits and only a few good market opportunities that are rather uncertain. A positive point is that there are only small non-technical barriers that can be overcome.

Wine

Although some of the major wine producing countries such as France and Italy are not included in the sector review, it is fair to state that the conclusions from this study apply to some extent to most of the wine producing countries in the EU. Based on the different aspects on which the sector's overall suitability has been inventoried and evaluated by the researchers, the wine sector is considered to have sufficient basis for further research into the feasibility of establishing IBLCs. Most importantly this will include research into feasible solutions to overcome the logistical bottleneck, as well as into the proposition of a market portfolio that will provide a balance between low – and high value added products from the IBLC.

Grain

Based on the sector analysis the grain sector does not seem to provide a convincing basis for the establishing of IBLCs. However, the analysis also showed that there are large differences between countries of the sector's suitability. The analysis of the grain sector in Ukraine and Sweden indicated a good basis for setting up IBLC activities both from production and market point of view, while the analysis of the grain sectors in Spain and Greece showed less favourable conditions. Given the fact that the grain sector is an important contributing sector in European (and global) agriculture, it is advisable to investigate the feasibility of establishing IBLCs in connection with the grain sector in those countries that have a sufficient starting point (amongst which the availability of feedstock and facilities, market perspective, business awareness, governmental support, etc.).

Sugar

In some European countries, the sugar industry is considered as one of the more innovating agro-industries in the field of bio-refinery and biobased products. The analysis of the sector that was done for 4 countries in this study shows, however, an outcome that the sector's suitability is characterised as medium to poor. An aspect that cannot be ignored is the recent change in the EU quota regime that has raised uncertainty within the sector of market prices and revenues within the sugar chain (for both sugar beet growers and processing industries). This may perhaps have changed once the transition to a market regime will be completed by the industries and their suppliers. But given its potential as an important European large scale agro-industry and its innovating potential in bio-refinery it is worthwhile to further investigate the feasibility of IBLCs in the sugar sector on a case-by-case basis.

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6 Annex A. Overview of supporting country reports

The supporting country reports have been published as separate deliverables with the following numbers:

D6.2.1. Country report Spain - SPANISH CO-OPS

D6.2.2. Country report Greece - CERTH

D6.2.3. Country report Sweden - RISE and Lantmännen

D6.2.4 Country report Ukraine - UCAB

D6.2.5 Country report Serbia - UBFME

D6.2.6 European view - AESA

7 Annex B. Traffic light analysis per country

The traffic light analysis was performed by each individual country. The explanation of the colours for the various categories can be found in section 2.1.6 in Table 3.

Table 17. Integrated traffic light analysis for the six sectors for Spain (Sugar not covered).

IBLC feasibility per sector						
	Vegetable oil	Olive oil and olive pomace oil	Feed & fodder	Wine	Grain	Sugar
	Sector Profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 18. Integrated traffic light analysis for the six sectors for Greece (Feed & fodder not covered).

IBLC feasibility per sector						
	Vegetable oil	Olive oil mills	Feed & fodder	Wine	Grain	Sugar
	Sector Profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 19. Integrated traffic light analysis for the six sectors for Sweden (olive oil and wine not covered).

IBLC feasibility per sector						
	Vegetable oil	Olive oil mills	Feed & fodder	Wine	Grain	Sugar
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 20. Integrated traffic light analysis for the six sectors for Ukraine (olive oil and wine not covered).

IBLC feasibility per sector						
	Vegetable oil	Olive oil mills	Feed & fodder	Wine	Grain	Sugar
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

Table 21. Integrated traffic light analysis for the six sectors for Serbia (olive oil not covered).

IBLC feasibility per sector						
	Vegetable oil	Olive oil mills	Feed & fodder	Wine	Grain	Sugar
	Sector profile					
Volume sector						
State sector						
Typical size companies						
Distinctive facilities sector						
Degree of innovation						
Miscellaneous						
	Opportunities for IBLCs					
Sector related residues						
Synergies & benefits						
Market developments						
Non-technical barriers						

AGROinLOG

INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors

D6.2.1 Country Report Spain

Project AGROinLOG "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe"
Grant agreement: 727961
From November 2016 to April 2020

Prepared by: SPANISH CO-OPS

Date: 07/05/2018

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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).

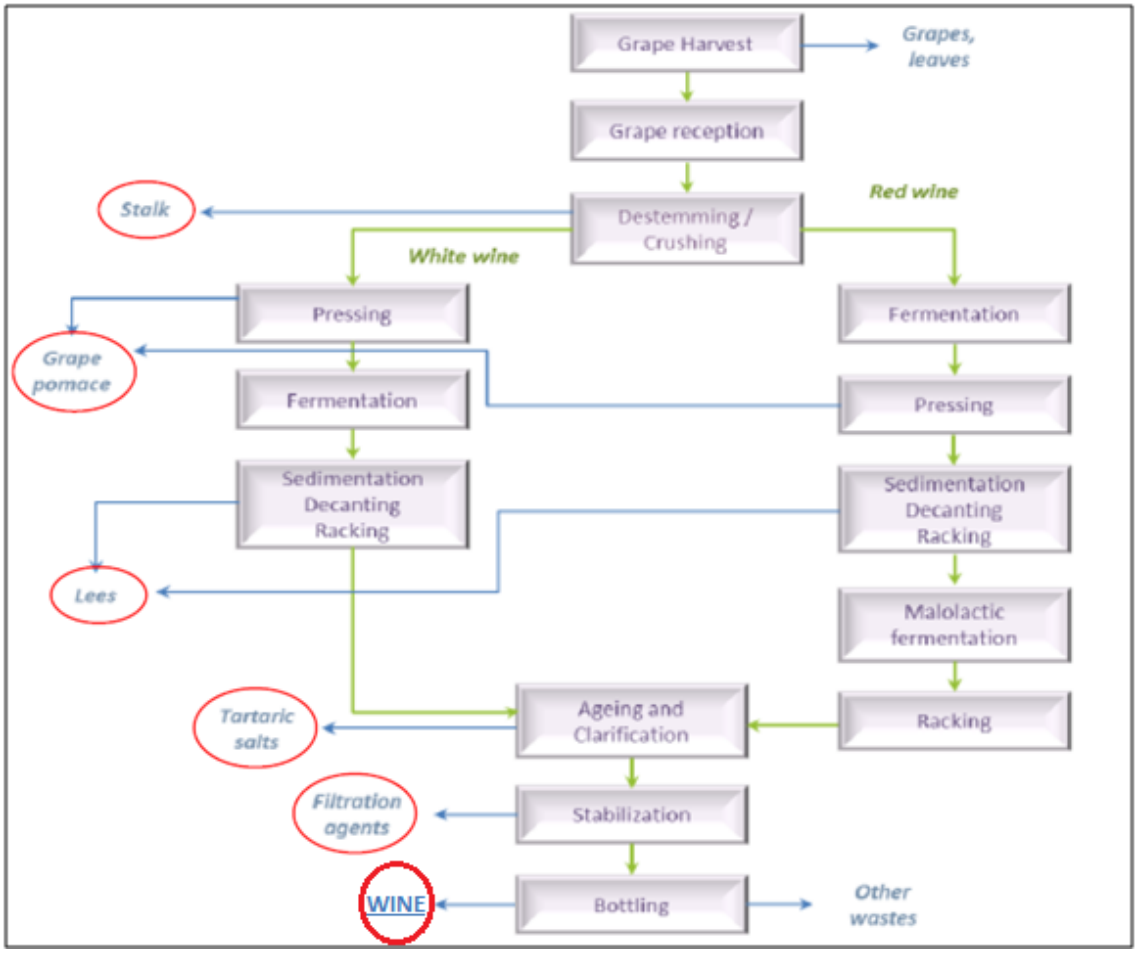

Figure 1. Wine production process residues and by-products generation. Source: UPM, 2017.

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.

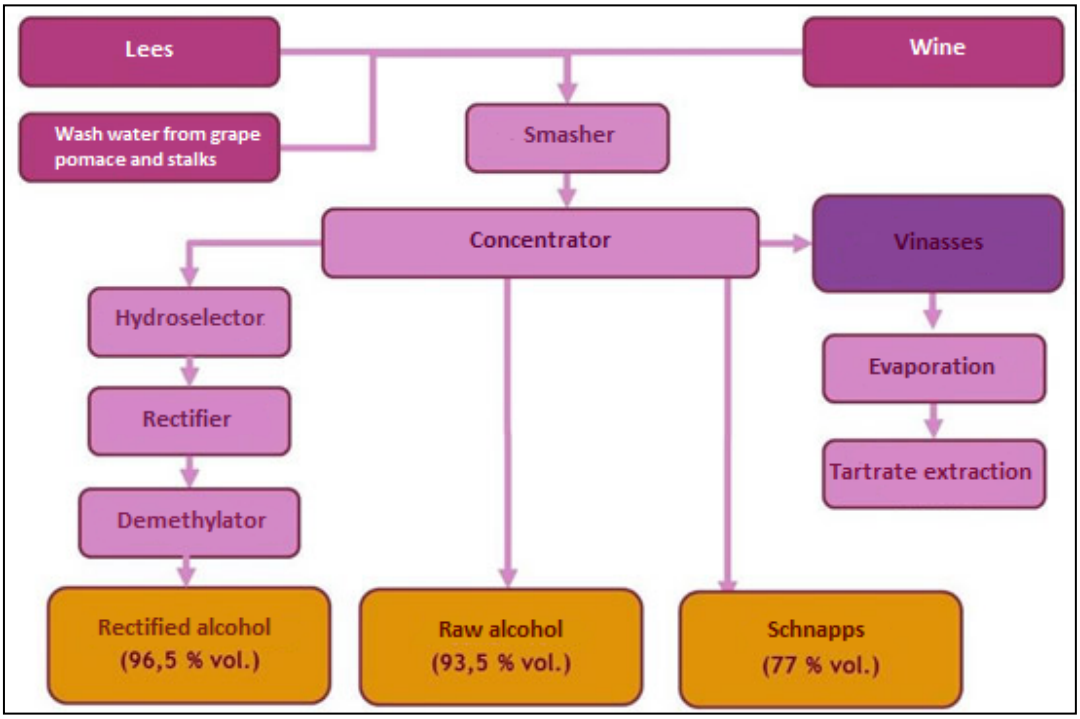

Figure 2. Distillation process. Source: Agralco S.C.L., 2017.

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].

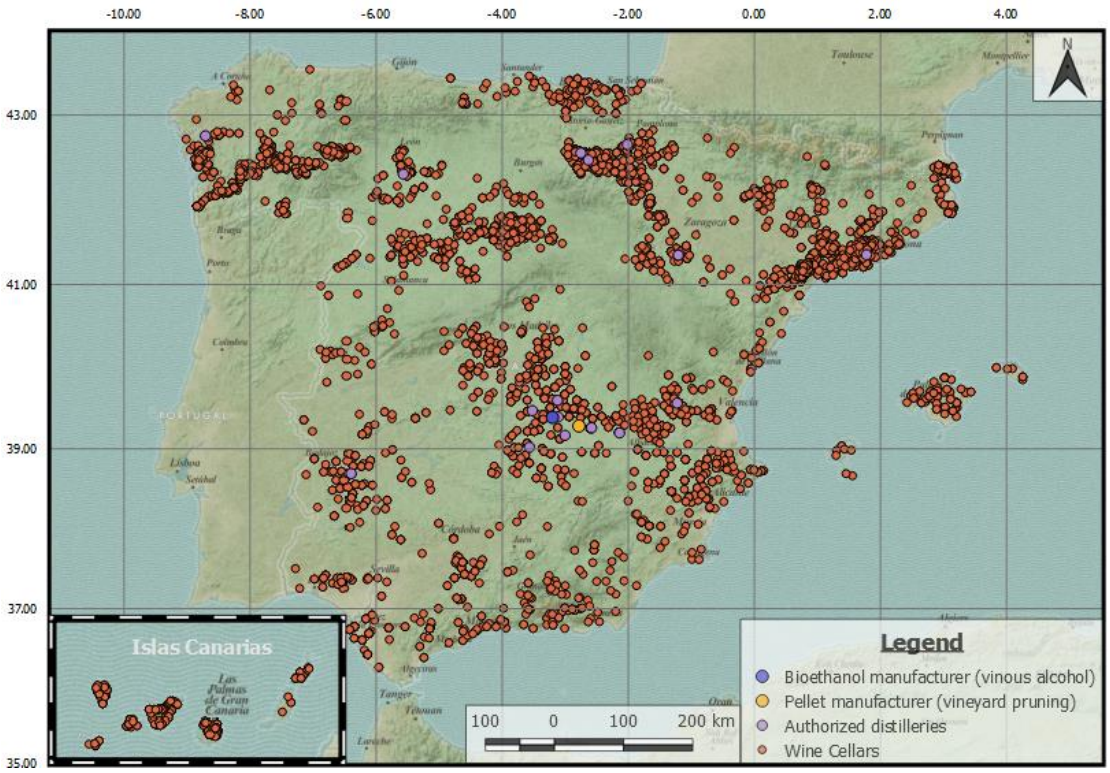

Figure 3. Locations of Spanish wine sector and related industries. Source: SPANISH CO-OPS (elaborated from Designations of Origin, 2017; AECOSAN, 2017; BioDieselSpain.com; 2017 and APPA, 2011/2017 data).

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.

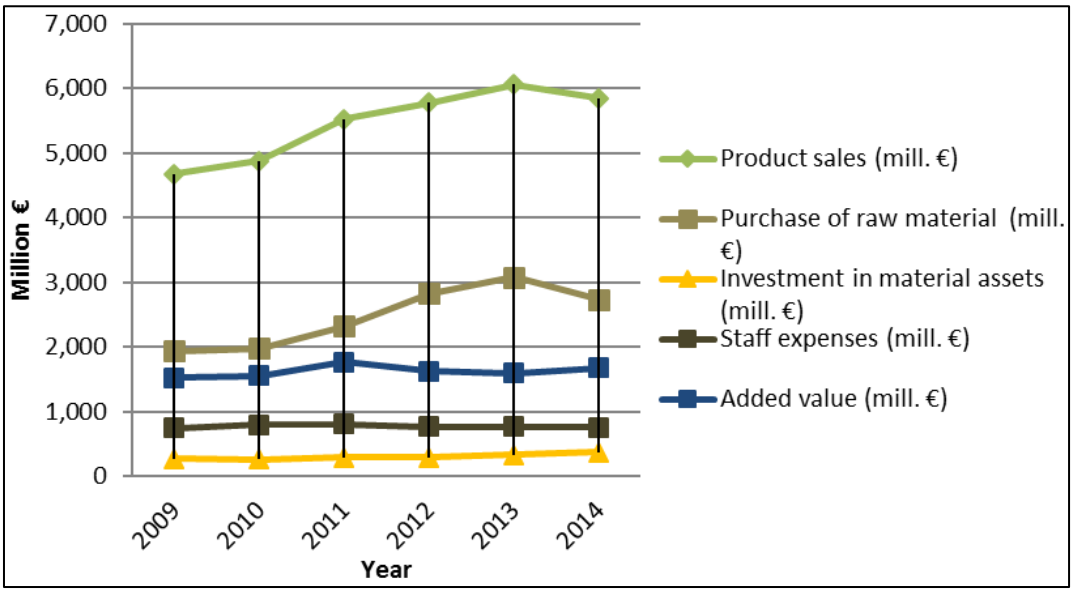

Figure 4. Wine sector industries financial features. Period 2009-2014. Source: SPANISH CO-OPS (elaborated from MAPAMA data, 2015).

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].

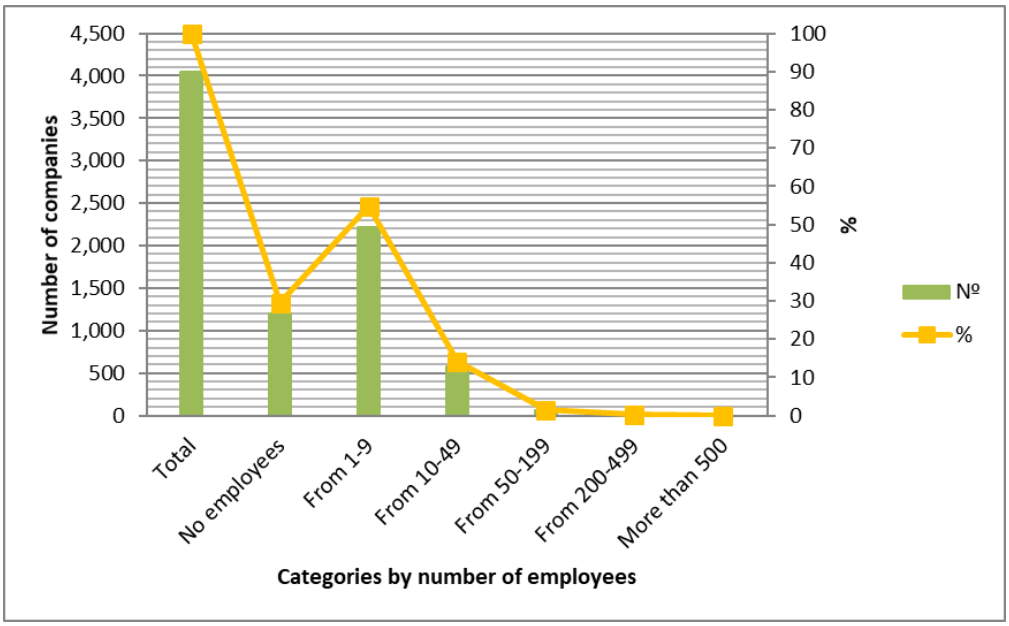

Figure 5. Typical size of wine sector companies (by number of employees). Source: MAPAMA, 2016.

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):

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
IDLE PERIOD OF TARGETED AGRO-INDUSTRIES												
Wine cellars												
Distilleries												
RESIDUES AVAILABILITY												
Vineyard prunings												
Distillery residues												
Cellar residues												
	Periods where facilities equipment or other compatible resources used to be idle											
	Periods when the biomass is produced by harvest or processing activities											
	Differences between regions are represented in striped box											

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

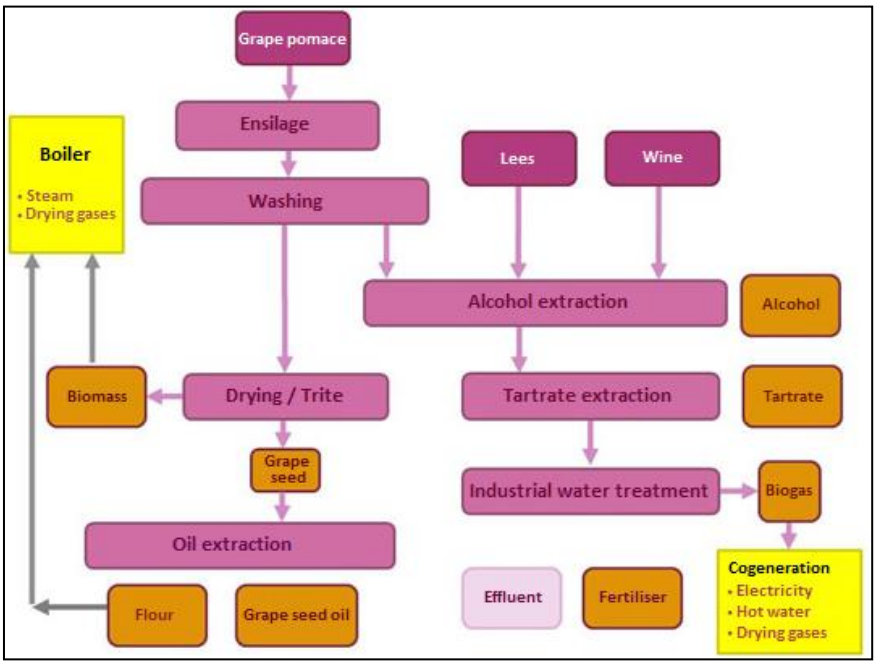

Figure 7. Residues and wine process of a Spanish cooperative distillery. Source: Agralco S.C.L, 2017.

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.

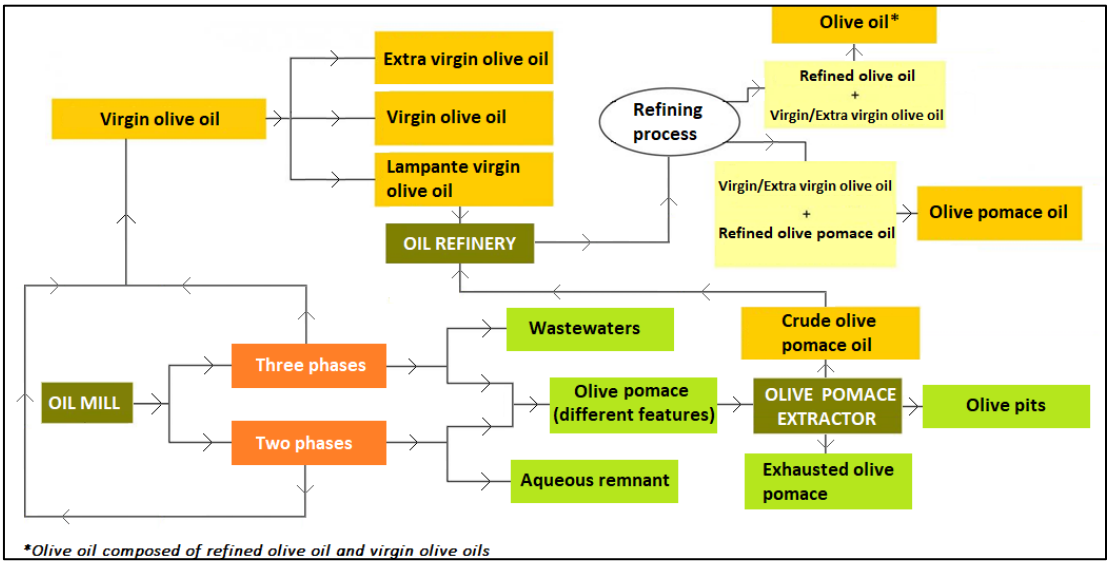

Figure 8. Olive oil production process. Source: SPANISH-COOPS, 2017.

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].

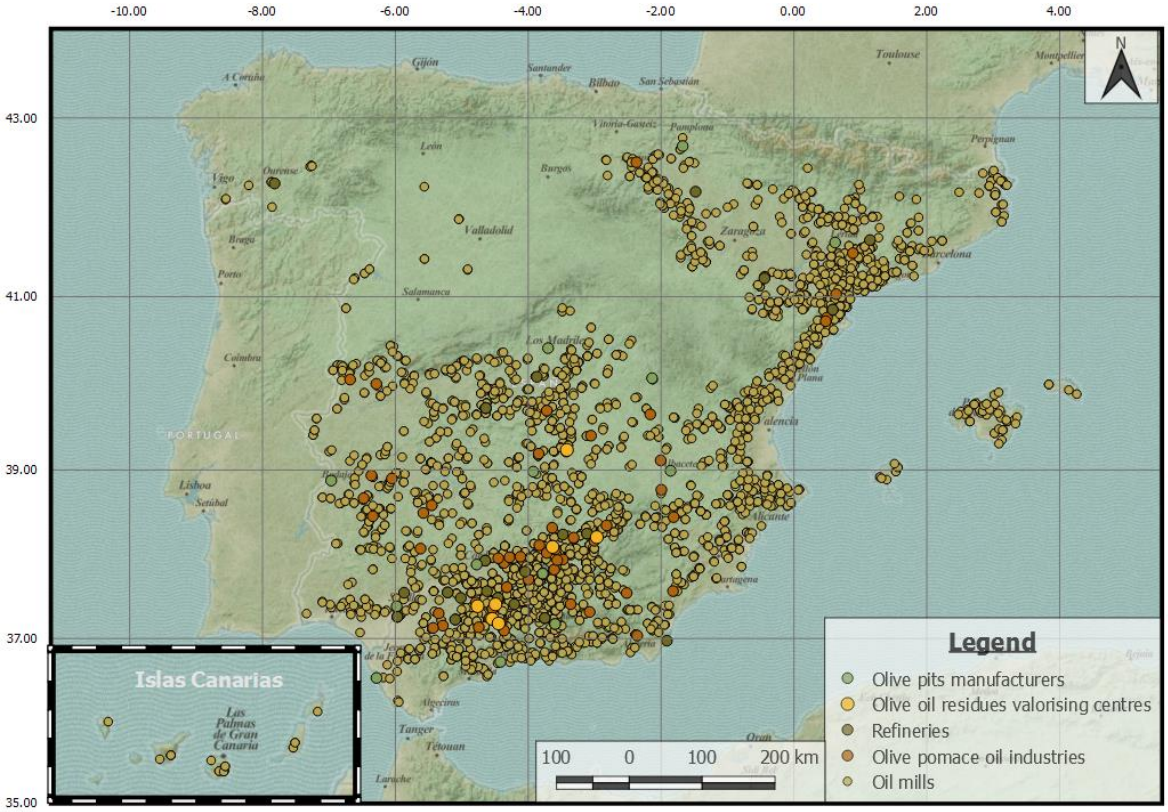

Figure 9. Location of Spanish olive oil sector and related industries. Source: SPANISH CO-OPS (elaborated from AICA, 2017; ANEO, 2017; AECOSAN, 2017; Expobiomasa, 2017 and APPA, 2011/2017 data.

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].

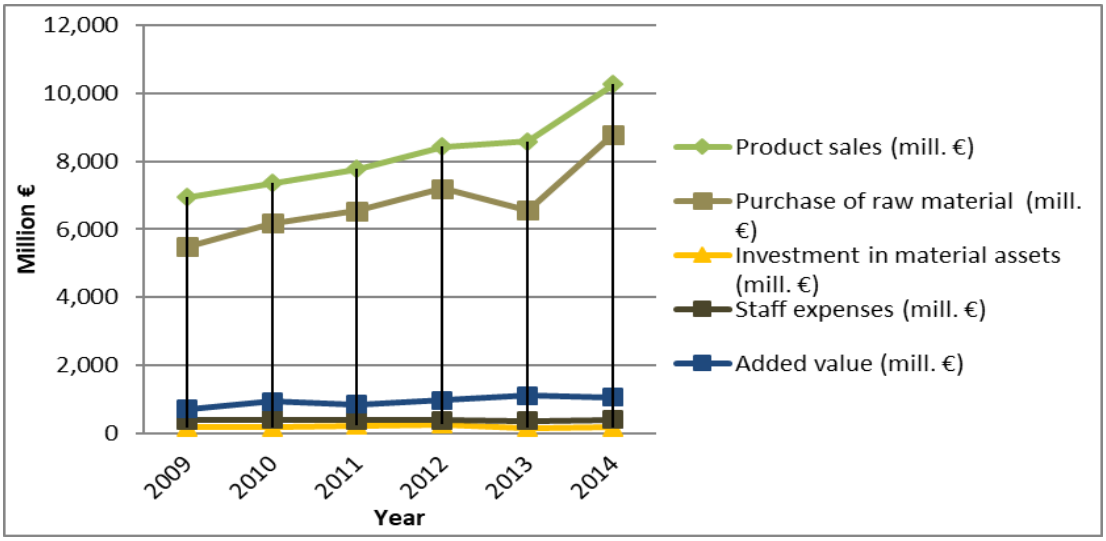

Figure 10. Fats and oils sector industries financial features. Period 2009-2014. Source: SPANISH CO-OPS (elaborated from MAPAMA data, 2015).

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.

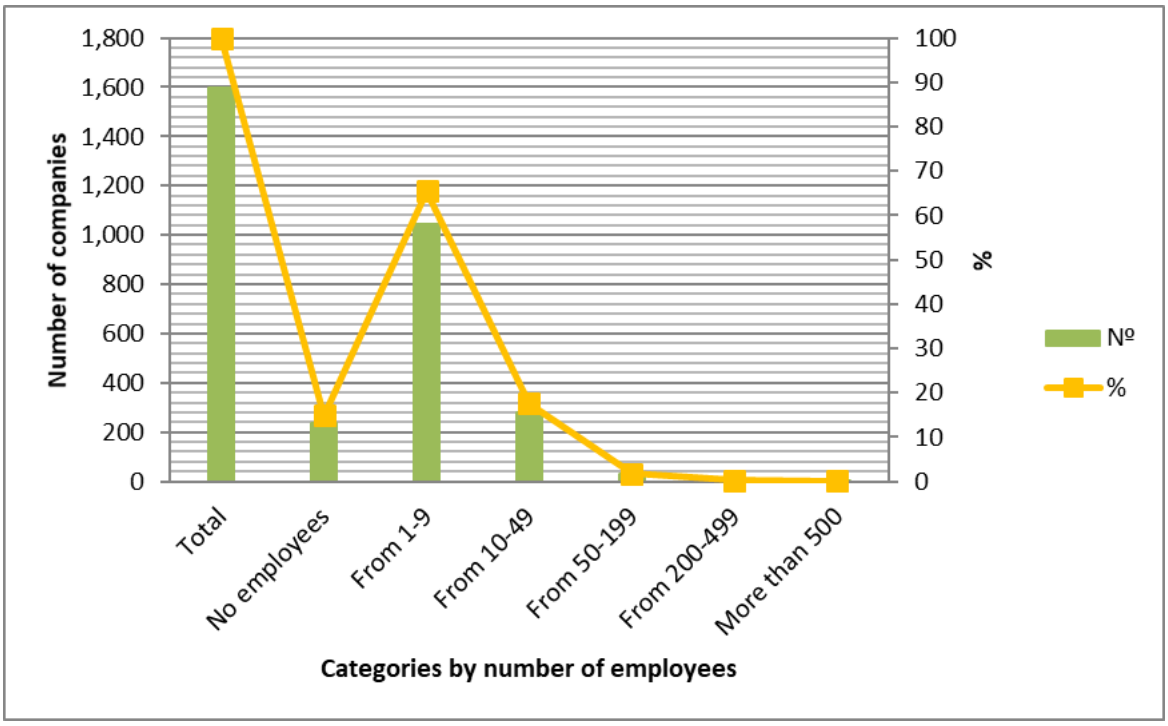

Figure 11. Typical size of fats and oils sector companies (by number of employees). Source: MAPAMA, 2016.

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.

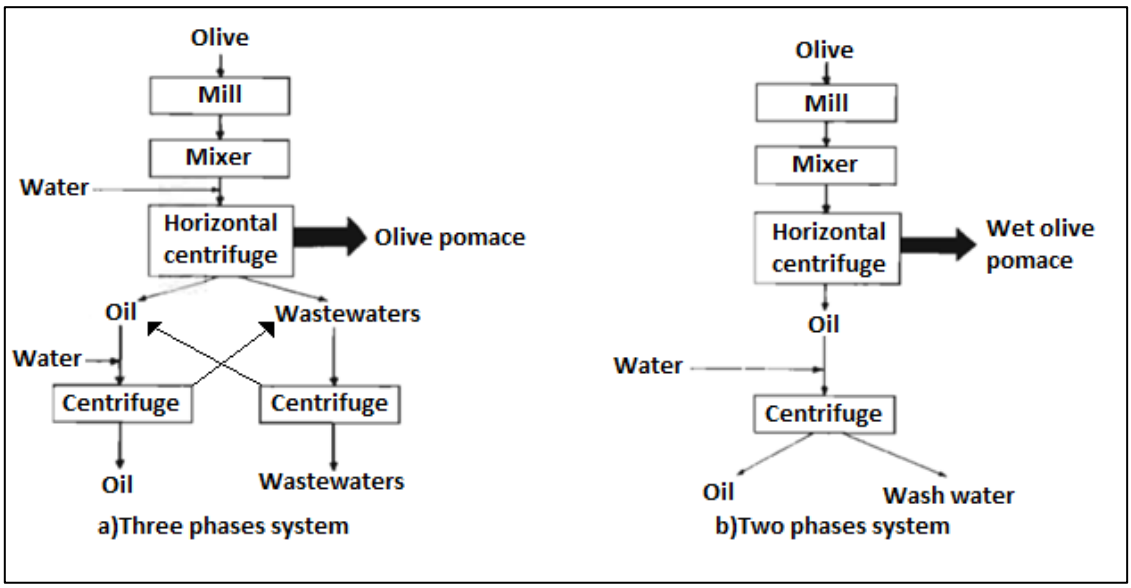

Figure 12. Comparison between three and two-phases systems. Source: Expoliva, 1993.

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):

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
IDLE PERIOD OF TARGETED AGRO-INDUSTRIES												
Oil mills												
Olive pomace oil industry												
RESIDUES AVAILABILITY												
Olive prunings												
Olive leaves												
Wastewater												
TPOMW												
Olive pits												
Exhausted olive pomace												
	Periods where facilities equipment or other compatible resources used to be idle											
	Periods when the biomass is produced by harvest or processing activities											
	Differences between regions are represented in striped box											

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].

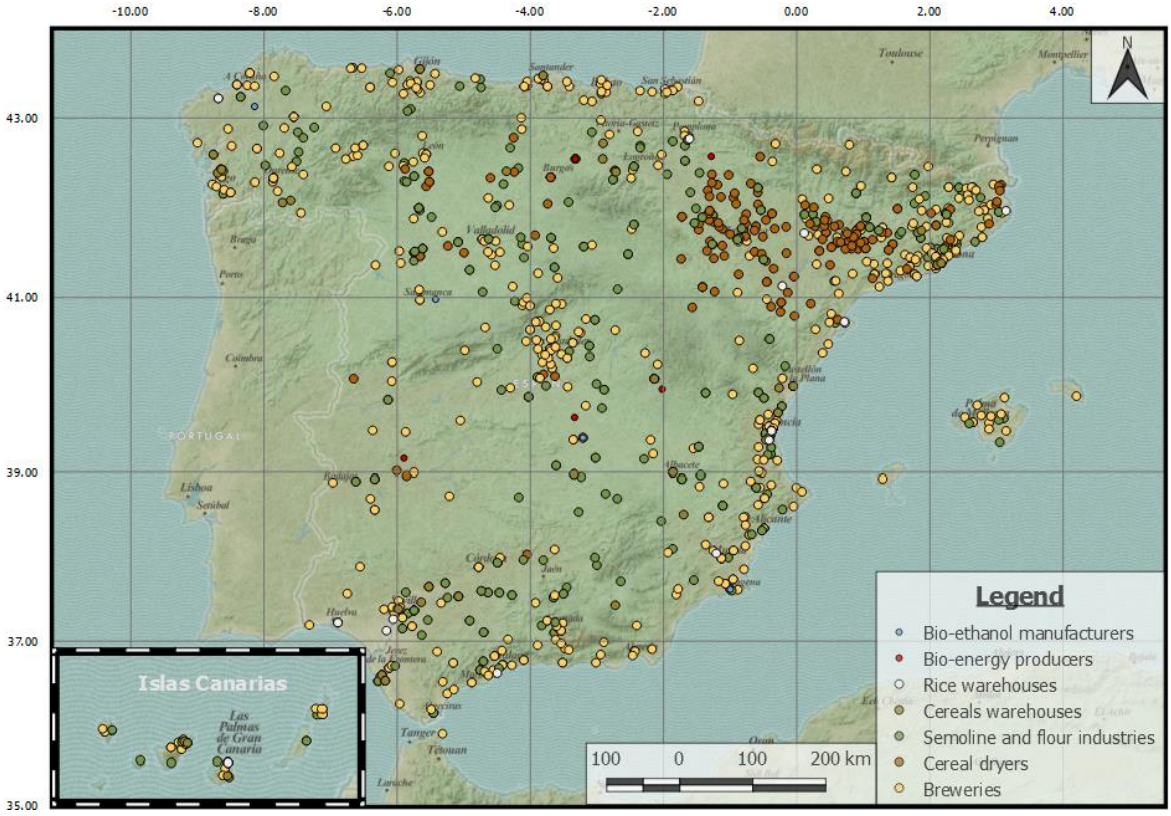

Figure 14. Location of Spanish grain chain sector and related industries. Source: SPANISH CO-OPS (elaborated from APPA, 2011/2017; Cerveceros de España, 2017; AECOSAN, 2017 and AFHSE, 2017 data).

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.

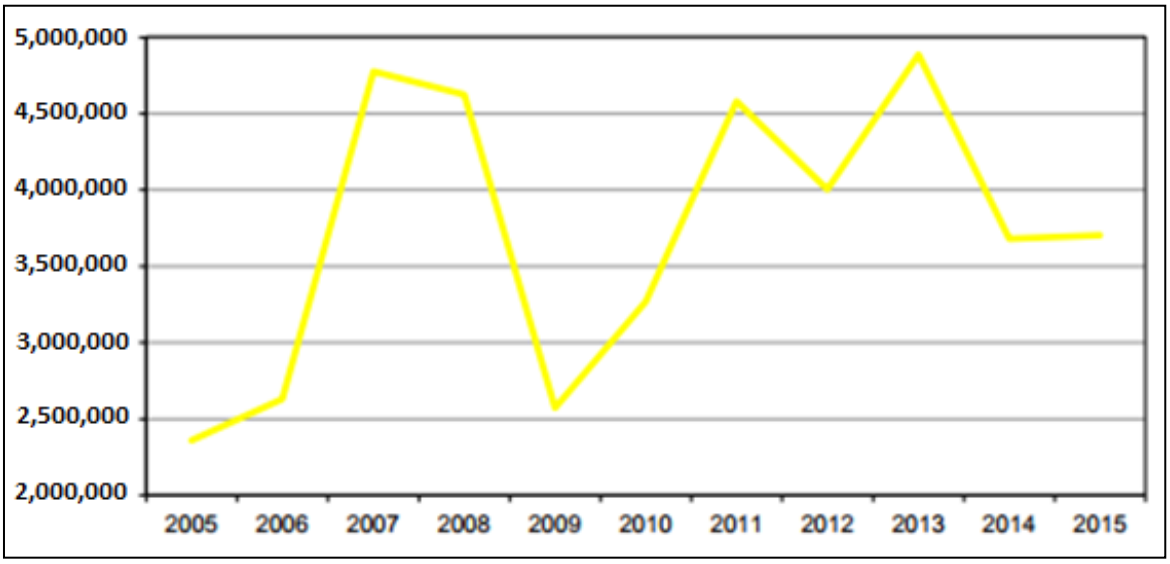

Figure 15. Grain cereal value evolution. Source: MAPAMA, 2017.

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).

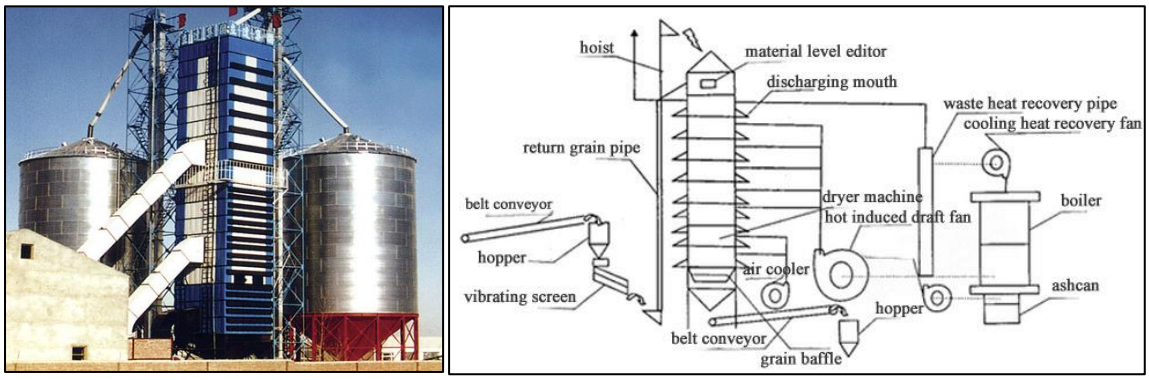

Figure 16. Grain dryer and storage silo. Source: Kefan, 2017.

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.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
IDLE PERIOD OF AGRO-INDUSTRIES												
Cereal dryer												
Rice dryer												
Breweries												
RESIDUES AVAILABILITY												
Cereal straw												
Maize stalks												
Corn cobs												
Rice husks												
Bagasse												
	Periods where facilities equipment or other compatible resources used to be idle											
	Periods when the biomass is produced by harvest or processing activities											
	Differences between regions are represented in striped box											

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].

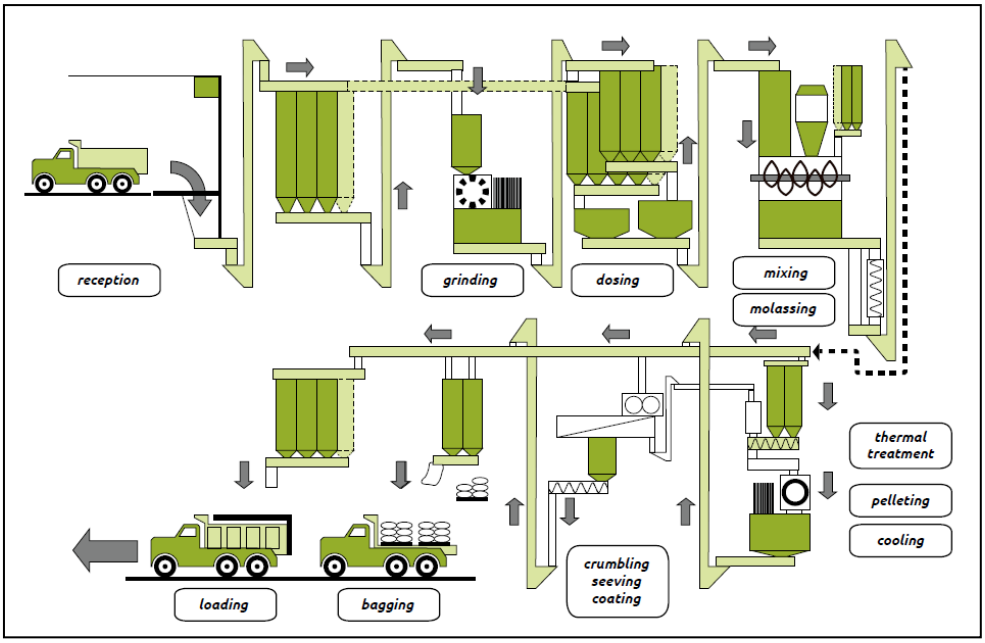

Figure 18. Pre-grinding process flow diagram of feed manufacturer industries. Source: Tesla, 2014.

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].

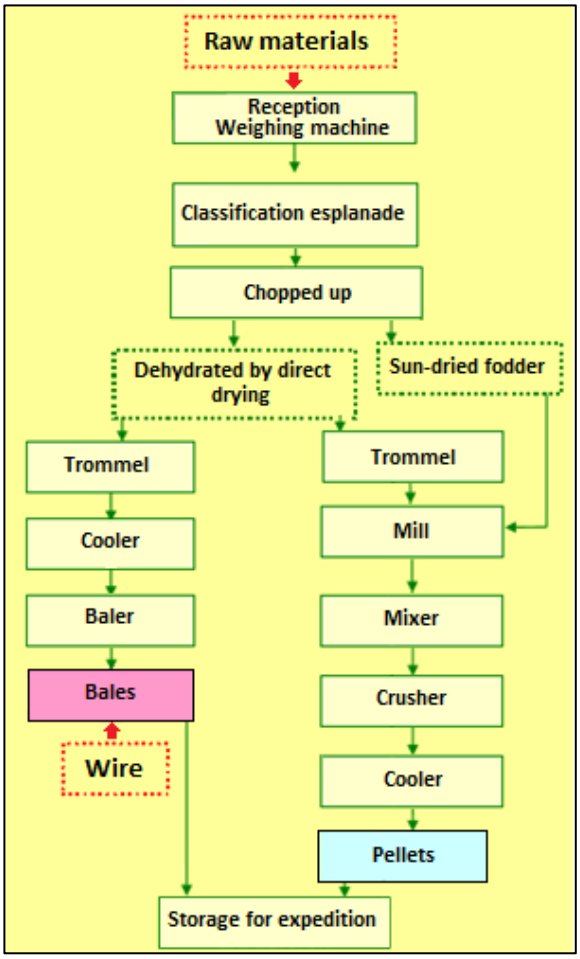

Figure 19. Process flow diagram of fodder dehydrator industries. Source: AEFA, 2013.

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].

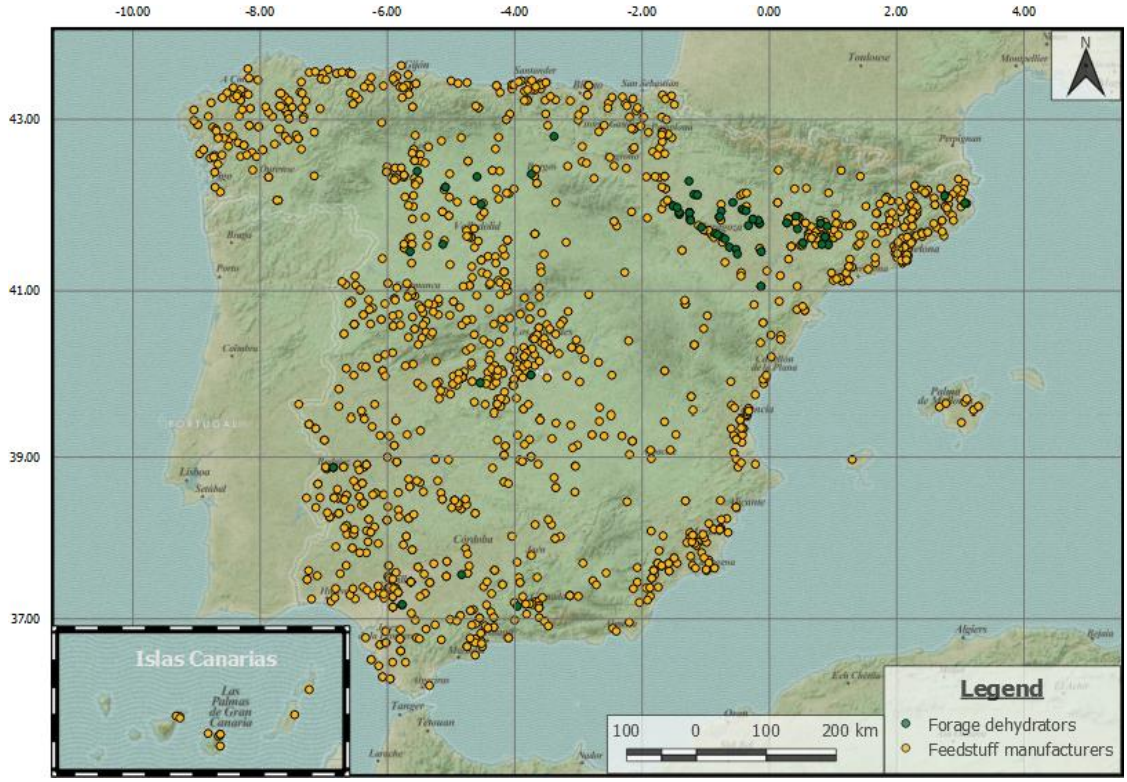

Figure 20. Location of Spanish feed and fodder sector industries. Source: SPANISH CO-OPS (elaborated from SILUM, 2017 and AEFA, 2017 data).

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.

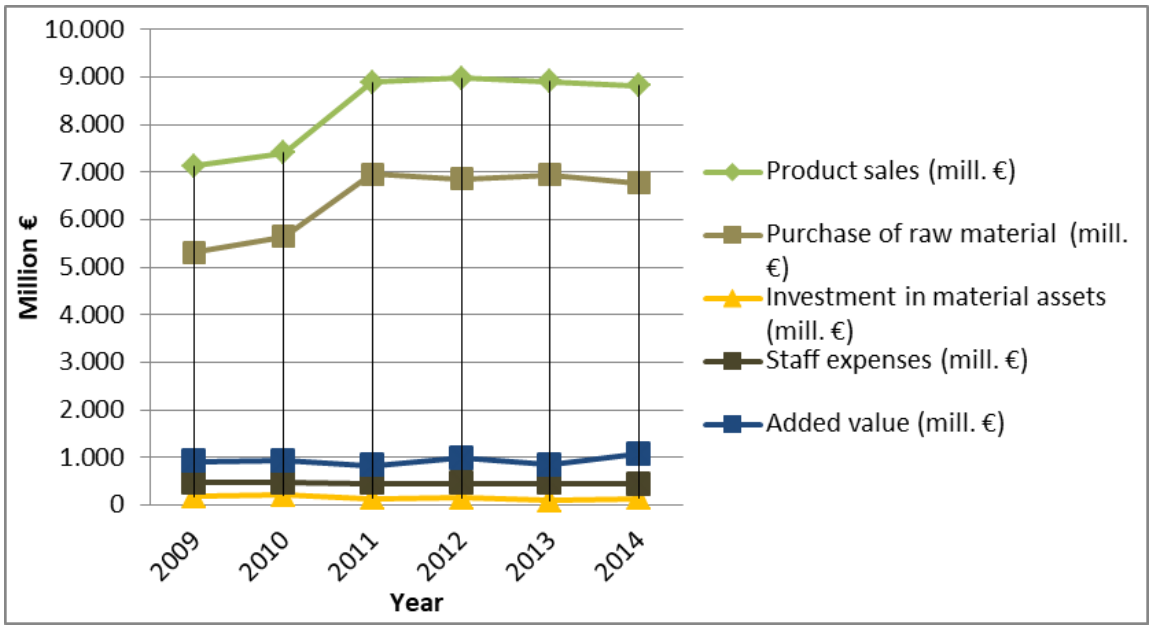

Figure 21. Animal feeding products industries financial features, period 2009-2014. Source: SPANISH CO-OPS (elaborated from MAPAMA data, 2015).

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).

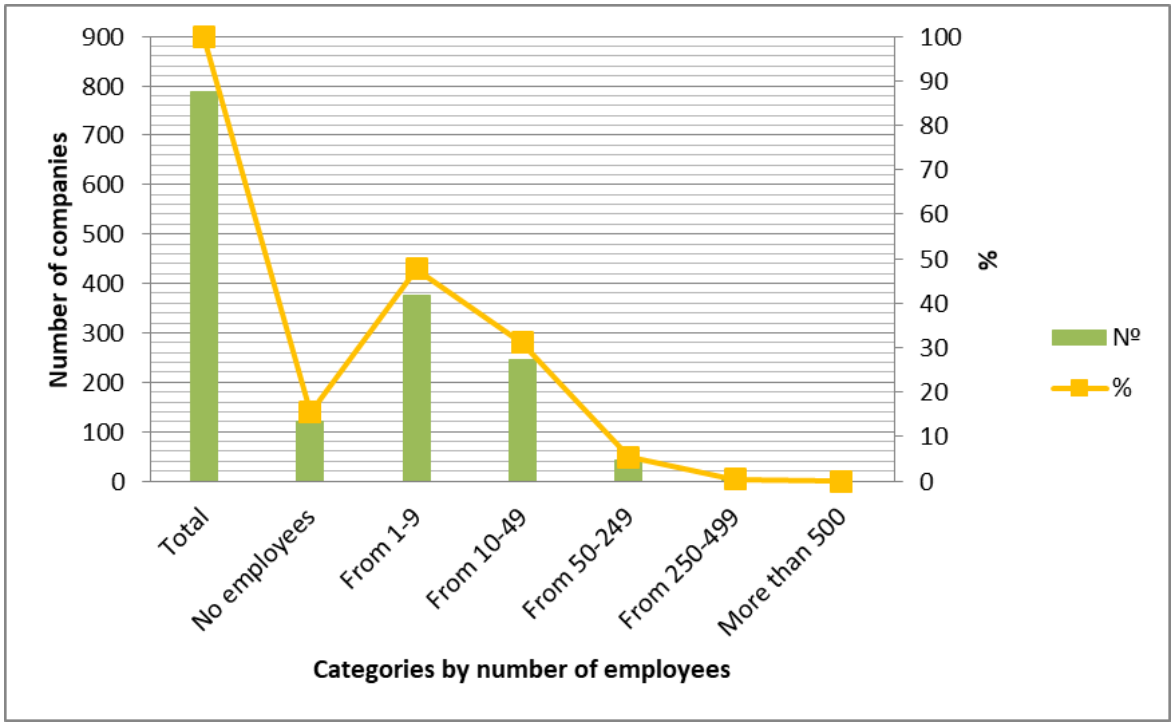

Figure 22. Typical size of animal feeding products industries (by number of employees). Source: MAPAMA, 2016.

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.

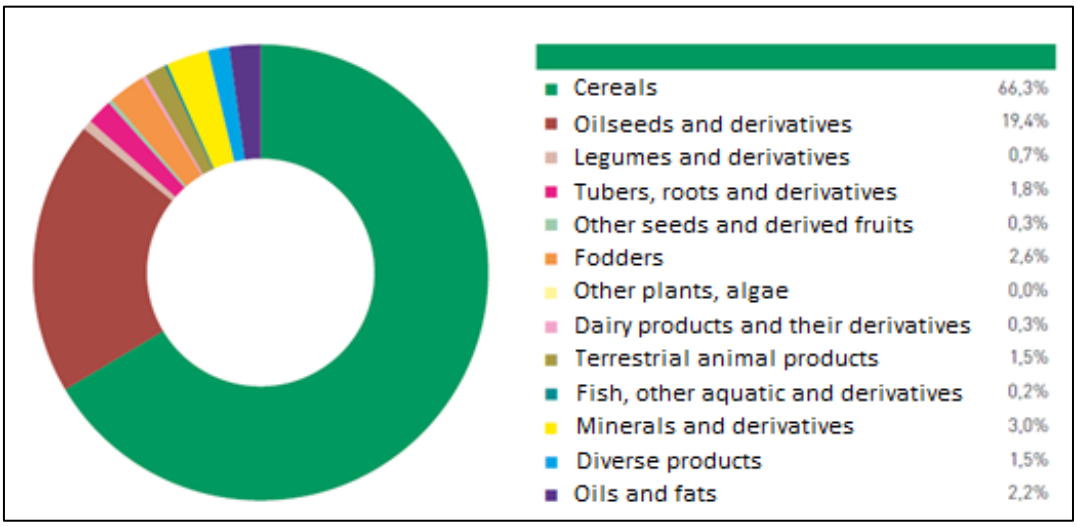

Figure 23. Raw material consumes in the animal feedstuff production, 2015. Source: CESFAC, 2016.

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												
	Periods where facilities equipment or other compatible resources used to be idle											
	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.

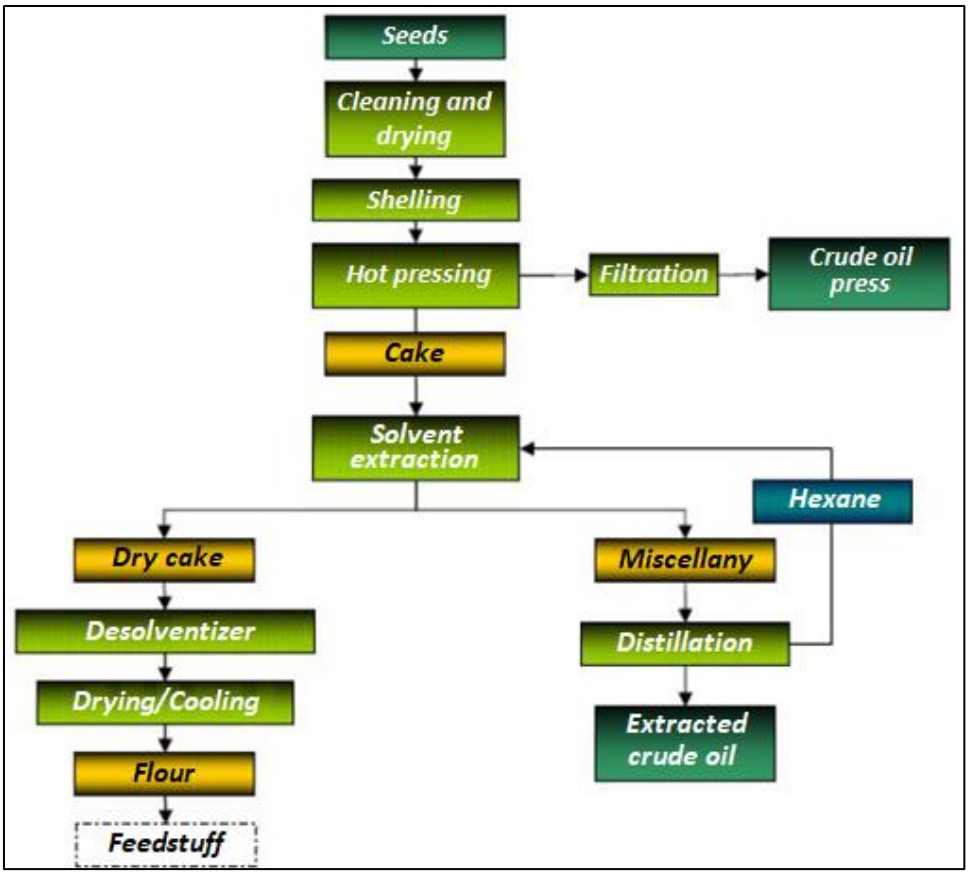

Figure 25. Process flow diagram of vegetable oil industries. Source: UPM, 2017.

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].

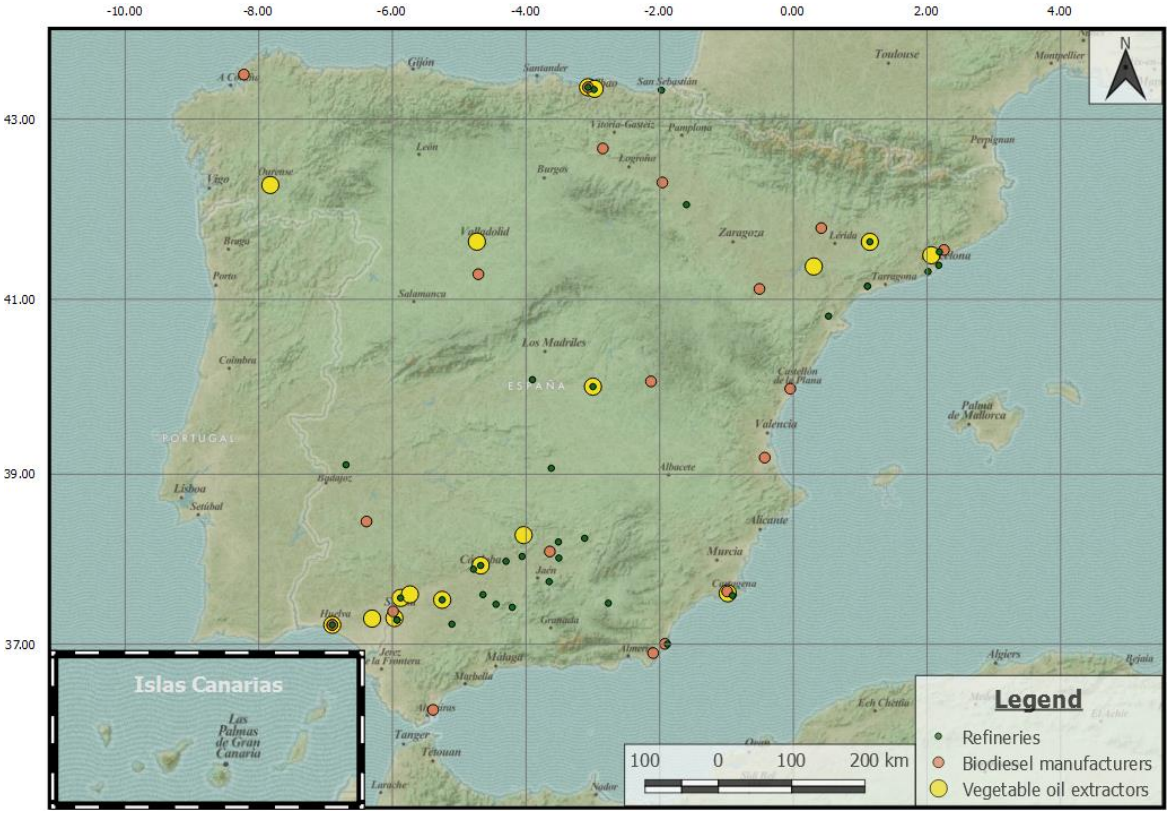

Figure 26. Location of Spanish oilseed sector and related industries. Source: SPANISH CO-OPS (elaborated from AECOSAN, 2017; APPA, 2011/2017 and AEFA, 2017 data).

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:

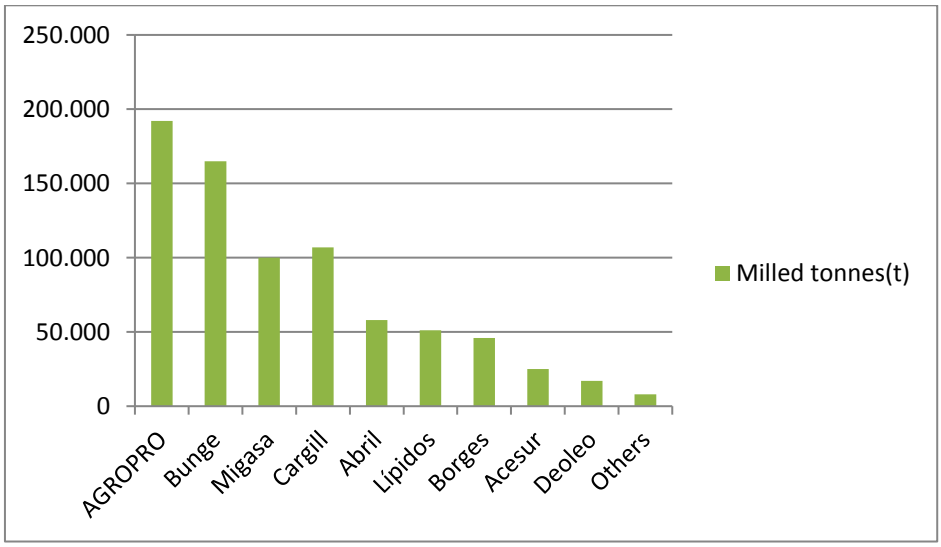

Figure 27. Main vegetable oil extractors (soy oil not included), 2017. Source: Interviews with sector professionals, 2017.

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												
	Periods where facilities equipment or other compatible resources used to be idle											
	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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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).

AGROinLOG

INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors

D6.2.1 Country report Greece

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ABBREVIATIONS

EBITDA: Earnings Before Interest, Taxes, Depreciation and Amortization

EBIT: Earnings Before Interest & Tax

GDP: Gross Domestic Product

ELSTAT: Hellenic Statistic Authority

HSI: Hellenic Sugar Industry

IBLC: Integrated biomass logistics centre

KEOSOE: Central Cooperative Union of Wine Products

OECD: Organisation For Economic Co-Operation and Development

OMWW: Olive Mill Waste Water

SPEL: Association of Olive Kernel Oil Producers of Greece

TPOMW: Two-phase 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

SCO-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

The current report investigates the following main agricultural sectors of the Greek economy: olive oil, sugar industry, wine industry, grain supply chain and the vegetable oil extraction. Each sector chapter consists of two main parts: i) general information on the sector, such as production process, productivities, current state of the sector and degree of innovation and ii) opportunities of the IBLC concept to be implemented on each sector/ existing agro-industries. IBLC is a concept that diversifies regular activity of the agro-industry on both the input (feedstock) and output (biocommodities, intermediates).

The olive oil and wine sectors are considered as the most important sectors for the Greek agricultural economy not only because of their annual production but also because of the vast amounts of by-products that both of them produce during their production process. These residues can be used as feedstock for the production of solid biofuels (e.g. pellets from olive or wine prunings), biochemicals from olive and wine by-products etc.

Furthermore, the sugar industry sector also generates residues and by-products, which can be used as biomass feedstock – primarily, sugar beet pellets and molasses. The first, in particular, is used as animal feed, whereas the second one is used as feedstock for the production of bioethanol. Unfortunately, it should be mentioned that the sugar industry in Greece faces many challenges considering its economic strength due to the economic crisis, thus, the quantities of the products and by-products have been decreased for the last years.

Both, the vegetable oil extraction sector and the grain chain sector, produce significant amounts of residues. These residues can be also used as feedstock for the production of solid biofuels (e.g. straw pellets, briquettes.). However, a large portion of these by-products is used as raw material for the feed and fodder sector or as bedding material. Another agricultural sector in Greece that could be investigated regarding the IBLC concept implementation is the feed and fodder. However, the scarcity of available statistical data and the difficulty to achieve communication with stakeholders from this sector, made unfeasible to analyse this sector on the current report.

For a more detailed summary on every sector, Chapter 7 “Summary analysis of the country” can be consulted, where all the information can be found.

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1 INTRODUCTION

The current report constitutes part of the AGROinLOG project "Demonstration of innovative integrated biomass logistics centers for the Agro-industry sector in Europe" (#727961) and is within the scope of the Task 6.2 "Basic analysis of targeted agricultural sectors". AGROinLOG supports the demonstration of Integrated Biomass Logistic Centres (IBLC) for food and non-food products, evaluating their technical, environmental and economic feasibility. This report aims at providing an overview of the current state of the sectors and evaluating them with respect to the IBLC related topics.

The following chains are considered in this report, due to their importance for the Greek agricultural economy, the volume of residues and by-products produced every year and the opportunities they represent to implement IBLC concepts: olive oil sector, sugar industry, wine sector and grain supply chain. These sectors are also thought to have unexploited synergies in terms of underused production, processing or storage capacities. In addition to the abovementioned sectors, the vegetable oil extraction sector was investigated. However, due to lack of available data, the sector is not described in the same detail as the other sectors.

A basic analysis, depending on the available public data sources (official statistics from the Hellenic Statistical Authority and relevant Ministries, general information from different studies and papers, webpages of main stakeholders and industries involved in the sectors), has been performed for each sector. Moreover, additional information was gathered from the selected stakeholders in order to have a clearer picture of the current state of each sector. More specifically the stakeholders that were consulted are listed in Annex A.

More specifically on this report, basic information for each sector is analyzed. The analysis of each sector is divided into two main parts:

- One part regarding general information on the profile of the sector. Information about the annual productivities, the production process, the volume, economic strength / state, typical size of the companies, distinctive facilities and R&D activities of the sector are presented.
- Another part regarding the IBLC opportunities in each sector. Information is provided on each sector's residues, potential synergies of existing equipment during idle times, market use of sector's residues and non-technical barriers that can be encountered when the IBCL concept will be implemented.

During the desk study performed in order to find data on the abovementioned Greek sectors, several challenges were encountered due to the limited statistic data available on the residues of the Greek sectors, economic data of the sectors etc. When applicable, in order to overcome difficulties such as quantifying the amount of residues of each sector, worldwide literature and scientific papers were used to estimate these amounts. In addition, difficulties were faced in

retrieving data of the sector from the stakeholders, since they could not be shared some detailed data for confidentiality reasons.

2 Olive Oil Sector

2.1 Profile of the olive oil sector

2.1.1 Production

The main input for the olive oil sector is the fruit of the olive tree, while the main outcome are various categories (based on quality) of olive oil. According to Annex I of the Community Regulation 865/04 "on the Common Organization of the Market in Olive Oil and Table Olives", (EU Legislation, 2004) the quality categories of olive oil and olive-pomace oil authorized to be sold and marketed within the Community are defined as follows (from highest to lowest quality ranking, IOC, 2017):

1) Virgin Olive Oil: olive oil obtained from the fruit solely by mechanical or other physical way that do not lead to alterations in the oil.

   Virgin Olive Oil is classified with the following names:

   - Extra Virgin Olive Oil: virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 0.8 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.
   - Virgin Olive Oil: virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 2 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.
   - Ordinary Virgin Olive Oil: virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 3.3 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.
2) Refined Olive Oil: olive oil obtained from virgin olive oils by refining methods, which do not lead to alterations in the initial glyceridic structure. It has a free acidity, expressed as oleic acid, of not more than 0.3 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards (International Olive Council, 2006).
3) Olive Oil: olive oil consisting of refined olive oil and virgin olive oils. It has a free acidity, expressed as oleic acid, of not more than 1 gram per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.
4) Crude Pomace Oil: olive pomace oil whose characteristics correspond to the requirements of International Olive Council standards. It is intended for refining for use for human consumption, or it is intended for technical use.
5) Refined Pomace Oil: oil obtained from crude pomace oil by refining methods, which do not lead to alterations in the initial glyceridic structure. It has a free acidity, expressed as oleic acid, of not more than 0.3 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.

6) Pomace Oil: oil comprising the blend of refined olive pomace oil and virgin olive oils fit for consumption as they are. It has a free acidity of not more than 1 gram per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.

After the harvesting, the olives are transported to the olive oil mill where oil is produced by cold or hot pressing of the olive fruit. The mills carry out the first phase of olive oil production, which is then either directly available for consumption in bulk or promoted to commercial enterprises for resale in Greece or abroad, or is supplied to processing and/or standardization companies.

In general, there are three main types of olive oil mills depending on the production process:

a) Traditional olive mills, where hydraulic presses are used;
b) Three-phase centrifugal mills, where the extraction process produces olive oil, pomace (~60% moisture content) and olive mill waste water (OMWW); and
c) Two-phase centrifugal mills, which produce olive oil and wet pomace (Two-Phase olive mill waste/ TPOMW, ~70 % moisture content).

Between the two types of centrifugal extraction, two-phase mills are both more productive (in terms of the amount of extracted olive oil) and more environmentally friendly. The main difference is that two-phase mills require less water during the extraction process, leading to lower energy costs, less water is wasted during the process and a higher extraction rate of olive oil (output/input ratio around 20 % for two-phase and 18 % for three-phase mills) achieved. Overall, the average processing cost of two-phase mills is about € 0.16 per kg of olive oil compared with € 0.19 per kg of olive oil in three-phase mills (National Bank of Greece, 2015). Moreover, the higher concentration of natural antacids enhances the quality of olive oil produced in two-phase mills and makes it more resilient during storage.

Greek olive oil mills mostly use two-phase technology. The stakeholder of the Association of Olive Kernel Oil Producers of Greece (SPEL) consulted estimates that there is a 60/40 split between the two-phase and the three-phase systems in Greece. The promotion of two-phase mills is expected to continue, aiming for higher productivity combined with improved environmental protection (National Bank of Greece, 2015). The current trend in Greece is for three-phase olive mills to turn into two-phase olive mills as there are corresponding legislations that support and push towards this conversion.

Analytically the whole process of olive oil production, as it can been seen in Figure 1, is generally the following:

- Receiving the fruit: After harvest, the olives are transported to the mill, where they are temporarily stored until they are processed.
- Defoliation – Washing: Placement in a picking hopper of olives, transport by conveyor or endless screw to a leaf removal, where leaves and other foreign bodies are removed and then washed to remove other impurities.
- Crack-milling of olives: Extrusion of the fruit and production of olive oil (or olive paste).

- Malaxation: The olive oil is blended in softeners to achieve the merging of the oil traps into larger drops of oil.
- Extraction of olive oil: In the traditional process (hydraulic press), a liquid / water mixture is first extracted, which is separated in a subsequent phase by centrifugation to obtain the olive oil.
- Three-phase centrifugation: In this step a significantly amount of hot water is inserted to wash the oil. Separation of solid residue (olive cake) from the other two liquid phases occurs in the decanter.
- Vertical Centrifugation: The final separation of olive oil from the vegetation water.
- Two-phase centrifugation: Same process as in three-phase centrifugation but the horizontal centrifugation is performed without the addition of water. There are two output streams as olive oil is separated from solid phase (TPOMW-wet pomace)

The olive mill wastes (pomace) are sent to pomace mills where further processing occurs for retrieving edible pomace oil. Pomace mills are necessary steps in the olive oil value chain. They use as raw material the crude olive cake produced by the olive mills, dry it and extract the residual oil (usually using chemical solvents, such as hexane), known as pomace oil. Moreover, they produce one or more solid biofuels originated from the stone, flesh and skin of the olive fruit (along with some small quantity of residual oil). Depending on the process adopted, these can be olive stones (mostly the pit part of the olive fruit), exhausted olive cake (mostly the flesh part of the olive fruit) or “combined” fractions.

Concerning the pomace oil mills there are two main stages of pomace oil production:

- Drying process: During the drying process, the olive pomace is propelled into large cylindrical dryers, heated and rotated. With this procedure, the large amount of water is reduced and the oil is easier to be removed.
- Distillation process: The pure hexane (C_6H_{14}) is used for the distillation process of the olive pomace, which literally "rinses" the oil from it. The oil-hexane mixture is then propelled into special distillation tanks where the two components are completely separated. After this stage, the pomace oil is ready for storage.

The whole process of oil production is depicted in Figure 1. The olive oil production processes are presented in blue boxes, the main by-products of the whole olive oil chain are in red boxes and the final edible products in the green boxes.

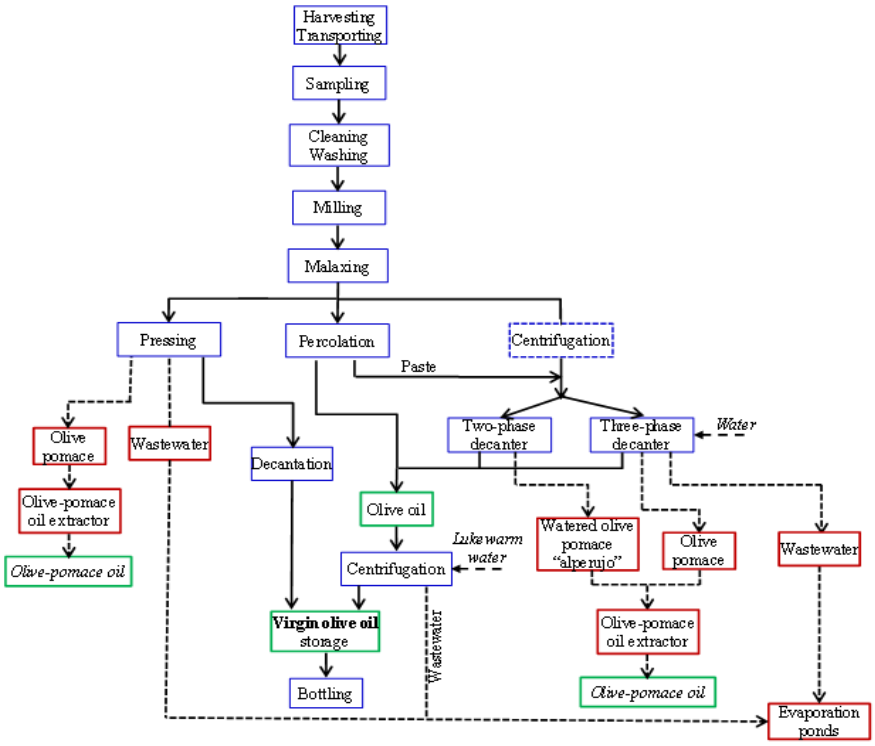


Figure 1. Schematic process of olive oil production in Greece. Source: (AOCS Lipid Library, 2017)

2.1.2 Volume of the sector

Greece is the third olive oil producer in the world, after Spain and Italy with a typical annual production ranging from around 300 to over 400 kt (in a very productive year) of olive oil depending on the olive oil year. Table 1 presents the olive oil production and cultivated areas of olive groves from 2012 to 2014 (ELSTAT, 2014).

Table 1. Olive Oil Production and cultivated areas of olive groves from 2012-2014. Source: (ELSTAT, 2014)

Olive Oil Production and Cultivated Area (2012-2014)			
	2012	2013	2014
Olive Oil Production (kt)	331.9	291.4	251.4
Cultivated Area (10^3 x ha)	807	797	823

Table 2 shows the production of olive oil for year 2014 across the geographical regions of Greece. The majority of olive oil is produced in Peloponnese, Crete and Western Greece (ELSTAT, 2014).

Table 2. Olive Oil Production based on geographical areas in Greece 2014. Source: (ELSTAT, 2014)

Olive Oil Production based on Geographic Regions for 2014		
	Olive Oil Production (kt)	Percentage (%)
Peloponnese	78.3	31.2
Crete	60.7	24.1
Central Greece	28.9	11.5
Northern Greece	11.4	4.5
Western Greece	62.4	24.8
Aegean Islands	9.7	3.9
Total	251.4	100

The value of domestic olive oil production is estimated at around € 800 million contributing to 0.4 % of Greece's GDP per year (average during 2010-2015), compared to 0.3 % of GDP for the Spanish industry and 0.1 % for the Italian (National Bank of Greece, 2015). Furthermore, in the latest years, the olive oil sector contributes more than 0.4 % on the domestic GDP (personal communication, ELSAP, 2017). Olive oil is one of the most significant economic sectors in Greece. However, according to the sector analysis of the National bank of Greece, olive oil production is expected to decline to 280 kt in 2020 (National Bank of Greece, 2015).

Considering the organization of the sector, Greece has a high proportion of small (and largely cooperative) mills that amount to 2,500 (National Bank of Greece, 2015). Stakeholders in the olive-milling sector however indicate that the total number of olive mills in Greece may be even higher, up to 4,000.

Table 3 provides the difference in the number of olive and pomace mills in the three main olive oil producing countries in the EU: Spain, Italy and Greece (MoRE project, 2008). Greece has around 35 pomace mill facilities (according to the members' directory of SPEL). Furthermore, according to stakeholder's feedback (personal communication, NUTRIA, 2017), in Greece there are 7 large scale refineries and another 3-4 small scale companies that refine olive and pomace oil.

Table 3. Number of olive mills and pomace mills in the three main olive oil producing EU countries. Source (MoRE project, 2008)

Olive and pomace mills		
Country	Olive mills	Pomace mills
Spain	1,722	50
Italy	4,743	40
Greece	2,500	35

Figure 2 presents the geographical distribution of olive mills around Greece. The majority of olive mills (36.5 %) are located in Peloponnese, whereas Crete follows with 23.3 % of the total national olive mills.

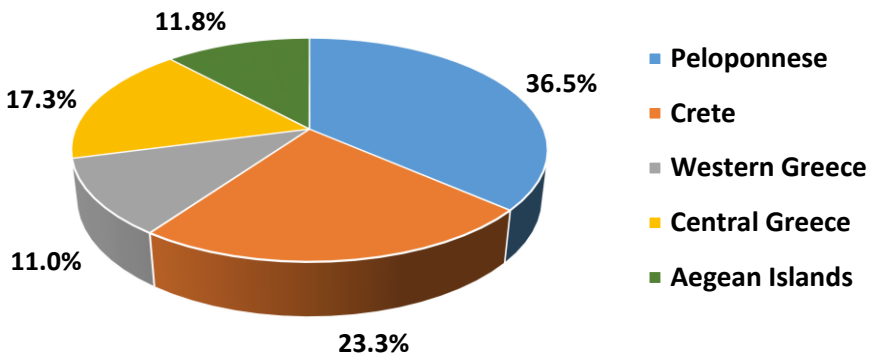
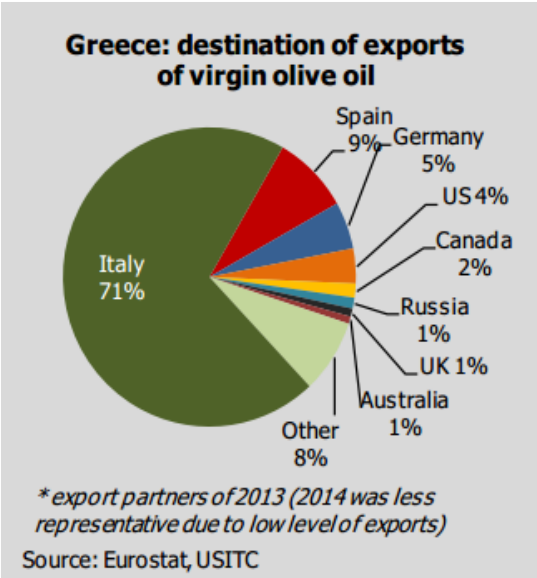


Figure 2. Geographical distribution of olive mills in Greece. Source: (Prodosol, 2009)

2.1.3 State of the sector

Regarding the economic strength of the olive oil sector, it is worth to mention that only the 27 % of the Greek olive oil is distributed for domestic consumption or exported as a branded product while most of it is sold in bulk form (National Bank of Greece, 2015). Domestic consumption absorbs about two thirds of olive oil production in Greece while the rest is exported (100,000 to 135,000 t). Due to lack of an effective export strategy and relevant sector organization, most of the exported quantity (about 70 %) is exported to Italy in bulk form where it is mixed with different origin olive oil and re-exported as an Italian brand olive oil. Figure 3 below presents the main destinations of the Greek olive oil production and some statistic data for the main olive oil producers (National Bank of Greece, 2015).



Main olive oil producers	Spain	Italy	Greece
Available supply			
Production	1.45	0.42	0.31
Imports	-	0.54	-
Total	**1.45**	**0.96**	**0.31**
Consumption			
1. Domestic consumption	0.63	0.61	0.20
branded	*0.32*	*0.41*	*0.05*
bulk	*0.24*	*0.19*	*0.13*
bulk - non food	*0.07*	*0.01*	*0.02*
2. Exports	0.82	0.35	0.11
branded	*0.41*	*0.35*	*0.03*
bulk	*0.41*	-	*0.08*

* in million tons (average data for 2010-2012 due to high volatility)

Source: IOOC, Faostat, Comtrade, NBG estimates

Figure 3. Statistic data of exports of the main olive oil producers. Source: (National Bank of Greece, 2015).

The total sales for the large, medium and small-sized industries amounted to 832.7 million euros for 2014 (decreased by 16.2 million euros in value and 2 % in percentage compared to 2013). Based on the statements of the interviewed stakeholders, the current state of the olive sector in Greece

is in good weather after the very low productivities and profits of years 2011-2014. Table 4 summarizes the financial figures for the olive oil sector industries for 2011-2014.

Table 4. Consolidated financial figures of olive oil and pomace industries. Source: (inr.gr, 2014)

Consolidated financial figures of olive oil and pomace industries for 2011-2014				
	2011 (k€)	2012 (k€)	2013 (k€)	2014 (k€)
Total assets	684,773	948,911	917,652	942,892
Sales	631,721	837,686	848,844	832,679
Gross profit	95,929	125,327	140,338	133,394
EBITDA	51,305	64,512	74,536	66,920
Net profit	5,206	6,011	13,437	10,527

Table 5 presents the economic sizes of the top ten industries of the olive sector in Greece based on the sales (inr.gr, 2014). The main business line of most of these industries is the standardization of olive oil (and pomace oil) and the marketing of olive oil products; ELSA S.A. is the only company on the list whose primary activity is the operation of pomace mills.

Table 5. Economic size of the ten biggest Olive Oil Industries in Greece, mainly standardization industries. Source: (inr.gr, 2014)

Economic Size Of The Biggest Olive Oil Industries In Greece, 2014				
Company Name	Location	Total Assets (k€)	Sales (k€)	EBITDA (k€)
INTERCOMM FOODS S.A. AGRICULTURAL PRODUCTS	Larisa	70,154	77,556	10,951
MINERVA S.A. OIL OPERATIONS	Athens	70,265	75,798	2,757
KORE S.A. OLIVE PRODUCTS – FOODSTUFFS	Athens	45,370	65,549	2,813
DEAS S.A. OLIVE - AGRICULTURAL PRODUCTS	Chalkidiki	39,213	37,904	6,496
NUTRIA S.A. STANDARDIZATION OF AGRICULTURAL PRODUCTS	Fthiotida	33,458	36,948	1,537
KONSTANTOPOULOS OLYMP S.A. OLIVE PROCESSING	Katerini	32,229	34,793	5,928
AGROVIM	Messinia	14,796	28,874	1,057
AGROTIKI S.A. OIL OPERATIONS	Attiki	22,160	17,108	-791
ELANTHI S.A. FOODSTUFFS	Attiki	23,738	7,837	1,977
ELSAP S.A. OIL OPERATIONS	Argolida	19,334	3,026	-844

Furthermore, Table 6 presents ten pomace mills in Greece with the highest sales for year 2011.

Table 6. Economic size of the ten biggest Pomace Mills in Greece based on sales. Source: (inr.gr, 2014)

Economic Size Of The Biggest Pomace mills in Greece, 2014				
Company Name	Location	Total Assets (k€)	Sales (k€)	EBITDA (k€)
AGROTIKI SINETAIRISTIKI RETHIMNOU S.A. (A.S.E.A.R.)[1]	Rethimno	18,074	9,838	583
PIRINAS S.A.	Messinia	3,421	3,741	444
ELSAP S.A.	Argolida	19,334	3,026	-844
CHATZELIS K. S.A.	Lakonia	3,420	2,846	220
ILEIA OIL MILLS	Ilia	5,198	2,182	94
MESSINIAKI	Messinia	4,547	2,024	-27
EAIOURGIKI VOIOTIAS PYRINELAIOURGEIO S.A.	Voiotia	3,630	1,598	131
ELEOURGIKI KENTRIKIS ELLADAS S.A. (EL.K.E.)	Lamia	6,438	1,587	97
KOUFAKI AFOI ELAIOURGIAI ARGONAUPLIAS	Argolida	2,826	1,564	208
ELAIOURGIAI MAGNISIAS MICHAIL KOUFAKIS	Magnisia	2,474	1,384	-601

[1]*A.S.E.A.R. produces and trades feed and fodder, apart from pomace oil*

2.1.4 Typical size of the companies

The typical size of the Greek companies in this sector differs from the Spanish or the Italian ones. In Greece, olive mills are mostly owned by cooperatives controlled by farm owners (50 % of oil olive production). Greek olive mills are relatively small and thus they lack economies of scale and access to international distribution networks. Greek olive mills have an average annual capacity of 200-230 t of olive oil compared with 120 t in Italy and 750 t in Spain. Regarding the size of the pomace mill, a typical pomace mill in Greece has a capacity of treating around 450-500 t pomace /day (personal communication, ELSAP, 2017).

There is no exact data about the amount of workers that are employed in the olive sector in Greece. The stakeholder interviewed stated that a typical olive mill has 5-6 employees, all of them seasonal employees (personal communication, Agios Konstantinos Cooperative, 2017). Assuming that in Greece, there are 2,500 olive mills and considering a typical size of them, the total amount of seasonal employees working in olive mills is around 15,000. Furthermore, the stakeholder from the pomace oil sector estimated that in each pomace mill there are 5-6 permanent workers and around 25 seasonal workers during the olive oil production period (personal communication, SPEL, 2017). Thus, it is estimated that in the 35 pomace mills in Greece, there are employed 210 permanent workers and 875 seasonal workers. Moreover, Figure 4 presents the labour force productivity in the Greek olive sector, regarding the farming and harvesting of olives. Based on this figure, the labour productivity in Greece is estimated at 19 t of olives per employee according to the statistical

data from the National Bank of Greece (National Bank of Greece, 2015). Taking into consideration that a typical annual production of olives in Greece is 2,646,000 t, it is estimated that the seasonal employees working in the farming/ harvesting of olives amount to 140,000 workers.

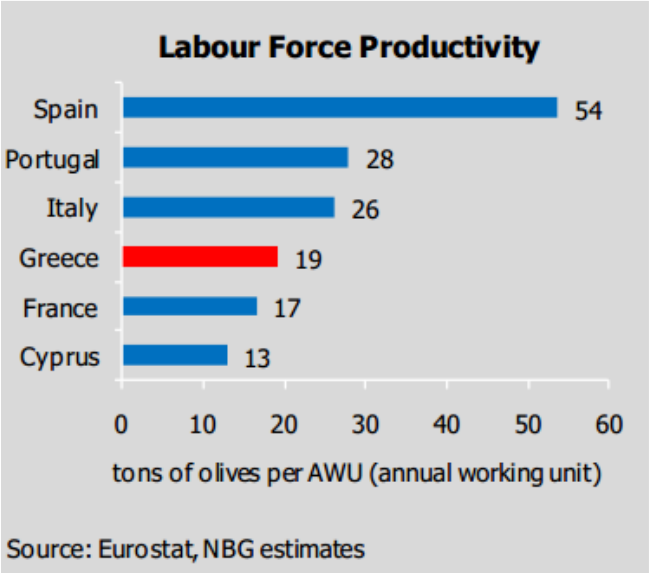


Figure 4. Labour Force Productivity. Source: (National Bank of Greece, 2015)

2.1.5 Distinctive facilities of the sector

The facilities that are used for the olive oil and the pomace oil production are in full operation during the months from September to March with the exception of a few areas (e.g. Corfu) where the olive season is larger due to local peculiarities. In some cases, during summer months, pomace mills operate with edible olives, that have been expired, and extract pomace oil from them (personal communication, Loukision Cooperative, 2017). In overall, there is a lot of idle time for implementing an IBLC concept in the olive oil sector. Facilities such as storage areas, dryers, centrifuges or purification systems can also be used for different purposes. For example, the storage areas can be used in order to store prunings or mulched material from olive or vine prunings that are produced from the olive trees or vineyards of the nearby areas.

Moreover, the centrifuges and the purification systems can be used from the vegetable oil extraction sector in order to extract their main products. Furthermore, dryers used in pomace mills, can find various applications during their idle times like drying other materials such as olive prunings, cereals etc.

From the interview with the representative of Association of Olive Kernel Oil Producers of Greece (SPEL), he stated that the facilities of pomace mills could be exploited during idle times and treat other raw materials such as alfalfa, clover etc. However, investments on the modifications of current equipment and/or purchase of new equipment would be essential for such implementation. For example, she stated that a pomace mill in Messologi, Western Greece, during its idle months, it treats alfalfa. This feedstock has a similar moisture content with two-phase

pomace, around 80 %. Thus, when the pomace mill does not operate with pomace, it dries alfalfa and packages it.

2.1.6 Degree of innovation

As mentioned before, about 40 % of the olive oil mills in Greece use the three-phase centrifugation method for the extraction of olive oil. However, more and more olive oil mills have the tendency to change their process from the three-phase to the more sustainable two-phase centrifugation.

Two-phase centrifugation is the best solution in the olive oil process treatment, because it is more eco-friendly than the three-phase system (by saving water, reducing the volume of liquid waste, etc.) and for that reason it is proposed for the new olive oil industries. Moreover, the two-phase centrifugation advantages over the three-phase are the following:

- It produces much smaller quantity of olive oil wastes than the three-phase system.
- The quality of the virgin olive oil that is produced by the two-phase is better than that of the three-phase system, mainly regarding the content in polyphenols and antioxidants.
- The two-phase systems do not require additional quantities of water to produce the olive oil paste by reducing the operating cost of the installation.
- The energy demand of the two-phase systems is smaller, due to the lower amount of olive paste that is going to be processed.
- In the two-phase systems, no extra centrifuge is required for the treatment of the extra produced fluids because they are recycled.

Concerning all the above properties of the two-phase centrifugation method, the latest prevailing tendency in Greece is the alteration of the remaining three-phase centrifugation systems to two-phase systems in the olive oil mills. This trend does not occur only because of the advantages of two-phase over three-phase technology but also because of the national legislation that forces olive mills to this change.

The interviewed stakeholder mentioned that there are some olive companies that invest in R&D activities, however it is a minority. Furthermore, he stated that because the olive sector industries (mainly pomace mills) are out of the development law and national grants, the R&D activities are very limited.

2.2 Opportunities IBLC

2.2.1 Sector related residues

The three-phase olive mills during the extraction process of the oil produce, apart from the olive oil, two residue streams, an aqueous solution with a solid content of no more than 6 % called olive oil waste water and the olive pomace which is a solid stream residue. The latter is sent to pomace mills for further processing whereas the olive wastewater is disposed. In case of the two-phase olive mills, there are two output streams, one stream of olive oil and another with the two-phase olive

mill waste (TPOMW), a solid stream residue with high moisture (~70-80 %) that is sent to pomace mills for further processing. Pomace mills have as input the residues produced from the olive mills. Pomace mills, after extracting the pomace oil from the pomaces, they produce one or more solid biofuels originated from the stone, flesh and skin of the olive fruit. Depending on the process adopted, these can be olive stones (mostly the pit part of the olive fruit), exhausted olive cake (mostly the flesh part of the olive fruit) or "combined" fractions.

Table 7 presents some estimated values of the wastes produced in the olive mills and pomace mills. It should be noted that for the estimation of the annual produced products and residues it was assumed that the annual olives production for olive oil in Greece is 1,571 kt (value for year 2014, Eurostat, 2014) and also that the 60 % of the olive mills in Greece use the two-phase technology. From the above percentages, we can assume that the input for the mills that use the two-phase technology is 942.6 kt olives and 628.4 kt olives for the ones that use the three-phase technology. In Table 7 a clearer picture of the mass balance of the products/ residues along the olive and pomace mills is depicted.

Table 7. Mass balance of olive and pomace mill products estimated based on year 2014 olives production

	Estimated Olive and Pomace Mills Products and Residues for 2014		
	Procedure	Two-Phase (60%)	Three-Phase (40%)
Olive Mill	Olive Fruits Input (kt)	942.6	628.4
	Olive Oil Production (kt) [a]	188.5	125.7
	Olive Mill Residues		
	Olive Mill Waste Water (ML)[b]	-	345.6 - 439.8
	Olive Pomace (kt), sent to pomace mills [c]	754.0 [d]	314.2 [e]
	Pomace Mill Products		
Pomace Mill	Pomace Oil (kt)	10	3.6
	Exhausted Olive Cake (kt)	273.8 [f]	173.8 [f]
	Exhausted Olive Cake (kt - available to the market after covering own consumptions of pomace mills)	70.0	65.0

[a] 20% of live fruit is converted into olive oil; [b] Retrieved from https://www.agroenergy.gr; [c] 80% of olive fruit is converted into pomace in two-phase mills, 50% in three-phase mills; [d] 68% wt moisture and 5% wt d.b. oil content; [e] 52% wt moisture and 3% wt d.b. oil content; [f] 15% wt moisture and 1% wt d.b. oil content. Source of all values: Communication with Greek stakeholder, SPEL

Apart from the above-mentioned residues, the olive sector produces prunings. Currently, in Greece, there are two ways that olive prunings are treated. The most frequent use is that of burning them in open fires and thus, having negative impact on the environment and increasing the risk of fires. The other way, less used, is to mulch the prunings onto the soil of the olive groves. Currently, there are no recent national surveys based on field data regarding the availability of APPR biomass in Greece. The standard reference study for prunings from olive groves derives from a study of Apostolakis et al. from as back as 1987. This study presents residue-to-product ratios (RPR) for the prunings produced from various types of permanent crops in Greece. The statistical data of crop productivity on which the pruning results are based dates from 1980. Another, way to estimate the pruning potential is via the biomass supply tool developed in the FP7 S2Biom project. This tool forecasts the pruning potential from permanent crops for 2020 and for all the EU-28 countries. The evaluation is based on applying country specific residue-to-surface ratios (RSRs) for certain tree crop types (olive, vineyards, citrus and fruit trees) to projections of the surface area used for the cultivation of these crops, as taken from the CAPRI model. Moreover, a third method for estimating the olive pruning potential at national level was performed via Biomasud Plus H2020 project and CERTH calculations. In this method, the pruning potential estimation is based on RPR from various references. The calculations for this method is based on the productivities of the crops in year 2014.

The moisture considered in all methods is 35 % wt for olive prunings. The olive pruning potential is presented in Table 8 based on these methods.

Table 8. Potentials (kt of dry matter per year) for olive prunings in Greece according to several data sources

Potentials for olive prunings (kt of dry matter per year)			
Source	Reference Year	Methodology	Olive Prunings
Apostolakis et al.	1980	RPR + national production statistics	1,135
Biomasud Plus	2014	- // -	1,718
S2Biom	2020	RSR + CAPRI surface projections	1,165

From the three methods, the national pruning potential is estimated in a range of 1.13-1.72 dry Mt. Finally, in the framework of uP_running project (Grant Agreement No 691748) on-field measurements of olive pruning production were performed in several olive groves around Greece. Based on these on-field measurements, Apostolakis et al. and Biomasud's RSR values are more in line with the RSR values found from the on-field measurements for olive trees.

In addition, another residue deriving from the olive sector is that of olive stones. Olive stones amount to 8.3 % of the weight of the olive fruit (dry basis) (Rodero et al., 2017). However, actual production volumes depend on the production systems employed. Only a limited number of companies in Greece perform the separation of olive stones from the olive cake. The stones typically end up in the exhausted olive cake produced by the pomace mills. Based on some initial discussions with such producers, CERTH estimates that the volume of production of separated olive stones in Greece is around 5,000 – 7,000 t.

Finally, another residue related to the olive oil sector is that of the olive leaves that remain unexploited. The olive leaves can be retrieved either during the harvesting of olives or during the

preparation of olives prior to the olive oil extraction. Olive leaves are rich in phenolic compounds that can be exploited in pharmaceutical or cosmetics industry.

2.2.2 Potential synergies & benefits

The residues from three-phase olive mills are wet pomace and OMWW (olive mill wastewater). Wet pomace is sent to pomace mills for further exploitation whereas the OMWW have to be disposed. OMWW possesses a double nature. It is a strong pollutant and at the same time a possible source of valuable components, such as polyphenols, flavonoids, anthocyanins, inorganic trace elements, etc., that could be isolated. Several treatment options have been considered including physical, physicochemical, biological, thermal technologies and combinations thereof, as well as other combined approaches that could improve decontamination efficiency.

- Physical treatment, which involves the separation of different phases through mechanical means. When used, so far, the physical treatment of OMWW is unable to reduce alone the organic load and toxicity of the wastes to acceptable limits.
- Physicochemical treatment, which involves the use of additional chemicals for their neutralization, flocculation, precipitation, adsorption, chemical oxidation and ion exchange.
- Biological treatment, which involves the use of microorganisms in order to break down biodegradable chemical species, which are present in OMWW, is considered environmentally friendly and effectively in cost. The actual type of microorganisms depends on the treatment option, i.e. anaerobic or aerobic.
- Thermal treatment involves the concentration of OMWW by reducing their water content and total volume (Prodosol, 2017).

Olive mill wastes contain an important amount of phenolic compounds, such as the exhausted olive cake from the two or three-phase pomace. In this sense, wet pomace after being treated in the pomace mills to produce pomace oil, can be used to extract the phenolic compounds (mainly hydroxytyresol). These phenols can find several applications in cosmetics, pharmaceuticals or as anti-oxidants. However, to perform such processes, additional investments are needed for the pomace mills.

Moreover, the olive prunings as residues of the olive sector can be exploited. They can be used as raw material for the production of pellets or as fuel for covering the energy demands of the mills. However, new investments are needed for the harvesting equipment of the pruning. Continuously, dryers that exist in the pomace mills can be used in order to dry the prunings before exploited, offering a synergy in the iddle times of the pomace mills.

Finally, Fernández (Fernandez-Bolanos, 2006) proposed a technological scheme (as seen in Figure 5) in order to exploit all the valuable compounds found in the olive wastes of two-phase mills. According to his strategy-technology, valuable phenols, chemical, bioethanol, biofuel etc. can be retrieved from the olive mill wastes. Thus, this is an example of the integrated valorisation of agro

residues in an existing agro-industry by expanding traditional processes with additional biorefinery steps.

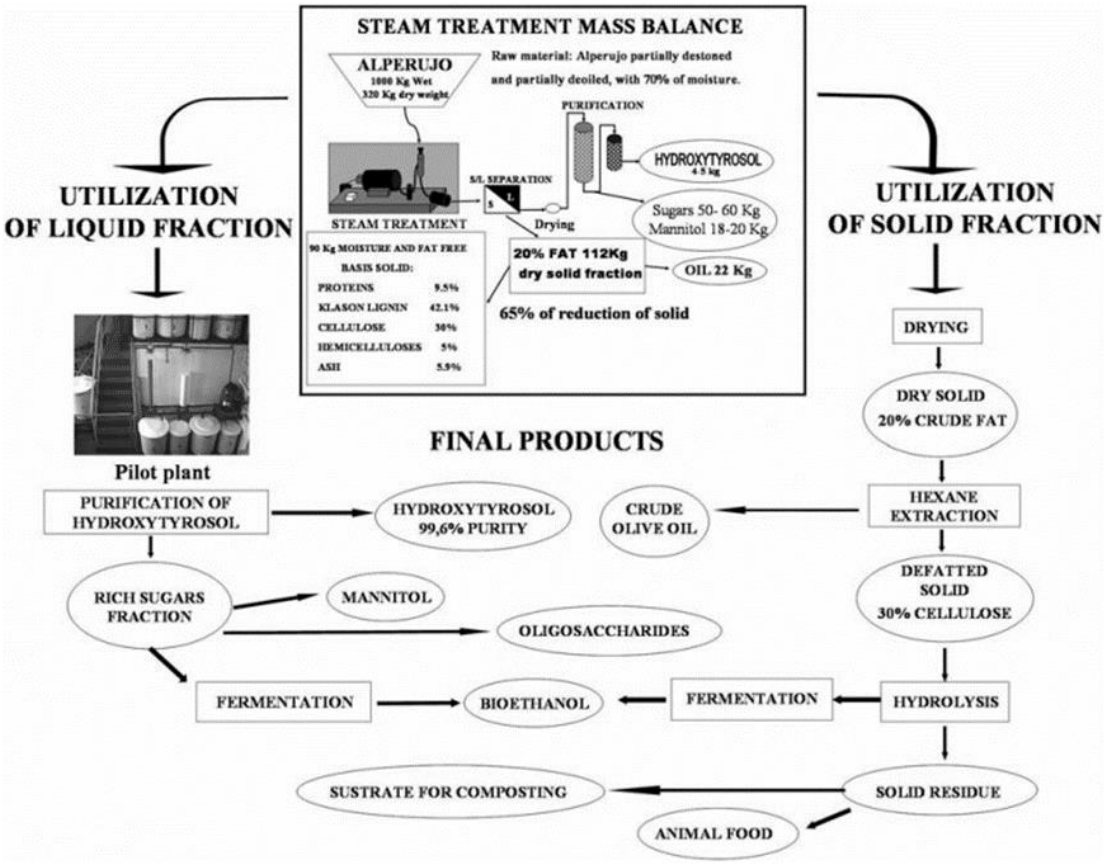


Figure 5. Strategy for an integral recovery and revalorization of olive mill waste- alperujo (TPOMW). Source: (Fernandez-Bolanos, 2006)

2.2.3 Market developments

Usually the exhausted olive cake and olive stones, produced from the pomace mills as by-products, are sold as a fuel in the solid fuel market. Olive stones are much better fuel than exhausted olive cake due to lower moisture and ash content. However, in practice, the separation of olive stones by the Greek mills is rare. In most cases, all solid by-products end up in a single fraction, which is marketed as “pirinoksilo”, as it is known in Greek. The exhausted olive cake is mainly used as fuel for covering the own consumptions of the pomace mill. In addition, exhausted olive cake is used as fuel for space heating in the residential sector. It contributed to 2.34 % (ELSTAT, 2013) of the biomass consumption for residential heating. In 2017, the market price for the exhausted olive cake was in the range of 70 €/t (VAT included). However, the exhausted olive cake is exclusively consumed in rural areas as in urban areas its odour causes complaints. A specific requirement that legislation imposes on exhausted olive cake and relative fractions used for non-industrial applications in Greece is that their oil content should not exceed 2 % wt on a dry basis (Ministerial Decree 198/2013).

On the other hand, the OMWW can be used on soils and crops as a fertiliser, due to the organic matter and nutrients contained that could improve arid soils. However, the properties of soil (e.g. texture, nutrient, organic matter content and productivity) can be damaged due to the continuous application. OMWW can also be used as feedstock for biogas production. Almost 80 % of organic compounds in OMWW are suitable for anaerobic digestion. Theoretically, a yield of 37 m^3 of methane per m^3 of OMWW could be achieved (Tsagaraki, 2005). Potential feedstock for biogas production is also the TPOMW. In the frameworks of AGROinLOG project, the biogas production from the exhausted olive cake from TPOMW, via anaerobic digestion will be investigated.

In addition, both TPOMW and OMWW have the ability to be transformed into products for its use in the pharmaceutics industry as well as in the food industry, by recovery of antioxidants. The olive fruit is rich in simple and complex water-soluble compounds with potential antioxidant properties. The most important of them are polyphenols, flavonoids, anthocyanins, tannins, oleanolic acid and maslinic acid. Polyphenols in olive wastes have shown to be antioxidant, antibiotic, antimicrobial, and antifungal activity. Formulas of these olive-derived substances can be used as nutrition supplements or skin cosmetics. Due to their antimicrobial properties, they are also used as antimicrobial agents in detergents and rinsing and cleaning agents. Hydroxytyrosol is the most active component of them and it can be used as a food preservative and in pharmacology and cosmetology in topical preparations with anti-aging and anti-inflammatory action. Oleanolic acid regulates cholesterol levels in blood and balances body weight. Maslinic acid has been widely investigated during the last years and it seems to possess anti-inflammatory and antihistaminic activity. It also could be used in pharmacology as an inhibitor of AIDS virus (Tsagaraki, 2005).

Another interesting market for the olive residues is the animal feed industries. The exhausted olive cakes can be used in animal feeding, as they are rich in oil, carbohydrates, and proteins.

Finally, olive prunings can be used for producing pellets or chips that can be sold as solid biofuels or used directly for power and/or heat production in plants. An example is Fiusis power plant, located in Puglia, Italy. Fiusis is a small-scale power plant (1 MWe) producing electricity exclusively from olive tree prunings. It is considered the first plant of its kind to use exclusively olive prunings as a fuel source (Up_running project). In addition, other products can be produced from olive prunings such as particle boards used in the construction sector. Another residue that could be exploited from the olive sector is that of leaves. Leaves also contain a high amount of phenolic compounds. However, the extraction of phenols and the exploitation of leaves for added value products has to be further investigated.

2.2.4 Non-technical barriers

According to the information received from the interview with the stakeholder (personal communication, SPEL, 2017) one non-technical issue that has emerged these years is the reluctant behaviour of the Greek citizens regarding the potential exploitation of the current facilities (olive and pomace mills) for other activities during their idle periods. In many regions, most of the citizens are against to the current operation of the pomace mills because of the odour and smoke (due to the high moisture of the feedstock) that comes out of the pomace mills. Thus, the stakeholder

consulted is pessimistic about how residents will accept continuous operations of such facilities by implementing the IBLC concept. Furthermore, the stakeholder stated that the fact that pomace mills are constantly absent from national funding and support schemes makes it difficult for themselves to invest on such implementations. Continuously, some additional barriers were identified regarding the exploitation of residues of the olive chain. The synergy of launching the exhausted olive cake, as a residue from the pomace mill, in the residential solid fuel market for consumption in urban areas would find several barriers such as its high ash content and intense odour. Finally, another barrier/ problem of the sector is that due to the production of olives which is climate-dependent, technologies for exploiting by-products and residues of the oil sector have not yet been developed.

3 SUGAR INDUSTRY

3.1 Profile of the sugar industry sector

3.1.1 Production

The main product in this sector is sugar, which is contained in the beet. A sugar factory's task consists in extracting sugar out of the beet with a chemical transformation.

Mainly the beet contains (Figure 6):

- 14-17 % sugar
- 76-78 % water
- 4-5 % insoluble dry ingredients (marc)
- 2-3 % soluble dry ingredients (nitrogenous and non-nitrogenous organic and inorganic components).

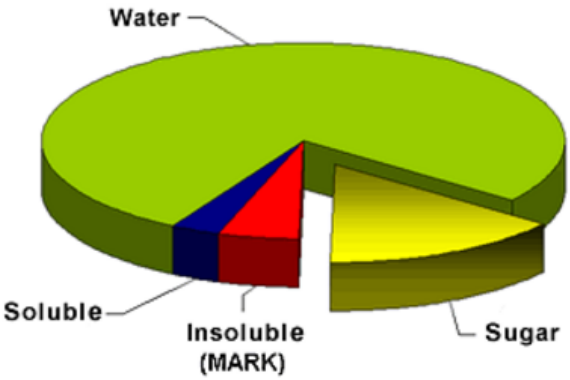


Figure 6. Main ingredients of a sugar beet. Source: (Hellenic Sugar Industry)

The insoluble dry ingredients called marc (consisting of cellulose, lignin, pectine, pentozane), consist the main component of the by-product called pulp (fresh or dry, or in compressed form as pellets). The soluble dry ingredients, after removing approx. 1/3 of the juice in the purification stage, are found again in the molasses, where they bind also a part of sugar.

The sugar production is a fairly complicated process. The industrial production in Greece follows the stages below:

1. *Acceptance, washing and beets cutting:* Beets are carried over from a collection point that ranges up to 70 km around the sugar factory.
2. *Diffusion:* Diffusion is the process where the sugar contained in the bits is received. This process is based on the principle of osmosis. The sugared juice is collected at one edge, while the diffused bits, called pulp, are recovered at the other edge and are used after a compression and possible drying as cattle feed.

3. *Pre-liming, liming:* The sugared juice derived from diffusion contains 12-13 % sugar and -85 % foreign materials called non-sugars. A portion of these foreign materials is removed.
4. *Saturation (carbonation):* Carbon dioxide is introduced into the limed juice where the sugar-lime breaks down and a sediment of calcium carbonate is formed.
5. *Filtration:* The sediment of calcium carbonate lays down on the filters. The sweet juice is clear and contains ~1.6 % non-sugars, ~12 % sugar and ~86 % water (thin) juice.
6. *Evaporation:* In order to remove the water, wherein sugar is dissolved, the thin juice gets through a stage of successive evaporation.
7. *Crystallization:* The juice is condensed to an increasing extent in apparatuses operating under vacuum. It thereby reaches a stage of super-saturation (Hellenic Sugar Industry, 2009).

The whole production process is shown in Figure 7.

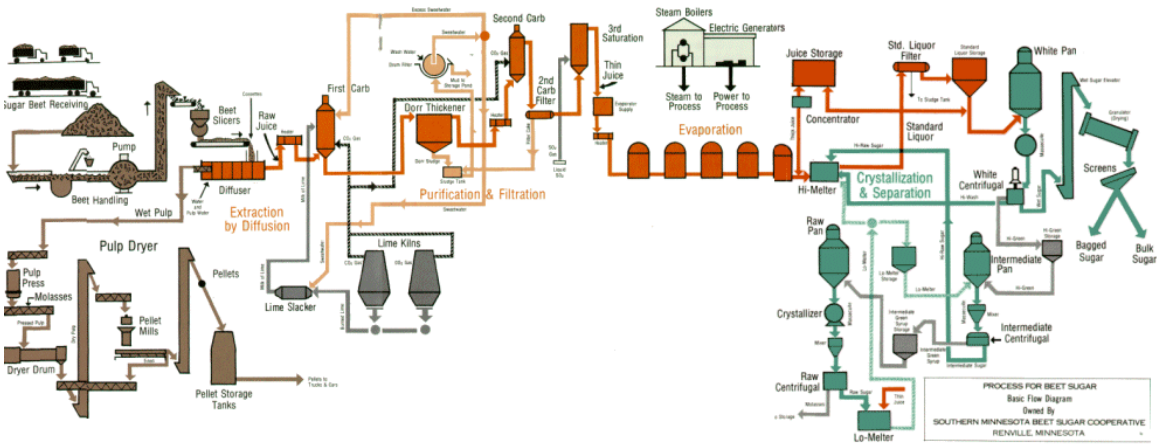


Figure 7. Main stages of the sugar production process. Source: (Hellenic Sugar Industry, 2009)

3.1.2 Volume of the sector

The Hellenic Sugar Industry SA (HSI) is the sole sugar producer in Greece. The main activity of the company is the production and trade of sugar, as well as the trade of its by-products. The company produces white crystal sugar whereas in the course of production, a set of by-products is also being produced which, following a proper processing, are made available in the market. In concrete terms, the products produced and traded by the company are as follows:

- White crystal sugar
- Molasses
- Sugar-beet pulp pellets
- Fresh pulp
- Beet seed

For many years, the HSI has been producing at its 5 factories all the amount of sugar needed to cover all domestic needs (320,000 t/year). For this production, the company supported the cultivation of hundreds of thousands acres (about 450,000) with contracts with over 6,000

producers for the production of sugar beet. However, in February 2006, EU agriculture ministers approved a radical reform of the sugar sector in the EU and all EU countries have been forced to reduce their production of sugar by at least 50 %. For Greece, the new ceiling amounts to 158,702 t/year. As part of the implementation of the regulation, farmers were compensated not to grow beets, and the industries were compensated by stopping their operation and dismantling productive sugar refineries. All of this finally has led to an intense fluctuation of the sugar production due to the unstable number of beet growers as it can be seen in Table 9 for the last years.

Table 9. Beet growers, cultivated area and sugar production from 2010-2014. Source: (private communication, HIS, 2017)

Beet growers, cultivated area and sugar production in Greece for years 2010-2014			
Year of production	Beet growers	Cultivated area (ha)	Sugar Production (kt)
2010	4,144	13,367	77,2
2011	2,133	5,791	38,3
2012	3,100	9,309	54,7
2013	1,875	5,799	40,2
2014	2,360	7,400	53,4

3.1.3 State of the sector

As mentioned above, HSI is the only sugar producer in Greece and since 2010 it has regained a large part of the internal market which had been lost, because of the economic problems during the past few years. HSI also owns two factories in Serbia where around 60,000 t of sugar is produced (in 2008). In this framework, the company exports important quantities to Bulgaria with sugar from the neighbouring factory of Orestias. The by-products of sugar, like molasses and sugar beet pellets, cover the needs of industries and cattle-breeders in the internal market while the additional quantity is exported to the countries of the European Union or even to Third Countries (Hellenic Sugar Industry). In the following Table 10 HSI sugar sales from year 2004/2005 until 2008/2009 are shown.

Table 10. Sugar sales from 2004 to 2009 Source: (Hellenic Sugar Industry, 2009)

Sugar Sales from 2004 to 2009					
	2004/2005 (t)	2005/2006 (t)	2006/2007 (t)	2007/2008 (t)	2008/2009 (t)
Yearly production	259,500	310,178	184,806	78,388	157,375
Production sugar sales	155,549	346,307	247,840	88,215	169,783
Importation sugar sales	75,051	58,579	65,712	82,052	56,729
Total sales H.S.I.	230,600	404,886	313,552	170,267	226,512

Despite the fact that white crystal sugar is the staple of the company, in order to cover any additional demand, sugar is also imported from the EU countries. Moreover, the company is engaged in producing beet seed out of sugar beets which, after a proper processing, is being sold to the beet-growers while some quantity is being exported to seed producing companies abroad.

In Table 11 the economic analysis of the years 2006-2009 regarding the production and trading of the company is shown. For the period 2006-2009, 89.77 % of the total sales of HSI came from selling products of own production, whereas only the 10.23 % of these total sales came from trading goods. The total sales of sugar amounted to 88.19 % of the total sales (Hellenic Sugar Industry, 2009).

Table 11. Economic analysis of the last year's production in the Hellenic Sugar Industry. Source: (Hellenic Sugar Industry, 2009).

Economic analysis of Hellenic Sugar Industry, 2006-2009				
Products:	2006/07 (M€)	2007/08 (M€)	2008/09 (M€)	Three-year Total (M€)
Sugar	150.9	66.9	84.6	302.4
Molasses	6.9	5.4	5.1	17.5
Dry pulp	8.7	6.0	4.4	19.2
Fresh pulp	1.1	0.8	0.8	2.7
Beets Seeds	0.9	0.9	1.4	3.2
Services (sprayings)	3.2	1.3	1.9	4.0
Other services	0.4	0.5	0.7	1.6
Sales of other materials	2.6	2.6	4.0	9.2
Imported goods:	2006/07 (M€)	2007/08 (M€)	2008/09 (M€)	Three-year Total (M€)
Sugar	29.9	44.9	42.8	117.6
Molasses	0.3	0.9	0.8	2.1
Seeds	0	1.1	1.0	2.1
Total	**205.2**	**131.5**	**147.7**	**484.4**

As it can be concluded from the economic data of the three years (2006-2009), HSI has a downturn. Despite its tries to remain the main sugar producer in Greece, the Hellenic Sugar Industry is becoming year by year even more unable to respond to the national needs. Reason for this is the fact that farmers prefer other intensive crops (cotton, corn, sunflower, etc.), which (mainly cotton) enjoy higher subsidies from beet growing.

From interviews with a Hellenic Sugar Industry stakeholder, the bad weather in which the sugar sector is in Greece can be justified from 2014 year's production numbers. In 2014, the annual turnover amounted to 90.6 M€ with an annual sugar production of 53,400 t coming from a cultivated area of 7.400 ha of sugar beets. Furthermore, according to the stakeholder the current year (2017) is the worst year regarding production of sugar and selling it. Indicatively, the market

value of sugar for the last production year is only at 315 €/t. This shows that the last year was the worst production year of all times.

3.1.4 Typical size of the companies

Before it was decided to close the Larissa and Xanthi factories, HSI used to have two fully equipped units (the first in Xanthi and the second one in Larissa), and three sugar factories (Plati, Serres, Orestias) as well as one seed processing factory. Both of the two equipped units are now out of order and only the second unit in Larissa is used from the company as a beet gathering area and packaging unit. On the other hand, only the two sugar factories in Plati and Orestias are in full function, with the Plati sugar factory to have a daily beets processing capacity of 8,000 t and a potential of sugar output at 100,000 t per year. Continuously, the sugar factory in Orestias has a daily beets processing capacity of 5,400 t and around 70,000 t sugar output per year. The sugar factory in Serres has not been completely shut down but its operation is suspended. Every year, the board decides whether the sugar factory in Serres will work or not (personal communication, Hellenic Sugar Industry, 2017). According to the feedback from the stakeholder, the amount of permanent workers that are employed in the Hellenic Sugar Industry are around 220 people and around 280 more employees in the two subsidiaries companies in Serbia. The workforce is doubled during the production months (September to January) by hiring seasonal employees.

The geographical breakdown of the company's operating units is shown in Figure 8.

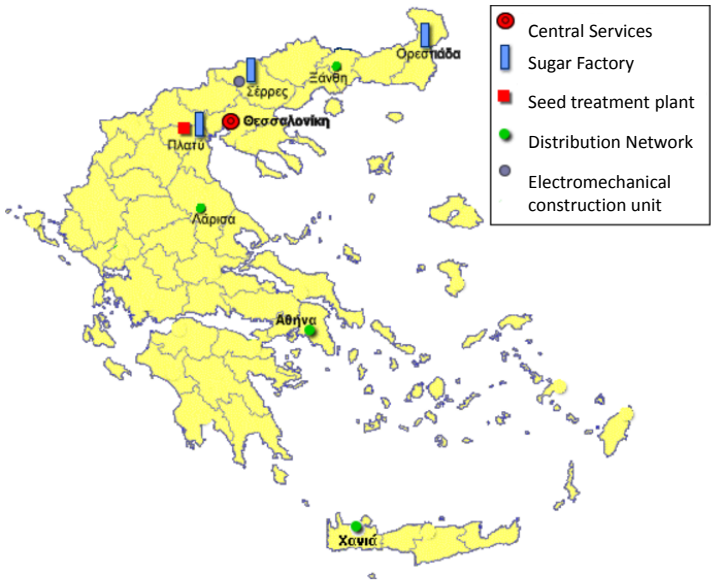


Figure 8. Geographical breakdown of the sugar units in Greece. Source: (Hellenic Sugar Industry, 2009)

3.1.5 Distinctive facilities of the sector

The sugar facilities are in full operation from September to January. Many times, the operation starts from August. The rest of the year, maintenance of the equipment and facilities occurs in order

for the facilities to be ready and deal with the next year's import of raw material. The equipment and the plant maintenance process takes too long (personal communication, Hellenic Sugar Industry, 2017). However, there is still idle time for implementing IBLC concept. This is justified by last year's production period (2017) which took place from September until only October.

However, there are facilities that can find further use in other biomass-treating processes such as storage areas, feed handling, dryers, evaporators, or pelletizer for producing pellets from different kind of biomass feedstock. Due to the complexity of sugar production process, it is uncertain whether an equipment within the production chain can be exploited by itself.

Furthermore, the current sugar facilities operate with HACCP (Hazard Analysis and Critical Control Points) for food safety and as a result, it is important to know the raw material that will be used in the above mentioned facilities and harmonize their use with the current operations rules of the facility.

3.1.6 Degree of innovation

Research in combination with continuous quality control and genetic improvement were main activities of the company. Hellenic Sugar Industry is the sole producer in Greece giving special emphasis to the support of all its productive procedures through the most modern technological advances.

One of the most remarkable programs of the company was the Genetic improvement for the creation of new sugar beet varieties acclimatized to the agro-climatic peculiarities of Greece. The extensive research program concerned all the sectors of relevant interest and all levels (plant-tissue-cell-chromosome-gene). Basic directions of the research aimed at the creation of appropriate genetic material, including endurance to biotic and abiotic factors, upgraded quality and optimum productive potential (Hellenic Sugar Industry, 2009).

Moreover, research in seed production and in seed technology aims to provide support in the whole sugar sector and especially the sectors of seed production and seed treatment, by increasing the company's revenue. Mainly the research comprises the following objects:

- Agronomic practice aiming at maximizing the production and optimizing the quality of the produced seed.
- Methodology and evaluation of the seed quality.
- Evaluation of the technical and pelletizing materials and investment practices of the seed (Hellenic Sugar Industry, 2009)

However, nowadays, the stakeholder from the Greek sugar sector stated that R&D activities are not performed or supported due to the bad economic situation the company is in.

3.2 Opportunities IBLC

3.2.1 Sector related residues

As it was mentioned above, the sugar production is a fairly enough complicated process. Taking into consideration that the cultivated area of sugar beets in Greece amounts to 9,309 hectares (in 2012-2013) (CEFS Sugar Statistics, 2013), the main by-products derived from the sugar process are molasses and beet residues, which are ranged as it is shown below:

- *Molasses:* It contains about 50 % sugar and is used as a substrate for fermentation processes for the production of alcohol, food or feed, citric acid, glutamic acid, amino acids (e.g. lysine) as well as feed additives. 2-4 % of beet production.
- *Sugar-beet pulp pellets*: A portion of the fresh pulp is not available directly for animal feed, but after it is driven for drying. The product resulting from drying is called pastry pie or dry pulp and is an excellent feed. It is marketed as produced or in the form of compressed particles as pellets. 2-4 % of beet production.
- *Fresh pulp:* The product resulting from the "recent beans" of the beets when the sugar which is contained into them has been extracted and called "extracted particles". The "extracted particles" are pressed to remove most of the water and sugar that they contain and the resulting product is called fresh pulp and sold as animal feed. Production depends on demand (Hellenic Sugar Industry).

From data taken from CEFS sugar statistical 2013 report, the annual beet production for the year 2013 amounted to 1,411,840 t. This estimation was made knowing that the annual sugar production was 158,126 t for this year and additionally that a percentage of 11-12 % is referred to the produced sugar. Continuously, it is worth to mention that during the collection process of the sugar beets another main residue derives and can be also estimated in the below table, the beet leaves which can be used as substrate for biogas production. Taking into consideration that the Product/Residue ratio is 2.51 (Apostolakis M., 1987) the produced amount of beet leaves was estimated for the year 2013. From the above, the estimated quantities of by-products are presented in Table 12.

Table 12. Main sugar residues and by-products.

By-products of sugar process production (2013)	
Main sugar residues and by-products	Produced amount, kt/year
Molasses[1]	19.5
Sugar-beet pulp pellets[2]	28.2
Fresh pulp[1]	24.8
Beet leaves[3]	562.5

[1] *Source: (Cefs Sugar Statistics, 2013)*
[2] *Estimated amount with the 2% of beet production (Hellenic Sugar Industry, 2009)*
[3] *Source: (Apostolakis M., 1987)*

3.2.2 Potential synergies & benefits

As it is mentioned above, the working months of the sugar industry in Greece is during September-January. Thus, there are many months where the equipment stays idle.

All the above-mentioned by-products, resulting from the production of sugar, cover the needs of industries and cattle-breeders in the internal market. Molasses is used as a raw material to produce alcohol, yeasts and cattle feed. Sugar beet pulp pellets is cattle feed, just like the fresh pulp, and is prepared by dry pulp (by-product of sugar) with the addition of molasses. Nutrica 135 is a sort of cattle feed which is used for fattening the calves and is prepared with dry pulp and molasses, with an addition of trace elements and vitamins.

Figure 9 presents a typical scheme of the sugar process production and the final use of its by-products and wastes.

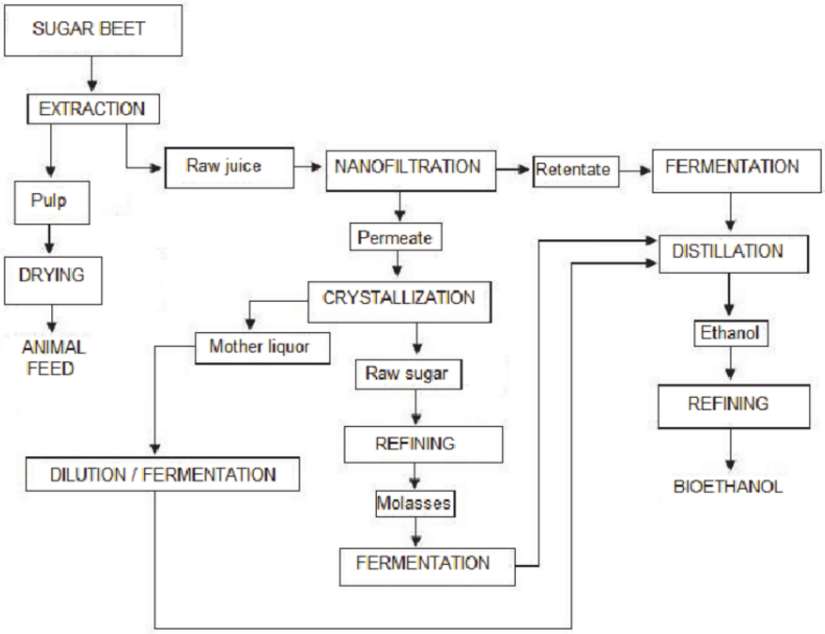


Figure 9. Schematic representation of the sugar production process and the use of its by-products. Source: (Giovanni Di Nicola, 2011)

3.2.3 Market developments

Most of the by-products produced during the sugar production process are already used in the market such as animal feed. It is worth to mention that molasses can be used as a raw material for the production of bioethanol. In Greece, there is no data available that confirms this exploitation.

3.2.4 Non-technical barriers

No specific barriers were arisen for the development of the IBLC concept in the sugar sector in Greece apart from the bad financial state of the sector. The IBLC could probably enhance the sector and push it to new markets and operations.

4 WINE SECTOR

4.1 Profile of the wine sector

4.1.1 Production

The primary feedstock for the wine production is grapes and the end products are wines of different variety. The main steps for the winemaking (which are presented in Figure 10) are the following (Recchia, Daou et al., 2009):

- Harvest: The grape clusters are cut from the vineyard and placed in bins or boxes and then transferred to larger containers for transport to the winery.
- Break: The grapes are crushed and their stem is extracted at the same time by a crusher consisting of a perforated cylinder with rotating blades.
- The separation of the juice: The crushed grapes are placed in a cylinder, and the tube being inflated presses the grapes against the sides of the rotating cylinder and causes the juice to be extracted through the perforations.
- The processing of must: White musts are often turbid and it is necessary to settle the suspended particles to separate them.
- Fermentation: During this process, the grape juice (sugars present in the must) transforms into an alcoholic beverage.
- Processing after fermentation: With suitable composition of the must, yeast type, temperature and other factors, the alcoholic fermentation stops when the available amount of sugar that can be fermented becomes too low.
- Mineral fermentation: In malonic lactic fermentation, malic acid degrades into lactic acid and carbon dioxide. Fermentation is caused by enzymes produced by certain lactic acid bacteria.
- Separation: Some wines expel part of them very quickly, and the extra wine remains almost shiny. Removal of the waste material during maturation is called separation.
- Refining: A process in which a material that helps to separate wine is added. The main processes involved are adsorption, chemical reaction and adsorption and possibly physical motion.
- Filtration: The original filters were made up of the rough fabric-covered holes through which the wine was poured.
- Centrifugation: Centrifugation, or high speed rotation, used to separate musts, is also applied to wines that are difficult to separate by other means.
- Cooling: Temperature reduction often prevents yeast growth and carbon dioxide production, which tends to keep yeast cells inhibited.
- Exchange: Another method to stabilize the tartrate is to pass a part of the wine through a device called ion exchanger.

- Heating: Pasteurization at 70 to 82 °C can also be used to precipitate proteins, but in modern practice this process is rarely adopted to help in the separation.

Furthermore, in most wineries another process is also followed in order to reuse the main by-products coming out from the winemaking procedure. This process concerns the part of the wine distillery. The feedstock for the distillery process is the grape marc. This is the residue from the pressing of the grapes and the removal of most of the juice destined for the production of wine. As a raw material it is also used for vinegar production and a very small percentage for pure and aromatic wines.

The process of distillery starts with the stirrer and heating of the marc in order to export the distillate. After the marc's heating, the vapors are collected into the distillation vessel where the distillate is separated from undesirable ingredients. Next, the distillate's alcoholic strength is checked by a special system and finally it is directed to the collection tanks. The final distillate' alcoholic strength is 75 % vol. Mixing and dilution tanks follows in order to obtain the required alcoholic strength (40 % vol) and desirable organoleptic characteristics.

Figure 10 below presents the above mentioned steps for the winemaking procedure and Figure 11 shows the main process stages of a wine distillery. More specifically it presents the main distillery process procedure of the Lafazanis winery, one of the biggest winery-distillery in Greece. Most of the Greek wineries include the distillery procedure in order to use all the residues produced by the winemaking process; there are also wineries and distilleries that are operated as separated units.

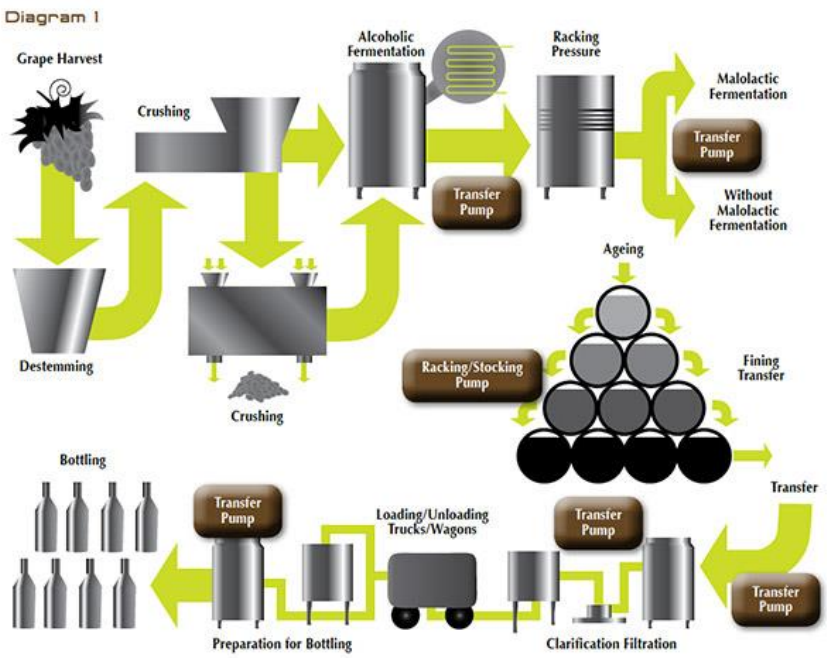


Figure 10. The main stages of the winemaking process. Source: (Food info)

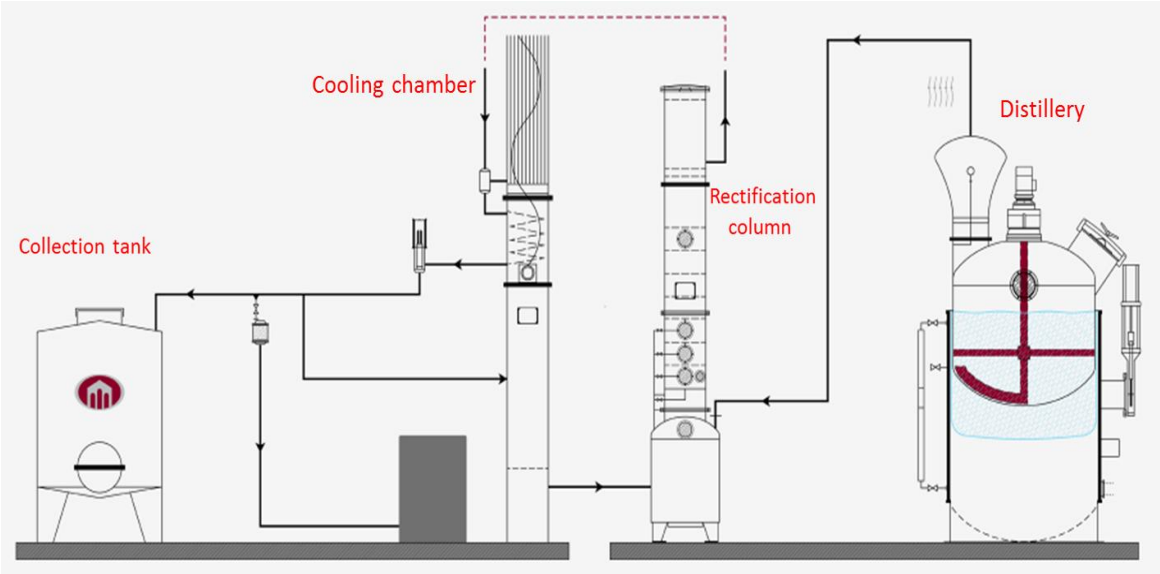


Figure 11. Distillery process. Source: (Lafazanis winery)

4.1.2 Volume of the sector

The wine sector in Greece, as director of KEOSOE (Central Cooperative Union of Wine Products) stated, is estimated to consist of 1,100 wineries, 40 cooperatives and around 100 distilleries producing more than 7,000 labels. Greece produces 34 PDO (Protected Destination of Origin) labels and 120 PGI (Protected Geographical Indication) labels. According to the statistical data from the Ministry of Agriculture the total wine volume for the wine-growing period of 2015-2016 was 2,458,421 hl of wine, from which 745,809 hl were red wine and the rest 1,712,612 hl were white wines. Moreover, in order to understand the volume of this sector, Table 13 presents the total wine production in accordance with the total vine cultivated area in Greece.

Table 13. Annual wine production from 2011 to 2016. Source: (KEOSOE)

Wine production from 2011 to 2016					
	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016
Total cultivated area (ha)	66,473	65,330	65,020	64,048	62,723
Total wine production (1,000 hl)	2,660	3,050	3,268	2,750	2,458

Figure 12 shows a clearer picture about the wine production in Greece. The most productive region in Greece is Peloponnese with a percentage of 29.30 % of domestic wine production and then follows Attica and Central Greece with a percentage of 20.16 % of the domestic wine production.

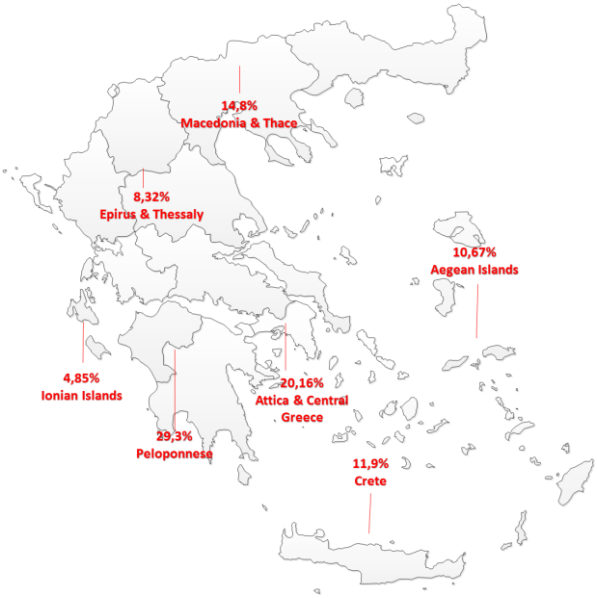


Figure 12. Percentage distribution of the wine production in Greece. Source: (KEOSOE)

Additionally, regarding the distribution of the cultivated wine grapes varieties by region, the next thematic map (Figure 13) illustrates the areas with the most important wine grape variety by region and their percentage contribution to the total produced wine of the region (ELSTAT, 2015).

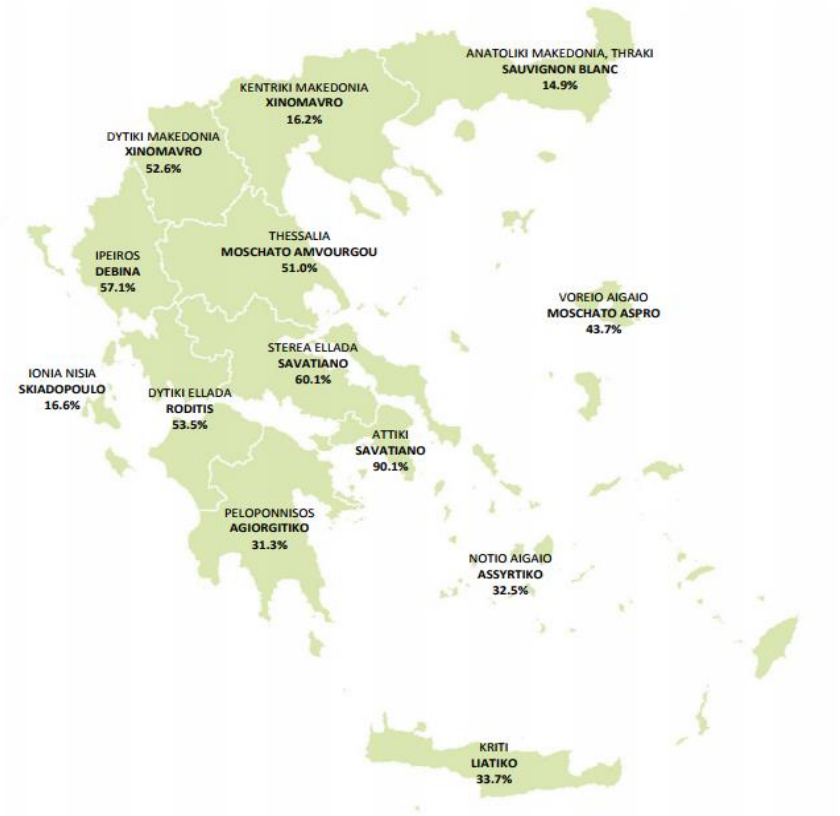


Figure 13. Main wine grape variety by region. Source: (ELSTAT, 2015).

4.1.3 State of the sector

The wine sector in Greece has a significant role in the economy of Greece. Apart from the employment positions that it offers, the wine sector has one of the highest turnovers in agro-industries. Table 14 presents an overview of the annual turnover of wine sector during the last years, 2011-2014 (inr.gr, 2014). For 2017, the annual turnover of wine sector was estimated at 380 M€ (personal communication, KEOSOE, 2017)

Table 14. Annual Turnover of Wine Sector in Greece. Source: (inr.gr, 2014)

Annual Turnover of Wine Sector in Greece				
	2011	2012	2013	2014
Turnover (M€)	200	197	180	181

Moreover, the Greek wine sector has significant imports and exports. For example, in 2015-2016 the imports of wine were rising at 208,952 hl with a value of 33 M€ and the exports were rising at 301,253hl, with a value of 74 M€.

Table 15 presents the main wineries based on their annual sales for year 2014.

Table 15. Economic size of the biggest Wineries in Greece. Source: (inr.gr, 2014)

Economic Size Of The Biggest Wine Companies In Greece				
NAME	LOCATION	TOTAL ASSETS (M€)	SALES (M€)	EBITDA (M€)
TSADALIS S.A.	Chalkidiki	83	31	4
GREEK WINE CELLARS-KOURTAKIS S.A.	Markopoulo	34	26	0,8
CAVINO	Aigio	22	17	0,9
BOUTARI S.A.	Naoussa, Crete, Santorini, Kilkis	46	12	-0,1
KOUTSODIMOS S.A.	Nemea	5	6	0,6
TSAKTSARLIS- GEROVASILEIOU S.A. (VIVLIA CHORA)	Kavala	11	6	1
LAZARIDI S.A.	Drama	36	6	0,5

4.1.4 Typical size of the companies

The total annual production capacity of a typical winery in Greece reaches 4,000 t of wine per year (Lafazanis winery). Although, it is worth to mention that the total annual production capacity of the biggest winery in Greece is 20 thousand hl (in wine and spirits).

Moreover, according to the feedback from the stakeholders the amount of permanent workers that are employed in the whole wine sector are around 24,300 employees.

4.1.5 Distinctive facilities of the sector.

The facilities that are used in this sector are in full operation during the months from October to February. The rest of the year, the facilities operate for the marketing of the wines (packaging, bottling and trade). Unfortunately, due to the complexity of wine production process these facilities cannot be used for every other procedure. Perhaps, the centrifugators and the distillation equipment that are used in the distillery process can also be used in other industries whose finally products are distillates like beer or other alcoholic industries. Furthermore, the storage facilities that are used in this sector can possibly store other material during idle months for the wineries.

4.1.6 Degree of innovation

Unfortunately, the stakeholder from the Greek wine sector stated that during the last years, due to the economic crisis, there is no currently interest for innovation/ R&D actions. He stated that most facilities in the wine sector do not operate with the state of the art machinery but they are trying to catch up with the latest developed technologies.

However, large wineries in Greece use the latest/ state of the art technologies for the production of wine. A minority of wineries have some R&D activities. For example, one of the biggest winery in Greece (Lafazanis) develops a new innovative technique in the field (precision agriculture), in order to maximize the productivity of grapes, by means of biological cultivation.

4.2 Opportunities IBLC

4.2.1 Sector related residues

The main solid by-products and residues produced in modern winery industries include: the grape pomace (marc), the grape stalk, the wine lees and the winery wastewater (vinasse). Moreover, the main by-products coming from the grape pomace are: the seeds and the skins left after the crushing, draining and pressing stages of wine production. Grape marc is commonly processed to produce alcohol and tartaric acid, which results in a new lignocellulosic by-product, spent grape marc. The wine lees are accumulated in the bottom of grape juice or wine fermentation tanks. The distillation of the alcohol from low-quality wine, wine lees and grape marc produces a large quantity of a viscose and acidic wastewater known as vinasse. In many wineries, an aerobic depuration process is operated after the distillation to treat the winery effluents such as vinasse and winery wastewater, therefore, generating waste biosolids. A large proportion of the wastewater comes from cleaning and cooling processes (Poonam Singh nee' Nigam, 2009).

Wine cellars by-products (such as the dried grape marc, lees and vinasses) and residues (such as the grape stalks) can be used for energy purposes. Figure 14 presents an estimation for the amounts and compounds of the most generated (in terms of amount of kg) by-product in winemaking.

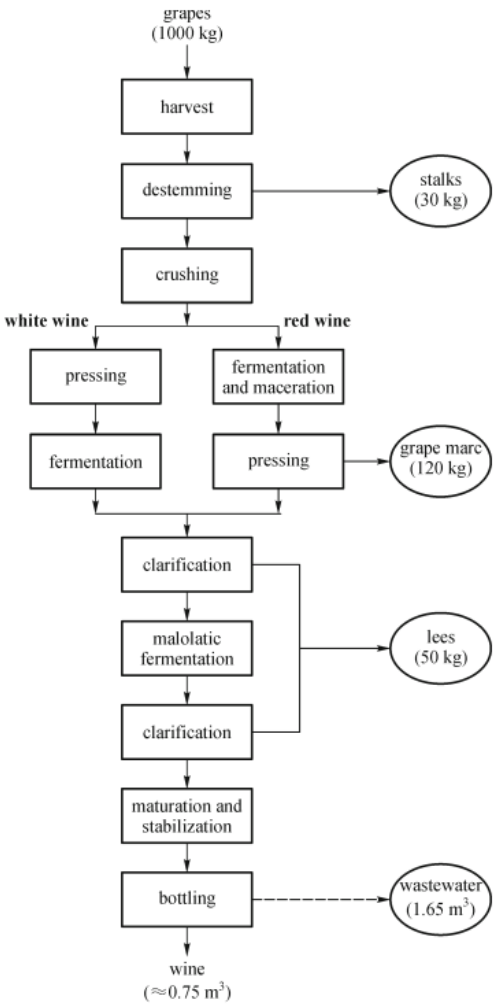


Figure 14. Winemaking by-products. Source: (Oliveira, 2014)

According to these estimations (from Figure 14) and assuming that 1 liter of wine corresponds to 1.2 kg of grapes, the estimated by-products of the wine sector are presented in Table 16.

Table 16. Greek primary wine industry by-product estimation for 2015-2016.

Greek wine industry by-product estimation (2015-2016)	
Material	kt/ year
Grape for wine production	295
	Ml/ year
Wine	245.8
By-products	kt/ year or Ml/year
Stalks (kt/year)	8.8
Grape marc (kt/year)	35.4
Lees (kt/year)	14.7
Wastewater (Ml/year)	487

Another main residue that derives from the wine sector is that of vine prunings. Vine prunings, as in the case of olive prunings, are not exploited. When pruning is performed, the most common practices followed for these residues is burning them in open fires, which contributes negatively to the environment, and mulching of this biomass in order to incorporate it into the soil as fertilizer. However, these residues can be exploited in different ways, mainly in the energy sector.

As in the case of olive prunings, there are no recent national surveys based on field data regarding the availability of vine prunings in Greece. Like in the olive sector, three methods estimate the potential of vine prunings. The methods are described in paragraph 2.2.1 "Sector related residues" of olive oil sector. The moisture considered in all methods is 40 % wt for vine prunings. The vine pruning potential is presented in Table 17 based on these methods.

Table 17. Potentials (kt of dry matter per year) for vine prunings in Greece according to several data sources.

Potentials for olive prunings (kt of dry matter per year)			
Source	Reference Year	Methodology	Vine Prunings
Apostolakis et al.	1980	RPR + national production statistics	566
Biomasud Plus	2014	- // -	398
S2Biom	2020	RSR + CAPRI surface projections	93

From the three methods, the national annual pruning potential is estimated in a range of 93-566 dry kt. Finally, in the framework of uP_running project (Grant Agreement No 691748) on-field measurements of vine pruning production were performed in several vineyards around Greece. Based on these on-field measurements, S2Biom's RSR values are more in line with the RSR values found from the on-field measurements for vine prunings.

4.2.2 Potential synergies & benefits

In the wine sector, several papers present the potential of using wastes from wine distilleries for the production of energy and biobased products.

Zacharof (Zacharof, 2016) investigated the valorization of winery wastes and their exploitation as feedstock to produce platform chemicals, biofuels, and energy. The paper proposes schemes to be applied in wineries at industrial scale in order to further use the wastes that are generated.

Both the solid and the liquid winery wastes can be used successfully as feedstock for the production of high value chemicals. This can be achieved either in a conventional chemical-biochemical biorefinery (wine lees, vinasses, grape marc) (Figure 15) or in green biorefinery (leafs, grape pomace) (Figure 16) or in a lignocellulosic biorefinery (stalks, peels, seeds, trimming vine shots, pips, pomace) (Figure 17).

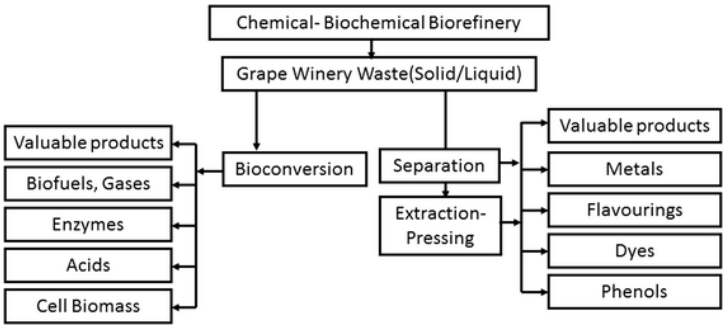


Figure 15. The chemical-biochemical biorefinery assortment applied to winery waste. Source: (Zacharof, 2016)

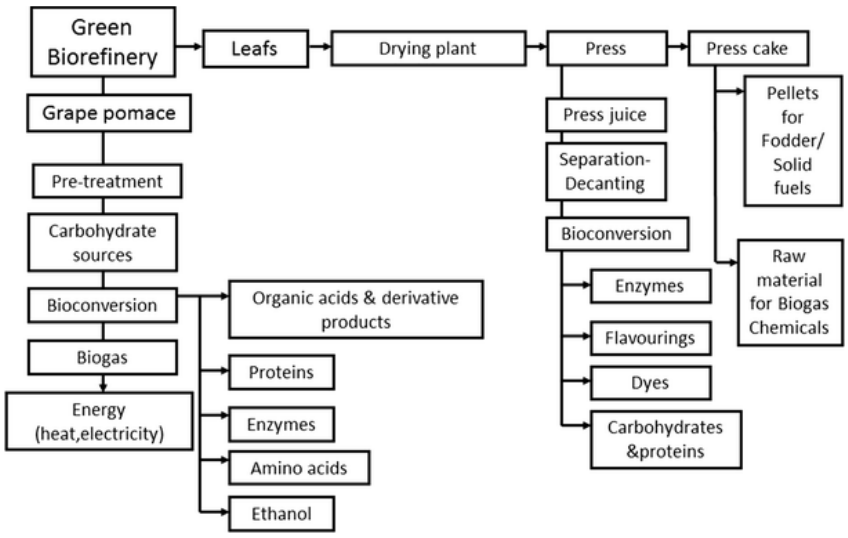


Figure 16. The green biorefinery assortment applied to winery waste. Source: (Zacharof, 2016)

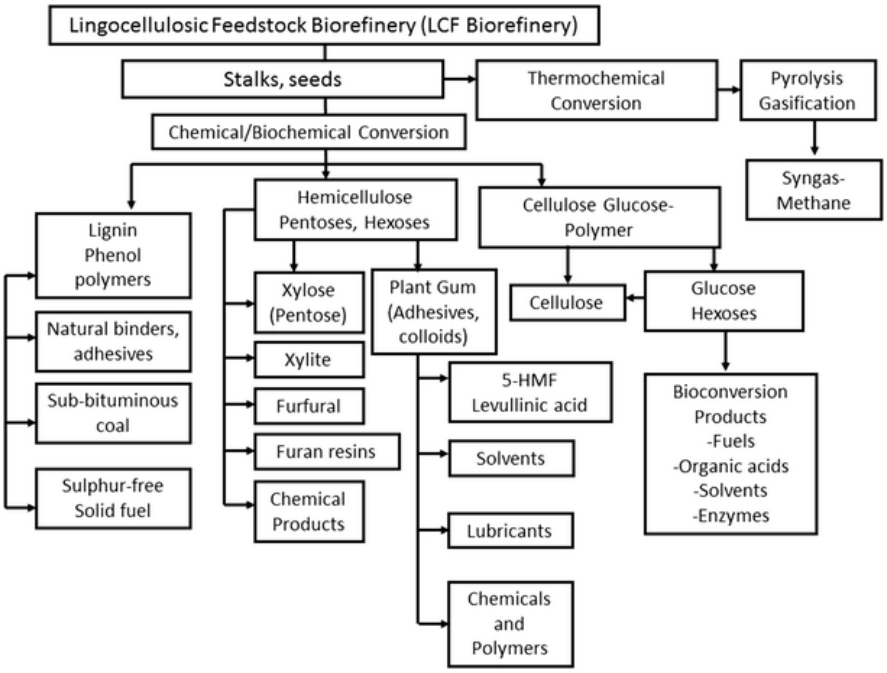


Figure 17. The Lignocellulosic Feedstock (LFC) Biorefinery assortment applied to winery waste. Source: (Zacharof, 2016)

4.2.3 Market developments

The winery residues (wine lees, grape marc, vinasses and wine leaves) can be used as feedstock to produce platform chemicals such as lactic acid, extract polyphenols (e.g. resveratrol) to be used in cosmetics, biofuels including ethanol, enzymes, chemical intermediates, and energy through pyrolysis and anaerobic digestion.

From the communucation with the stakeholder of the Greek wine sector, he stated that from the wineries residues, the grape marc is currently used in the market as fertilizer. It is not eligible for the production of animal feed due to the odor.

Furthermore, there are several ways to exploit the wastes from wineries. For example, an Australian company Australian Tartaric Products (ATP, 2015) collects wastes from local wineries, distills them to make grape spirit and extract tartaric acid which is used again in the wine industry. Continuously, the company generates steam by burning the grape wastes in a biomass boiler and sells the excess of electricity generated, after covering its own power consumptions.

In addition, the vine prunings can be used in order to produce pellets or chips for solid biofuels market or they can be used directly as feedstock for power and/or heat plants. Such is the case of Pelets de la Mancha. This company, which is located near the town of Socuéllamos in Spain, manufactures solid bio-fuels in pellet and chip exclusively form from vineyard prunings and sell its products either to public or private companies which use pellet for heating purposes as well as industrials units, or to large companies that produce power from biomass. Moreover, the pellets can be used in buildings with a high heating demand (where medium sized boilers above 200 kW can be installed) and the chips can be used for heating use and industrial use in small/medium/large enterprises (uP_running). Additionally, another recorded case is according to Corona & Nicole (Corona et al., 2010), Settesoli -a huge winery in Italy- which decided to construct a biomass energy plant of 1 MWe that would use as feedstock the vine canes from pruning, along with pomaces and wastes from the winemaking process.

4.2.4 Non-technical barriers

No specific barriers were found regarding the implementation of the IBLC concept to the wine sector apart from the fact that economic crisis has made most of the companies turn into themselves, unable to invest or be “open” to new innovative ideas or investments. Another main barrier is the lack of knowledge of the sector’s stakeholders on the exploitation of agro-residues.

5 GRAIN CHAIN

5.1 Profile of the grain sector

5.1.1 Production

The most important grains that are cultivated in Greece are wheat, both soft and durum, barley, oats, rye and maize (grown alone and grown with beans and other crops). Cereals are the most important category of plants grown for human nutrition. From cereals one of the basic types of human food, bread, is produced as well as raw materials for the food industry, fodder, etc.

The production process, that follows the harvest of wheat, has the following stages and it is presented in Figure 18 (Greek Flour Millers Association):

1. **Receipt and storage -** The wheat is received from ships and trucks. Cereals undergo meticulous sample checking, in order to verify the quality of the product. Upon unloading, the wheat is weighed and is subjected to an initial mechanical cleaning to remove impurities.
2. **Cleaning -** Before being milled, the wheat must be fully cleaned from any impurities and wetted to the desired level for milling. The impurities that may be present in wheat are: grains of other cereals, straw, paper, stones, sand, dust, glass, metal. Impurities are separated from the wheat mechanically based on:
    - Size
    - Shape
    - Specific gravity
    - Magnetism
3. **Wetting -** The wheat's moisture content must be kept at certain levels in order to achieve the best possible separation of the flour from the bran. The amount of added moisture and the residence time of the wheat before milling depends on its hardness, climatic conditions and the moisture specifications of the finished product. The wetting of wheat allows a more efficient separation of bran from the endosperm and the appropriate degree of softness of the interior grain to achieve good performance during milling.
4. **Milling -** The milling process aims to remove the endosperm (flour) from the bark (bran) of wheat. This is accomplished through a gradual milling process, carried out with the help of rollers and consisting of three steps:
    - The breaking system (which separates and removes the endosperm from the bran in relatively large pieces).
    - The scraping system (which removes small pieces of bran and germ, which are attached to the endosperm).
    - The reduction system (which mills the endosperm into flour).
5. **Mixing -** Mixing allows the creation of a large number of products, homogenising different flour and auxiliary materials at the desired ratio.

6. **Special Processing -** Special processing consists of:
    - Drying
    - Separation of proteins
    - Heat treatment of bran and milling fractions
7. **Storage and Packaging -** The flour created by milling is transferred into storage silos. From there, the flour will be taken to a control screen, a packaging device, a metal detector and finally a palletising device.
8. **Quality Control -** The quality control of the flour begins with the control of the received wheat, continues in the various stages of milling and ends with the control of the final product. The quality control ensures that the flour has the best qualities, while also performing tests to verify that the grains are free of harmful toxins, pesticides or other harmful microorganisms.

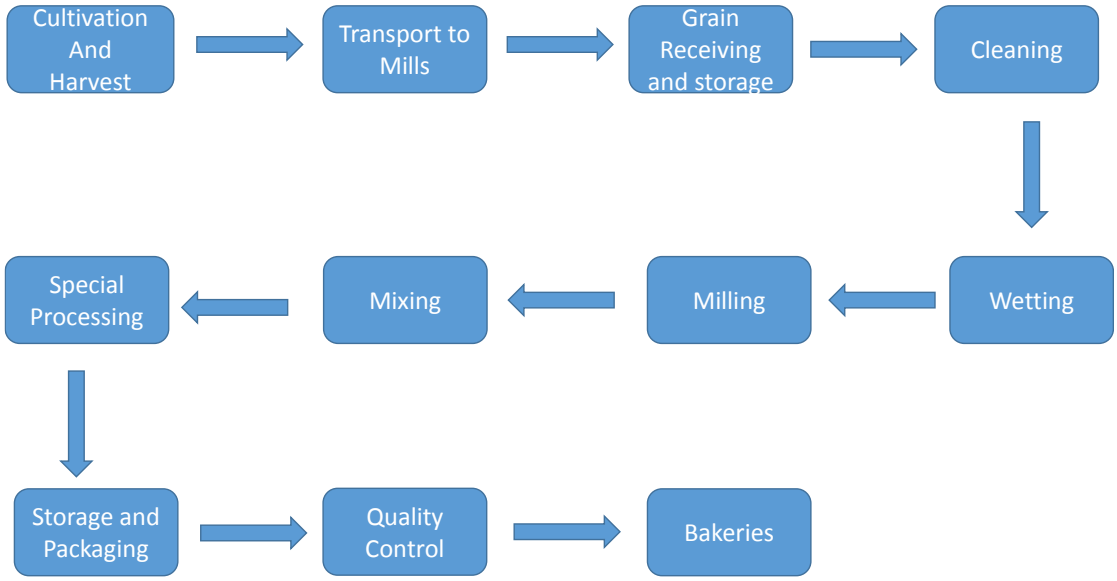


Figure 18. Overview of the grain production process. Source: (Greek Flour Millers Association)

5.1.2 Volume of the sector

According to the annual cereal balance for the production period 2015/2016, the total amount of the cereal production in Greece was 3,183,756 t in a cultivated area of 926,965 hectares. In Table 18 the cereal balance is presented for the economic year 2015/2016.

Table 18. Production of Grain in Greece. Source: (Ministry of Agriculture, 2016).

Cereal Balance 2015/2016					
	Initial stocks (t)	Using production (t)	Area (ha)	Yield (t/ha)	Human consumption
Soft wheat	80,000	352,975	154,843	2.28	615,000
Durum wheat	80,000	785,657	332,525	2.36	671,000
Barley	6,000	353,886	154,112	2.30	5,000
Maize	170,000	1,542,304	152,047	10.14	5,000
Rye	2,500	22,974	15,715	1.46	3,000
Sorghum	800	10,274	2,861	3.59	100
Oats	5,000	83,058	96,013	0.87	500
Triticale	2,500	31,989	18,888	1.69	200
Rest	1,500	639	234	2.73	300
Total cereal	**348,300**	**3,183,756**	**926,965**	**3.43**	**1,300,100**

5.1.3 State of the sector

Grain chain consists one of the most important sector in Greek economy with serious imports as well as exports quantities as it can be seen in the Table 19.

Table 19. Total imports and exports of grain chain in Greece. Source: (Ministry of Agriculture, 2016).

Grain Chain Imports/ Exports 2015/2016		
	Total imports (t)	Total Exports (t)
Soft wheat	907,773	11,607
Durum wheat	181,248	205,528
Barley	105,715	748
Maize	484,123	25,685
Rye	1,349	71
Sorghum	552	21
Oats	10,328	48
Triticale	84	28
Rest	15,183	80
Total cereal	**1,706,355**	**243,817**

Moreover, Table 20 presents an overview of the annual turnover of grain sector during the last years (2011-2014).

Table 20. Annual Turnover of Grain Sector in Greece (2011-2014). Source (inr, 2014)

Annual Turnover of Grain Sector in Greece				
	2011	2012	2013	2014
Turnover (k€)	400,045	382,868	361,099	343,164

As it can be seen from the annual turnovers, the grain sector in Greece has a decline during the last years due to the low profit margins and the economic crisis. Several grain mills operate in Greece. The largest mill according to the information gathered from the stakeholder as well as from the table below, is the LOULIS MILLS SA., with a market share of 25 %. After that, about 10 more companies follows with a total market share of 40 %. Around 100 smaller companies are also operating in the sector, the majority of which is facing serious economic problems. Table 21 presents the main grain mills based on their annual sales for year 2014.

Table 21. Economic size of the biggest Grain mills in Greece. Source: (inr.gr, 2014).

Economic Size of the main Mills In Greece				
NAME	LOCATION	TOTAL ASSETS (k€)	SALES (k€)	EBITDA (k€)
LOULIS MILLS S.A.	Thessaloniki, Kavala, Volos	161,303	88,006	9,589
PAPAFILI MILLS S.A.	Korinthos	44,054	39,565	3,212
KEPENOS MILLS S.A.	Patra	36,715	35,865	3,300
MILLS OF CRETE S.A.	Chania, Crete	77,666	35,533	2,446
MILLS THRAKIS S.A.	Evros	35,123	34,360	2,201

5.1.4 Typical size of the companies

Currently, grain chain sector in Greece consists of few large and high-tech industries, small amount of medium scale industries and a large number of small-family scale industries with low capacity and older equipment. Today, flour mills and industries in Greece that produce and trade flour account to 800 approximately (personal communication, AIXMEAS, 2018). These industries can be divided based on their capacity in:

- Units with production capacity over 500 t of grain grinding per day. Such industries are “AGIOU GEORGIOU MILLS” and “LOULIS MILLS SA”. The large industries of the sector are equipped with the latest technology machines. These industries have specialized personnel, labs for quality assurance of raw material and products and appropriate storage sites for the products.
- Units with capacity between 100-200 t per day such as "GIANNITSON MILLS SA." and AGIOU DIMITRIOU MILLS SA”.
- Units with capacity lower than 100 t per day. Under this group a large number of family businesses are included that usually have low productivity and satisfy local markets.

According to stakeholder feedback, around 3,000 permanent and seasonal employees, apart from the grain farmers, can be found in the whole grain chain sector.

5.1.5 Distinctive facilities of the sector

Unfortunately, the grain facilities are in full operation during the whole year, usually this refers to large companies of the sector, and as a result all the equipment is used for the production purposes. However, most of the grain chain sector companies possess numerous storage silos, in order to store the annual cereal production for their clients. These silos can be used for storing different kind of products when they are low on cereals.

5.1.6 Degree of innovation

According to the agronomist of the LOULIS MILLS SA., the large companies of this sector invest into innovative ideas considering the waste management of their residues or the use of them into renewable energy. Indicatively, LOULIS MILLS SA does not appear to have any residue during the whole year as they manage and exploit them for their energy purposes (e.g. for heating purposes during the procedure process of their main products).

Furthermore, companies in the grain sector invest in technologies in order to be able to produce "functional" products, meaning products with better quality, with no diseases, without gluten etc.

5.2 Opportunities IBLC

5.2.1 Sector related residues

The primary biomass residue, which is produced by the cereal production, is mostly straw with smaller biomass components such as chaffs. Usually producers leave the straw on the field with the aim to incorporate it into the soil as a natural fertilizer or they collect it in order to use it for livestock bedding. This biomass is identified as having most potential when used for ethanol production.

Residues are also derived from the industrial processing (milling and grinding) of the cereals. Today, the majority of these residues is used in animal fodder. A typical cereal flour plant in Greece produces almost 50,000 t of by-products each year and sell them either in bulk form or in packages as animal feed.

However, the evaluation of the quantities and geographical distribution of this category of residue is complicated because of the different processing technologies, the size and location of the processing plants and the characteristics of the final products. Furthermore, there is no official data on the production of agro-industrial products at regional level in Greece that could facilitate the estimation of the residues produced. Therefore, it is necessary to follow different methodologies, according to the availability of data for each type of residue. For this reason, in order to estimate the cereal residues quantities for the economic year 2015/2016, above mentioned amounts of cereals and the product/residue ratio which is found in literature (OECD, 2004), are used. The calculated quantities of the cereal residues, deriving from grain crops, are shown in Table 22.

Table 22. Grain crop residues studied for Greece sector.

Cereal Residues Quantities for the economic year 2015/2016					
	Moisture (%)[1]	Production (t)[2]	Product/Residue ratio[1]	Residues (t)	Type of residues
Soft wheat	15	352,975	1.00	352,975	straw
Durum wheat	15	785,657	1.00	785,657	straw
Barley	15	353,886	1.24	285,392	straw
Maize	60	1,542,304	1.42	1,086,130	stalks
	50		3.75	411,281	cobs
Oats	15	83,058	1.27	65,400	straw

[1] *Source:(OECD,2004)*

[2] *Source: (Ministry of Agriculture, 2016).*

5.2.2 Potential synergies & benefits

Mainly the straws produced as residues from cereals can find various applications. Straws can be used as raw material for energy purposes such as pellets or for the production of bio-chemicals and biofuels. Unfortunately, the existing facilities cannot cover the needs for the exploitation of this biomass. New technologies should be adopted in order for the grain mills to be able to process the generated residues.

5.2.3 Market developments

Cereals, are a major source of agricultural waste in many countries. As it was mentioned above the most common residue of the grain chain sector, straw, can be utilized as raw material in order to attain bio-energy markets through the production of solid bio-fuels (in the shape of pellets perhaps) or by directly using it. These agro-residues can be exploited in energy plants with the aim to produce energy from the straw combustion. This idea could open new roads in the bio-energy markets but so far it consists difficult the start –up of this business line (especially in Greece) due to the difficult economy situation as well as to the prices variability of this sector.

However, grain chain residues can be used for cattle feed, fertilizers as well as in compost production and this leads to the development of new markets. Already, these operations are followed in some countries (e.g. Vietnam) but due to the low finance sources, there are problems regarding the waste management. Nevertheless, it is worth to show a typical scheme of the available exploitation paths of grain residues that could be the pioneer for a new market business line in the existing agro-industries.

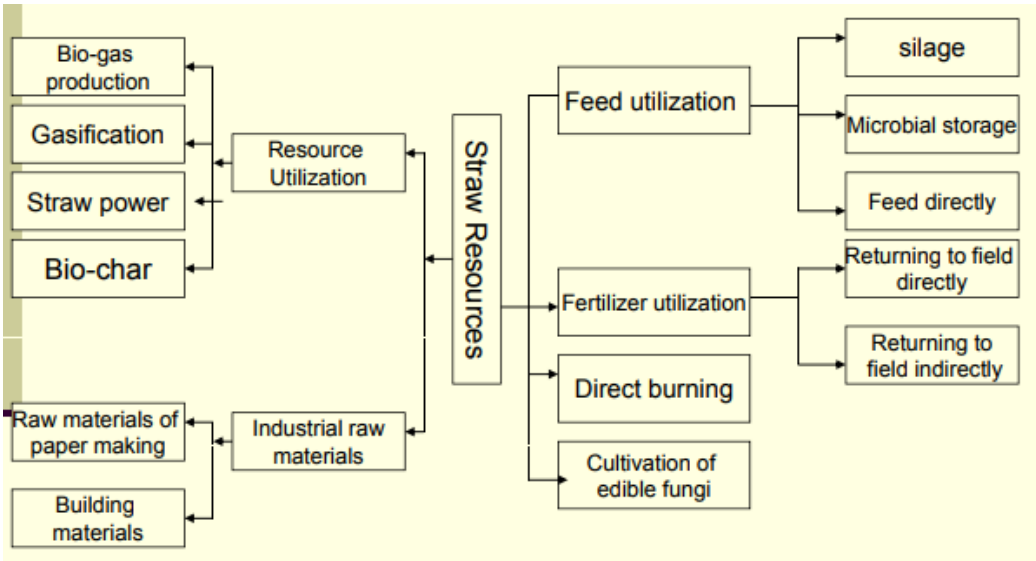


Figure 19. Typical management practice model of straw utilization. Source: (Dang Khanh, 2010)

5.2.4 Non-technical barriers

The main barrier, according to the interviewed stakeholder, is that eventually there are no idle times for the available equipment and the amount of by-products produced are totally consumed either as animal feed or for energy purposes.

Another barrier, mentioned by the sector's stakeholder (personal communication, AIXMEAS, 2018) is that it would be difficult for the farmers to give their agricultural residues (e.g. straw) to the IBLC as they incorporate them on their fields, giving organic matter to the soil. Thus, the farmer needs something else to replace the agro-residue and give the organic matter to his soil. As a result, the stakeholder stated that in order for the exploitation of agro-residues in the grain chain to be feasible, a synergy must be established between the grain farmers and the IBLC or end user. The farmers will have to take something in exchange of the agro-residues (straws), for example some money, in order to buy bacteria or the appropriate material to increase the organic matter of his soil.

6 VEGETABLE OIL EXTRACTION

6.1 Profile of the vegetable oil extraction sector

6.1.1 Production

There are several vegetable oil extraction industries in Greece. Vegetable oil is extracted from various primary feedstock like cotton seeds, soya, sunflower, etc. Apart from vegetable oils, other products derive from these crops like seeds and fats that are used in animal feed. Vegetable oil is used either for edible use or for the production of bio-diesel.

One of the main companies in the vegetable oil extraction sector in Greece is SOYA Mills with several units across Greece. SOYA Mills produces and exports seed oils such as sunflower oil, soybean oil, rapeseed oil and proteins derived from processing oilseeds. In its main processing unit there are two modern processing units which undergo the following procedures:

- **Oilseed Processing Unit**: Oilseeds (such as soybeans, rapeseeds, sunflower beans) are crushed to produce edible oil and protein meal. Incoming oilseeds, received by vessels, are transported to silos for storage. From there, they are forwarded to the pre-treatment plant. The process begins by cleaning the seeds to remove impurities. Next, they are cracked and dried, before they are formed into flakes, which are to be pressed crushed at the next stage. The cake produced is then subjected to an extraction process in order to remove any remaining oil. Before its storage, the protein meal is passed through a process of improving its nutritional value and digestibility. The other product resulting from the aforementioned treatment is crude vegetable oil.
- **Crude Vegetable Oil Processing Unit**: In order for crude oils to become edible, they ought to undergo a multi-stage process: Degumming, refining, bleaching and deodorization. In degumming, phosphatides (lecithin) are being removed by means of centrifugation. The refining process removes free fatty acids from the oil. Bleaching removes the pigments and various other impurities oil. Finally, the deodorization process removes volatiles through a distillation column.

The main overview of SOYA Mills processing procedures is presented in Figure 20 and the main stages that are followed during the vegetable oil extraction process are shown in Figure 21.

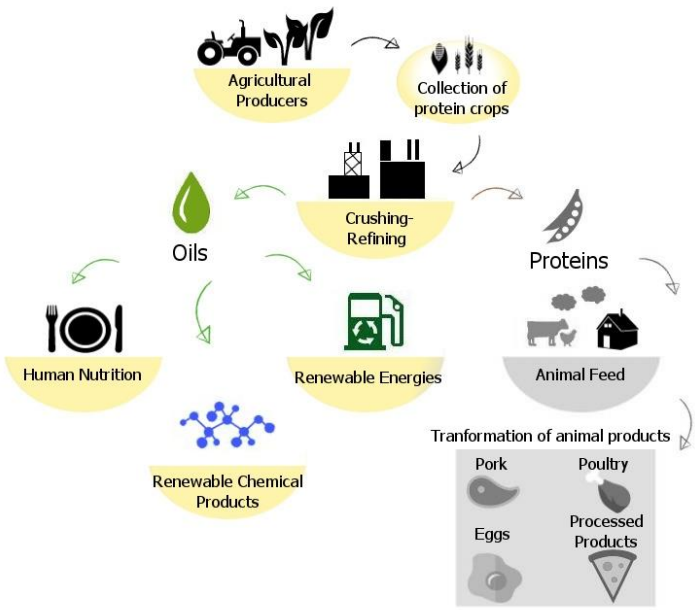


Figure 20. Overview of SOYA MILLS S.A. processing of oilseeds plant. Source: (SOYA MILLS S.A)

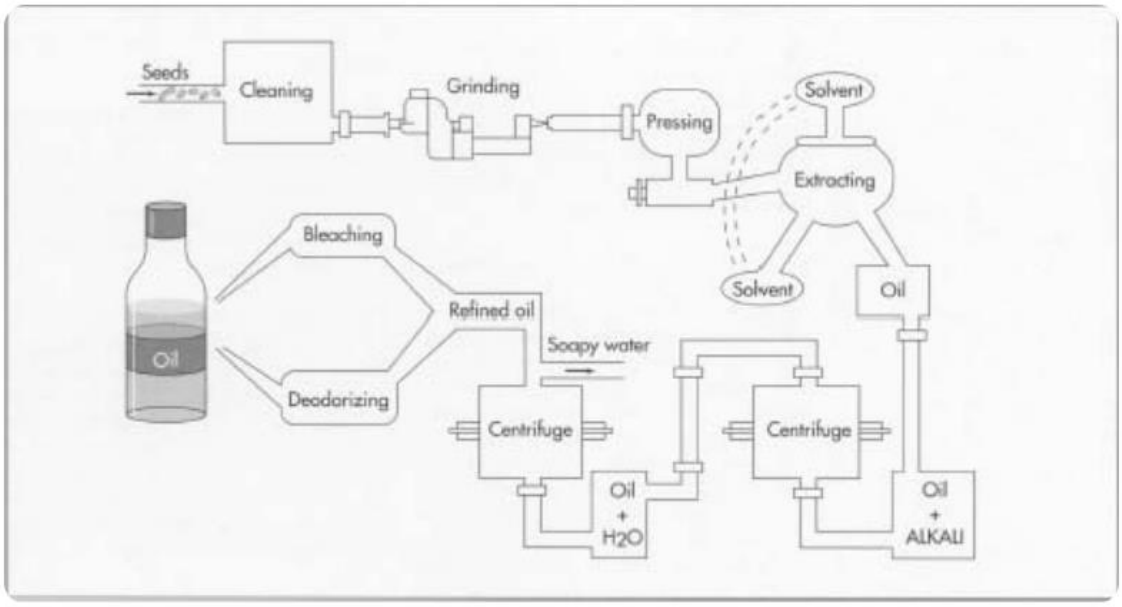


Figure 21. Main stages of the vegetable oil extraction process. Source: (madehow.com)

6.1.2 Volume of the sector

According to ELSTAT, a general view of the sector relevant to the productivity and cultivated area of the seed plants that can be used in vegetable oil extraction are presented in the following Table 23. The table shows the total seed production for the year 2014 (not only used for vegetable oil production).

Table 23. Production of Seed plants in Greece, 2014. Source: (ELSTAT, 2014).

Seed production in Greece, 2014			
	Production (t)	Cultivated areas (ha)	Oil content (%)
Seed Cotton	820,275	276,194	15-25
Sesame	187	184	50-60
Sunflower	192,227	76,381	35-52
Sorghum – Broom	371	76	-
Sorghum – Seed	101		
Groundnuts	2,693	757	25-30
Sugar beets	455,973	7,127	
Soya Seed	7,846	2,809	18-24
Rapeseed	8,173	4,623	30-50
Maize	1,861,149	167,364	3
Total	**3,348,995**	**535,515**	-

Moreover, the production of vegetable oils in Greece from different seeds is presented in Table 24 (Fediol, 2016) for the years 2014, 2015, 2016. The vegetable oil production in Greece these years remains almost stable.

Table 24. Production of Vegetable oils in Greece for 2014-2016. Source: (Fediol, 2016)

Vegetable oil Production, 2014-2016			
	2014 (kt)	2015 (kt)	2016 (kt)
Groundnut	4	4	4
Soya	50	50	61
Rape	9	7	7
Sunflower	45	48	38
Cotton	24	19	21
Maize germ	-	14	5
Total	**132**	**143**	**136**

Furthermore, there are 3 large scale vegetable oil extraction industries in Greece as well as a few industries of smaller scale (personal communication, NUTRIA, 2017).

6.1.3 State of the sector

The vegetable oil sector in Greece is relatively small compared to other EU countries. According to the production, imports, exports and consumption of vegetable oils (Table 25) the shape of the sector can be characterized stable as no major growth or decline appears in the latest years.

Table 25. Imports/ Exports and consumption of Vegetable oils in Greece. Source: (Fediol, 2016).

Vegetable oil Imports, Exports, Consumption in Greece			
	2014 (kt)	2015 (kt)	2016 (kt)
Imports	242	239	232
Exports	29	30	26
Domestic Consumption	345	353	342

In Table 26, the economic data of the most important vegetable oil production and standardization companies are concentrated. SOYA MILLS as well as SOYA ELLAS has the leading role in the Greek vegetable oil economy.

Table 26.Economic size of the most important Vegetable oil extraction and standardization companies in Greece. Source: (inr, 2014).

Economic Size of the main Vegetable oil extraction companies In Greece, 2014				
Company Name	Location	Total Assets (k€)	Sales (k€)	EBITDA (k€)
SOYA ELLAS	Evia	104,465	233,320	12,969
SOYA MILLS S.A.	Korinthos	120,587	210,276	11,733
PETTAS N.P.	Patra	11,649	126,619	12,355
MINERVA S.A.	Viotia	70,265	75,798	2,757
AGROINVEST	Fthiotida	118,929	92,096	9,181
XAIOTOGLOU	Thessaloniki	177,732	83,791	10,174
EGNATIA S.A.	Evros	5,473	2,928	154

6.1.4 Typical size of the companies

A typical Greek company that produces cotton oil is KAFANTARIS- PAPAKOSTAS S.A. Ginning & Oil Mills. They produce refined, bleached, deodorized cotton seed oil. The process they follow is by refining, bleaching and deodorizing neutral cotton seed oil. Neutral cotton seed oil is produced by pressing of cotton seeds. The annual production of the company is 2,000 t of seed oil.

A typical vegetable oil refinery can operate 300-400 t of seeds/ day (personal communication, NUTRIA, 2018).

6.1.5 Distinctive facilities of the sector

Vegetable oil industries mainly operate from September to April. The operation of the facilities depends on the feedstock these facilities use. For example, facilities that operate with sunflower, operate from September to April as mentioned above. However, facilities that use soya as feedstock, which is imported mainly in all periods, operate all year (personal communication, NUTRIA, 2018).

Some facilities of this sector can be also utilized for other purposes. Because of the similarities that are noticed among the vegetable oil extraction sector and olive oil sector, during the crushing and

centrifugation processes, equipment can be used for both purposes with modifications. Moreover, storage facilities can be used from the feed and fodder sector as the main by-products from this sector are intended for animal feed.

6.1.6 Degree of innovation

The vegetable oil extraction units use a simple technology, compared to other sectors such as pomace mills in olive sector. No special R&D activities have been performed on the vegetable oil sector in Greece.

6.2 Opportunities IBLC

6.2.1 Sector related residues

Oilseeds are supplied by agricultural producers and then crushed and processed into seed oils and vegetable proteins. In most cases, oilseeds can find various applications and especially as feedstock for renewable fuels. The primary use of vegetable proteins is that of animal feed. Vegetable oil is the main product derived by the processing of oilseeds and it can be used in animal feed industries, in chemical industries as well as for human's nutrition. The most important vegetable oils are soybean oil, sunflower oil, corn oil, rapeseed oil and palm oil. As we can see from the Table 27, the most valuable vegetable oil cultivations in Greece are the sunflower and the soya as they have the highest content of vegetable oil compared to all the other similar cultivations. Indicatively sunflower contains around 40 % of oil while soya 20 % of oil. After these two cultivations, cotton is followed with a content of oil around 20 % of the cotton seed. Due to the high cotton production in Greece, which is the highest in Europe (European Commission, 2017), the quantities of residues deriving from cotton cultivation are high compared to other residues. Currently, cotton-ginning residues are used as fuel in the cotton ginning plants for steam production for various internal uses (drying of cotton, wetting of lint, treatment of cottons seeds, etc.).

Table 27 presents the estimated residues of vegetable oil extraction regarding year 2016. The residues were estimated considering how much oil was produced from each seed specie and by knowing how much seed was crushed.

Table 27. Estimated Oilseeds Residues Quantities for 2016. Source: (Fediol, 2016).

Estimated Oilseeds Residues Quantities for 2016		
	Crushed oilseeds (kt)	Seed residues (kt)
Groundnut	10	6
Soya	329	268
Rape	16	7
Sunflower	86	48
Cotton	137	116
Maize germ	10	5

Furthermore, it is worth to mention that apart from the residues generated from seed crushing, there are also residues generated during the harvesting of seeds from the crops. These residues are agro-residues like straws, stalks etc. that can be exploited for energy or fuel use. Table 28 presents the estimated agro-residues generated from all the fields containing the corresponding crop used for the vegetable oil extraction in Greece. As a result, the table presents the potential of agro-residues of all the crops, not only the crops used for vegetable oil extraction but also for other sectors (e.g. grain-chain). The following quantities are estimated taking into consideration the RPR ratio and the seed crop production for 2014, as mentioned on Table 23.

Table 28. Estimated Field Residues Quantities for vegetable oil crops in Greece for 2014. Source: (Stephanie Searle, 2013)

	Estimated Field Residues Quantities for Vegetable oil crops, 2014			
	Moisture (%)	Seed production (kt)	Residue to Product Ratio (RPR)	Field Residues (kt)
Groundnut[1]	15	2.7	2.5	7
Soya[2]	15	7.8	2.5	20
Rape[2]	15	8.2	1.08	9
Sunflower straw[3]	40	192.2	2	384
Cotton stalks[3]	45	820.3	2	1,641
Maize stalks[3]	60	1,861.2	0.7	1,303

[1] *Source: (Gunther et al., 2007)*

[2] *Source: (Stephanie Searle et al., 2013)*

[3] *Source: (OECD, 2004)*

6.2.2 Potential synergies & benefits

Most of the residues produced during the crushing of oil seeds and extraction of oil, are used as feed and fodder. However, residues such as the husk of the oil seed can be used for different purposes and in different forms. In its primary form, it can be used as fuel in bioenergy plants, as well as for residential heating needs. In Greece and especially in Northern Greece there are several farmers or producers that prefer to use this type of biomass for heating purposes. However, due to technical problems when combusting it and its high logistic costs, sometimes this type of biomass must be transformed in different forms, like pellets. Because of the density of pellets, this format of biomass is much more easily transported or treated, thus leading not only to the reduction of the transportation costs but also it opens new markets for this kind of biomass.

6.2.3 Market developments

As it was abovementioned, the use of the husk that is annually produced in pellet form can help in the development of new markets for these by-products. These residues can be used for heat or electricity production. An indicative example consists a 1 MWe CHP plant in Greece (Biomasud plus, 2016) that uses residues from cotton seed as raw material to produce energy. Furthermore, pellets

coming from seed residues such as husks are sold in the fossil fuel markets as fuel for residential heating.

6.2.4 Non-technical barriers

The limited amount of seed cultivations in Greece along with the skepticism of Greek residents regarding the consumption of agro-residues as fuels in their houses instead of the “known” fossil fuels may create barriers for the current sector. The scarcity of available data and lack of communication among the stakeholder involved in the value chain makes it difficult to identify any further barriers.

7 SUMMARY ANALYSIS OF THE COUNTRY

Table 29. Summary sector "Olive Oil Mills"

Olive Oil Sector	
	Profile
Production	• The main input product in this section is the fruit of the olive tree. • In Greece there are two main types of olive oil mills: a) two-phase centrifugal mills and b) three-phase centrifugal mills • Greek olive oil mills mostly use two-phase technology (60 %) rather than the three-phase technology (40 %). • Olive mills' residues (pomace) are sent to pomace mills for pomace oil extraction and other by-products.
Volume of the sector	• Greek annual production ranges from 300,000 to over 400,000 t of olive oil per year. In 2014, the production of olive oil was at 241,400 t. • Total cultivated area in Greece is around 0.8 million hectares of olive groves. • The value of the produced olive oil is estimated at 800 M€ and contributes at 0.4 % of the national GDP (2010-2015). The recent years, the sector contributes more than 0.4 % of the GDP. • 31.2 % of the total olive oil produced in Greece comes from Peloponnese, 24.8 % from Western Greece and 24.1 % from Crete. • 2,500 olive mills, 35 pomace mills in Greece, 7 large scale and 3-4 small scale oil refineries. 36.5 % of olive mills in Peloponnese, 23.3 % of olive mills in Crete.
State of the sector	• Only the 27 % of the Greek olive oil is distributed for domestic consumption and the rest (70 %) is exported (100,000 to 135,000 t). • The total sales for economic year 2014 amounted to 832.7 million euros, 16.2 million euros lower than the previous year. • After the historical low productivities/ sales of olive oil of years 2011-2014, current year (2017) has increased productions and sales.
Typical size of the companies	• In Greece, olive mills are mostly owned by cooperatives controlled by farm owners. • An average capacity for a typical Greek olive oil mill ranges between 200-230 t of olive oil production per year. A typical pomace mill has a capacity to treat 450-500 t of pomace/day. • Around 15,000 seasonal workers in olive mills. Around 210 permanent workers and 875 seasonal workers in pomace mills.

	• Around 140,000 seasonal workers in farming and harvesting activities of olives.
Distinctive facilities of the sector	• Operation from September to March for olive and pomace mills. • Pomace mills larger than olive mills and more sophisticated. Better candidates for IBLC implementation. Several facilities could be available for implementing IBLC concept such as dryers, centrifuges and storage areas. • Facilities could be exploited in idle times with other raw material as alfalfa, clover etc., however additional equipment is needed.
Degree of innovation	• In Greece there is a tendency to change the three-phase to two-phase centrifugation as it is eco-friendlier and due to national legislation. • Sector trying to keep up with the state-of-art technologies. However, R&D activities are performed by the minority of companies. Pomace mills are absent from national development and funding schemes.
	Opportunities for IBLCs
Sector related residues	• Three-phase annual productions→ Olive Pomace: 314.2 kt, Olive Oil Waste Water: 345-440 Ml (year 2014 estimations). • Two-phase annual productions→ Olive Pomace: 754 kt, Olive Oil Waste Water: 0 (year 2014 estimations). • Greece produced 14 kt pomace oil, 135 kt exhausted olive cake available in the market (year 2014 estimations). • Estimated olive pruning production: 1.13-1.72 dry Mt. • Olive stones. • Olive leaves.
Potential synergies & benefits	• Several treatment options are proposed in order to improve the decontamination efficiency of the OMWW. • Synergies with olive prunings, exhausted olive cake are feasible.
Market developments	• Exhausted olive cake and olive stones can be sold in solid fuel market. • Phenols from exhausted olive cake (and leaves) can be used in pharmaceutics industry, food industry. • Exhausted olive cake can be used in animal feed industries as well as the biogas industry. • Reuse of OMMW as fertiliser due to the organic matter and nutrients contained that could improve arid soils. • Olive prunings can find various applications such as production of pellets, particle boards or as fuel in power plants.
Non-technical barriers	• Unwillingness of Greek citizens to have the pomace mills continue their operations during their idle times. They are unhappy with the

	existing pomace mills facilities when operating due to odours and smoke (optical disturbance). • Pomace mills are absent of national funding schemes, thus lack of funds for implementing new business concepts. • Difficulty of the solid fuel market to absorb exhausted olive cake as fuel for residential heating due to intense odours. • The production of olives and pomace as well, is climate-dependent. As a result, technologies for exploiting by-products and residues of the oil production process have not been yet developed.

Table 30. Summary sector "Sugar Industry"

Sugar Industry	
	Profile
Production	• In Greece, sugar is produced primarily from sugar beet. • A tonne of sugar beet yields on average 17 % of its mass in sugar. • Most of the by-products (molasses, sugar beet) are used in feed and fodder.
Volume of the sector	• HSI (Hellenic Sugar Industry) is the only sugar producer in Greece. • In 2014, 53.4 kt sugar were produced from 2,360 beet growers. • Total cultivated land (2014): 7,400 ha. • The EU has put a production limit at 158,702 t of sugar/ year. • Intense fluctuation of the sugar production due to the unstable number of beet growers.
State of the sector	• In 2014, the annual turnover amounted to 90.6 M€ with an annual sugar production of 53,400 t. • The economic strength of the industry continuously decreasing due to low production (lowest in years) and the high production costs. • Farmers prefer other intensive crops (cotton, corn, sunflower, etc.), which (mainly cotton) enjoy higher subsidies from beet-growing. • According to the stakeholder the current year (2017) is the worst year regarding production of sugar and the market value of sugar for the last production year is only at 315 €/t.
Typical size of the companies	• Two sugar factories are still in use: i) Plati factory with capacity outputs around 100,000 t of sugar per year and ii) Orestias factory with capacity outputs around 60,000 t of sugar per year. • A third sugar factory in Serres (Northern Greece) with suspended operation. Every year the board of HSI decides whether it will work.

	• Distribution Network unit in Larisa (Thessaly region) with a beet gathering area and packaging unit. • In the factories of the Hellenic Sugar Industry are employed 220 people and around 280 more employees in the two subsidiaries companies in Serbia. The workforce is doubled during the production months (September to January) by hiring seasonal employees.
Distinctive facilities of the sector	• Operation from September to January. Many times the campaign starts from August. The rest of the year, maintenance of the equipment and facilities are carried out in order for the facilities to be ready and deal with the next import of products. • Several idle equipment to implement IBLC concept such as storage areas, feed handling, evaporators, dryers, pelletizers. • Current sugar factories operate with HACCP, attention is needed to the raw material that will be used in the idle equipment (food safety).
Degree of innovation	• Research for the genetic improvement and creation of new sugar beet varieties acclimatized to the agro-climatic peculiarities of Greece. • Due to the economic crisis, investments on innovation are minimal.
	Opportunities for IBLCs
Sector related residues	• Molasses: 2-4 % of beet production. • Sugar-beet pulp pellets: 2-4 % of beet production. • Estimated annual beet production for the year 2013 around to 1,411,840 t→Molasses: 19.5 kt/year, Sugar beet pellets: 28.2 kt/year, Fresh pulp: 24.8 kt/year, Beet Leaves: 562.5 kt/year.
Potential synergies & benefits	• All the by-products resulting from the production of sugar cover the needs of industries and cattle-breeders in the internal market. • Molasses are used as a raw material to produce alcohol, yeasts and cattle feed. Sugar beet pulp pellets used as cattle feed.
Market developments	• Current by-products are used mainly in animal feed. • Molasses can be used as feedstock for ethanol production or biogas.
Non-technical barriers	• The current state of the sector is at bad weather (lowest production in recent years). • The economic crisis makes it difficult for investments to be performed.

Table 31. Summary sector "Wine"

Wine sector	
	Profile
Production	• The primary feedstock for the wine production is grapes and the end products are wines of different variety. • The main by-products (grape marc) from the winemaking procedure are used as raw material for the distillery process or vinegar production.
Volume of the sector	• In the wine-growing period of 2015-2016 the total wine production was 2,458,421 hl, 745,809 hl were red wine and the rest 1,712,432 hl were white wine. • For the period 2015-2016 the total cultivated area was 62,723 hectares. • The wine sector in Greece is estimated to consist of 1,100 wineries, 40 cooperatives and around 100 distilleries producing more than 7,000 labels. • Greece produces 34 PDO (Protected Destination of Origin) labels and 120 PGI (Protected Geographical Indication) labels. • 29.3% of the wine production comes from the region of Peloponnese while 20.16 % of the wine production comes from Attica and Central Greece.
State of the sector	• The annual turnover for the 2017 economic year was 380 M€. • In 2015-2016 the imports of wine were estimated at 33,863,007 € while the exports were 73,700,095 €.
Typical size of the companies	• Total annual production capacity of the biggest winery in Greece reaches 2 million litres. • Around 24,300 permanent workers are employed in the whole wine sector.
Distinctive facilities of the sector	• Operation from October to February. The rest of the year, the facilities operate for the marketing of the wines (packaging, bottling and trade). • Due to the complexity of process, perhaps equipment such as centrifuges, distillation columns and storage facilities can find further application.
Degree of innovation	• Typical wineries do not operate with the state of the art machinery but they are trying to catch up with the latest developed technologies. Large wineries use the state of the art technology. • Due to economic crisis, the sector does not invest much on innovation during last years.

	Opportunities for IBLCs
Sector related residues	• The main solid by-products and residues from the winery production are grape stalk, grape marc, wine lees and winery sludge (biosolids). • Moreover, vineyard prunings consist a potential residue for the wine sector as well as the wastewaters coming from cleaning and wine production processes. • Estimated annual by-products for 2015-2016: ○ Grape stalks → 8.8 kt ○ Grape marc → 35.4 kt ○ Grape lees → 14.7 kt ○ Wastewater → 487 Ml ○ Estimated wine pruning production: 93-566 dry kt • Leaves from vines.
Potential synergies & benefits	• Use the wastes from wine distilleries as feedstock to produce platform chemicals, biofuels, and energy and fertiliser.
Market developments	• Winery wastes can be used as feedstock to produce platform chemicals such as lactic acid, extract polyphenols (e.g. resveratrol) to be used in cosmetics, biofuels including ethanol, enzymes, chemical intermediates, and energy through pyrolysis and anaerobic digestion. • Grape marc can be used as fertilizer. • Vine prunings can be used as feedstock for energy plants or solid biofuels (pellets).
Non-technical barriers	• Economic crisis has isolated companies for expanding their business plans. • Lack of knowledge for exploiting agro-residues.

Table 32. Summary sector "Grain Chain"

Grain Chain Sector	
	Profile
Production	• The most important grains that are cultivated in Greece are wheat, both soft and durum, barley, oats, rye and maize. • By-products potentially suitable as biomass feedstock are generated during grain production, as well as during grain processing by industries.
Volume of the sector	• The annual cereal production for the period 2015/2016 in Greece was 3,183,756 t. • The cultivated area of cereals in Greece is 926,965 hectares. • Total imports for 2015-2016: 1,706,355 t. • Total exports for 2015-2016: 243,817 t.

State of the sector	• The annual turnover for the year 2014 was 343,164 k€ • Greek grain sector has a decline during the last years due to the low profit margins and the economic crisis that Greece is facing with.
Typical size of the companies	• Around 800 flour mills and industries in Greece that produce and trade flour. • According to stakeholder feedback, around 3,000 permanent and seasonal employees, apart from the grain farmers, can be found in the whole grain chain sector. • The largest mill in Greece has a market share of 25 %.
Distinctive facilities of the sector	• Operation during the whole year. • Facilities like silos can be used to store different feedstock (e.g. wood chips) when there is availability.
Degree of innovation	• Sector invests in waste-management for zero-waste strategies. • Large companies exploit the produced residues to cover own energy needs. • Companies in the grain sector invest in technologies in order to be able to produce "functional" products, meaning products with better quality, with no diseases, without gluten etc.
	Opportunities for IBLCs

Sector related residues	• Main by-products during crops production: straws, stalks, stubble, corncobs, bran and husk.
	• 50,000 t of by-products each year produced by a typical cereal industry in Greece.
	• Estimated annual agro-residues (2015-2016)
	  ○ Soft wheat straw → 352,975 t
	  ○ Durum wheat straw → 785,657 t
	  ○ Barley straw→ 285,392 t
	  ○ Maize stalks→ 1,086,130 t
	  ○ Maize cobs→ 411,281 t
	  ○ Oats →65,400 t

Potential synergies & benefits	• Most agro-residues produced are totally consumed either as animal feed or for energy exploitation.
Market developments	• Straw can be used as raw material for pellets, bio-chemicals or biofuels.
Non-technical barriers	• No idle times for the available equipment and the amount of by-products produced are totally consumed either as animal feed or for energy exploitation. • Difficult for the farmers to give their agricultural residues (e.g. straw) to the IBLC as they incorporate them on their fields, adding organic matter to the soil. A synergy must be established between the grain farmers and the IBLC/ end user in order for the farmers to

	get something in exchange of the agro-residues, e.g. money to buy bacteria/ materials to increase the organic matter of their soils.

Table 33. Summary sector "Vegetable Oil Extraction"

Vegetable Oil Extraction	
	Profile
Production	• Vegetable oil is extracted from various primary feedstock like cotton seeds, soya, sunflower, etc. • Vegetable oil is used for edible use or for the production of biodiesel. • Apart from vegetable oils, other products derive from these crops like seeds and fats that are used in animal feed.
Volume of the sector	• In 2014 around 132 kt of vegetable oil was produced. • In 2015 around 143 kt of vegetable oil was produced. • In 2016 the production fell at 136 kt of vegetable oil. • Three large scale vegetable oil extraction industries in Greece and some few more small-scale industries.
State of the sector	• The vegetable oil sector in Greece is relatively small compared to other EU countries. • For the last three years the sector can be characterized as stable.
Typical size of the companies	• A Greek company that produces cotton oil has an annual production of 2,000 t seed oil. • A typical vegetable oil company can operate 300-400 t of seeds/ day.
Distinctive facilities of the sector	• Operation from September to April. If feedstock is imported, the facility may operate all year. • Some equipment similar to the olive oil sector. • Centrifuges, storage facilities, crushers can find various applications.
Degree of innovation	• The vegetable oil extraction units use a simple technology, compared to pomace mills. No special R&D activities are performed on the vegetable oil sector in Greece.
	Opportunities for IBLCs
Sector related residues	• The primary use of vegetable proteins is that of animal feed. • Seed residues from crushing (2016): ○ groundnut →6 kt ○ soya →268 kt ○ rape → 7 kt ○ sunflower → 48 kt ○ cottonseed →116 kt ○ maize→ 5 kt

	• Agro-residues from all the crop fields in Greece, not only from fields used for vegetable oil extraction (2014 crop production): ○ groundnut →7 kt ○ soya →20 kt ○ rape →9 kt ○ sunflower → 384 kt ○ cottonseed →1,641 kt ○ maize→ 1,303 kt
Potential synergies & benefits	• Currently, residues from crushing seeds are used in feed and fodder. • Husks of seeds and residues from crushing seeds can also be used as fuel or converted into pellets.
Market developments	• Agro-residues can be used as feedstock for energy production (power/ heat).
Non-technical barriers	• Limited seed cultivations. • Scepticism of residents regarding the consumption of such agro-residues in their houses.

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9 Annex A. Consulted stakeholders

The following stakeholders were consulted:

- the executive director of KEOSOE (Central Cooperative Union of Wine Products) for the wine sector,
- the president of SPEL (Association of Olive Kernel Oil Producers of Greece), who provided data for the pomace mills as well as for the olive oil sector,
- the quality assurance manager of ELSAP S.A. (pomace mill in Nafplio, Southern Greece) who provided data on pomace mills as well as for the olive oil sector,
- the president of Agricultural Cooperative of Loukision (Central Greece) and owner of an olive mill,
- the president of Agricultural Cooperative of Agios Konstantinos (Central Greece), who provided data for the olive oil sector,
- the agronomist of LOULIS MILLS S.A., one of the most important Greek company in the grain chain sector,
- the president of AIXMEAS Agricultural Cooperative (Central Greece) who provided data for the grain sector,
- the representative of the Hellenic Sugar Industry who provided a clearer picture of the current state of the sugar sector in Greece and ,
- the financial manager of NUTRIA, an olive oil refinery plant that produces standardized olive oil, pomace oil and seed oils, who provided information on the vegetable oil extraction sector

AGROinLOG

INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors

Country report Sweden

Project AGROinLOG "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe"
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ABBREVIATIONS

DDGS: Dried Distillers Grains with Solubles, by-product from ethanol production

DM: Dry Matter

LM: Lantmännen

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

SCO-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

The specific objective of task 6.2 is to analyse the specific characteristics of various European agricultural sectors suitable for setting up an IBLC. This activity is a desk study that will target a limited number of six pre-identified high priority agricultural sectors with large expected synergies. The activity is a part of the AGROinLOG project "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe" (#727961) and is within the scope of the Task 6.2 "Basic analysis of targeted agricultural sectors". The results of this task will be used to achieve the goal with WP6 and the whole project, to establish a practical and theoretical framework for the development of new value chains in connection with Integrated Biomass Logistic Centres (IBLCs).

The following sectors of the Swedish agricultural industry are considered: the sugar industry, the vegetable oil extraction, the grain production and the feed and fodder. Each sector chapter consists of two parts: an overview and estimation of IBLC opportunities. The four sectors of the agricultural industry were selected primarily because they are existing large sectors in Sweden with large producing companies. The wine and olive oil mill sectors were not selected since the wine production is marginal in Sweden and there is no production of olives in Sweden. The methods used in the study have been interviews, literature reviews, compilations of market reports and statistical data.

In Sweden about 2 million tons of sugar beets are produced every year and that amount of sugar beets corresponds well to the amount of beets that Nordic Sugar Örtofta receives and processes. There is only one sugar factory and one sugar refinery in Sweden, situated in Örtofta and Arlöv. They are both owned by Nordic Sugar which is the only sugar producing company in Sweden. Örtofta is one of the largest and most efficient sugar-producing facilities in northern Europe with a yearly production of sugar of 382,000 tonnes/year. The sugar market was just deregulated, this can result in price falls and price pressure, but it can also lead to new markets and niches. Sweden produced around 2% of the total EU sugar production. The daily refinery capacity at Nordic Sugar Arlöv is around 1,000 tons raw sugar. Nordic Sugar Arlöv is a sugar refinery that is running all year round and Nordic Sugar Örtofta is a sugar factory that only runs part of the year during the production season from mid-September to mid-January. The sugar industry is a mature industry, historically a lot of resources have been put into research and development within the industry in Sweden. Nordic Sugar has become more and more involved in research projects the last couple of years, also in the Swedish part of Nordic Sugar, the projects they are involved in are focused on biobased products and processes, and the aim of the involvement from Nordic Sugar is to find a value chain increasement. They are involved in projects regarding biocommodities for bioplastic products. They are also involved in a project that will develop a value chain based on side streams from the sugar industry for the production of key basic chemicals. Examples of sector related residues from the sugar industry is sugar tops, which theoretically if all beet tops in Sweden were harvested amounts to around 80,000 tonnes dry matter. All biomass residues from the Arlöv and Örtofta refinery factories are utilized today. Just before the production season for sugar or just after the season there is a possibility to utilize some parts of the factory as the storage facilities and the drum drier. Some parts

of the production line are only adapted to the large flow of biomass, but some parts of the production line there are several smaller machines instead of one large.

In the last five years around 330,000 tonnes of oil crops were harvested in Sweden each year and the rapeseed crops are in a sharp rise. Most rape seed oils are hot pressed in Sweden, the rapeseed is pressed to oil at higher temperature, it is then refined, and more oil can then be extracted from the filter cake by use of solvents. AAK is the owner of the only largescale processing plant for oilseeds in Sweden. Total consumption of rapeseed oil for both food and technical purposes in Sweden is around 294,000 tonnes per year. The oil and fat industry in Sweden is a sector with high profit figures (the difference between the amount earned and the amount spent in buying, operating, or producing something). AAK had an economic turnover of approximately €650,000 in 2016. The production of rapeseeds in Sweden doesn't cover AAKs total need and therefore imported seeds are also used. The production of rapeseed oil and rapeseed meal at AAK Karlshamn is a year around production, there is no seasonal variation. The rapeseed oil and rapeseed meal industry is a mature industry. The vegetable oils is an agricultural product that is chemically most similar to mineral oils and therefore have a great potential as biological raw materials to replace the mineral oils in industries such as for biomaterials and chemicals. Example of a sector related residues from the vegetable oil industry are straw from oilseed crops in Sweden with around 740,000 tonnes per year. Only small amounts of biomass residual are produced in the vegetable oil production at AAK since the rape seed meal is utilized as well. Since there are no large amounts of biomass residues from the rape seed oil production and it is a year around production at the site there are no great opportunities for establishing a future IBLC at AAK Karlshamn. To become a supplier of biocommodities is not of interest for AAK Karlshamn. There is research projects investigating rapeseed straw used as raw materials in the manufacture of renewable plastic materials and to convert the press-cake from rapeseed to human food. The attitude of the industry is that they are not interested in becoming a supplier of biocommodities; this has a negative effect on the possibility to establishing a future IBLC in this sector.

The grain chain production raw material is crops wheat, barley, oats, rye and triticale. Annually in average, 5.5 million tonnes of grains are produced. The biggest crop in Sweden is winter wheat, which is produced in average 2.3 million tonnes per year or 41.8 % of total crop harvest. The three following crops are: barley, oats and spring wheat. The crops constitute to 49.7 % of total grain products. The most common grain crops occupy 999,940 ha of total 2,595,797 arable land excluding leys and pasture. The grain receiving plants are located at locations in high production areas, mainly southern Sweden to central Sweden. In total 60 % of the grain cultivated area is located in these regions. Processing products are mainly flour and groats, with the biggest quantities is 313,506 tonnes per year from wheat flour and 119,696 tonnes per year from mixed wheat and rye flour. Most processing facilities are utilized all year round, with lower production in grain driers from November to next year's harvesting period. The processing industry is actively researching in increasing value of side chains and residues. For example, husk residues from Järna mill are incinerated in boilers, where the steam is used for production and the heat is used for heating the house holdes in the local area. LM Agroetanol utilizes the CO_2 created by fermentation process of ethanol production to AGA industry commodities and the draff residues (the residual product in the production of ethanol from

cereals) is sold to the feed industry, mostly on export. The straw residues are estimated to 3.8 million tonnes per year, or 16 TWh per year, and the potentially usable amount for bio-energy is estimated to 3,600 GWh per year. A project is initiated in investigating possible uses of husk residues from oats for biobased furnishing and caskets. Researchers have found a way to produce polysaccharides from brans, possibly opening up for future use in biobased plastics like medicine capsules or protecting barriers around meat.

Feed and fodder consists of a mix of primary products of grain; mainly barley, wheat, oats, rape seed meal, beet pulps, molasses, peas, broad beans and grasses. Temporary grasses are produced in quantities of 4.9 million tonnes per year in leys and green crops are grown on 1,146,667 ha of arable land, in average 4.2 tonnes/ha. About 2,300,000 tonnes of grains are used as feed. The feed plants are mostly located at south to middle Sweden and also locally at animal production farms. The feed plants are utilized all year round with down time only for cleaning and maintenance. Grass are produced by the animal producers for their own animals need during summer period and to some extent bought in from the local area. Residues of primary products of grains are the same as in the grain sector. The innovation levels in this sector seems to be focused on reducing imported protein in the feed mix, and abandoned feeding plants have a history of being used for other productions. Biomass residues produced at feeding facilities are low to none and mostly reused in feed production. Grass production biomass residues consist of losses during harvest and transport and discarded amounts not suitable for feed. Potential benefits in IBLC are increased usage of today non-productive areas where grass is grown. If a decrease in animal production leads to an increased surplus capacity in the feed industry, this may also benefit IBLC. There are projects that are studying grass usage in larger extend than only feed, e.g. for biogas and to some extent ethanol production. The non-technical barriers are mainly potential competitiveness from feed industry, but a potential decrease in animal production may benefit bioenergy production. Barriers of grain production for feeds are considered to be the same as in the grain sector.

Interviews with representatives from the different industries showed that there are different levels of interest for the IBLC-concept in the different sectors. In Sweden, the sugar industry shows a large interest to utilize the industry in the time between productions of sugar. One possibility is to become a producer of biocommodities. The vegetable oil industry is not interested in becoming a producer of biocommodities, and their production is year around without large amounts of residues.

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1 INTRODUCTION

This report was written as a part of the AGROinLOG project "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe" (#727961) and is within the scope of the Task 6.2 "Basic analysis of targeted agricultural sectors". The report aims at providing an actual overview over the state of the sectors, as well as with respect to the IBLC related topics. The following sectors of the Swedish agricultural industry are considered: the grain production, the sugar industry, the feed and fodder and the vegetable oil extraction. Lantmännen was responsible for the parts on the grain production and the feed and fodder. RISE was responsible for the parts on the sugar industry and the vegetable oil extraction. Another goal is to determine, whether there is potential in all or in some of the selected sectors for an implementation of the IBLC concept. Each sector chapter effectively consists of two parts: an overview and estimation of IBLC opportunities.

The four sectors of the agricultural industry were selected primarily because they are existing large sectors in Sweden with large producing companies. The wine and olive oil mill sectors were not selected since the wine production is marginal in Sweden and there is no production of olives in Sweden.

The methods used in the study have been interviews, literature reviews, compilations of market reports and statistical data. One lesson is not to always trust the statistical data, sometimes the statistics differs from the practical reality in agriculture. In Sweden this was the case for the yearly production of biomass from pasture.

It has sometimes been difficult to get information from the companies with regard to their strict company confidentiality. But we would like to give a big thank you to all companies who generously shared all their information.

2 SUGAR INDUSTRY

2.1 Profile of the sugar industry sector

2.1.1 Production

All cultivation of sugar beets in Sweden is contracted by Nordic Sugar. In Sweden the majority of the sugar beets are grown in Skåne (the most southern county). The average area with sugar beets per year between 2012 and 2016 was 31,975 hectares, Table 1. During the first ten years of the 21st century, the number of beet growers in Sweden was reduced with 50% (Jordbruksverket, 2016). The cultivation area with sugar beets has also decreased during the same time period from around 60,000 hectares in 1999 to 2009. In 2015 the area with sugar beets was 19,465 hectares, a large decrease compared to 2014 with 34,401 hectares. A global surplus of sugar, combined with the new industry agreement, led to the reduction of sugar beet in 2015. In 2016 the area with sugar beets was almost back to normal again with 30 714 hectares. The standard harvest for sugar beets in Skåne was 64,547 kg/ha 2016 (17.8% sugar content) and slightly lower for other counties (Jordbruksverket & SCB, 2016). About 2 million tons of sugar beets are produced every year (Nordic Sugar, 2017).

Table 1. Area of sugar beets in Sweden in hectares (Jordbruksverket, 2012; 2013; 2014; 2015; 2016)

Area sugar beets, hectares						
Year	2012	2013	2014	2015	2016	Average 2012-2016
Area (ha)	39,046	36,250	34,401	19,465	30,714	31,975

The root of the beet contains 75% water, around 16-18% sugar, and 5% fiber (Nordzucker, 2017). The exact sugar content can vary depending on the cultivar and on the growing conditions.

The sugar production starts in the field with the sugar beets and ends with a diversity of products, including sugar products, feed products (molasses, beet pulp), sugar factory lime, stones, beet soil and water, see *Figure 1*. The sugar industry receives the sugar beets from the farmers and begins by the weighbridge on the industry site. The industry pays for the transports, by truck and tractor. Some products made in the factory are recirculated into the system as biogas, steam and water. As an example the biogas produced at the site is combusted and the heat is utilized in the process.

A refinery is an industry where the primary feedstock is raw sugar from sugar factories.

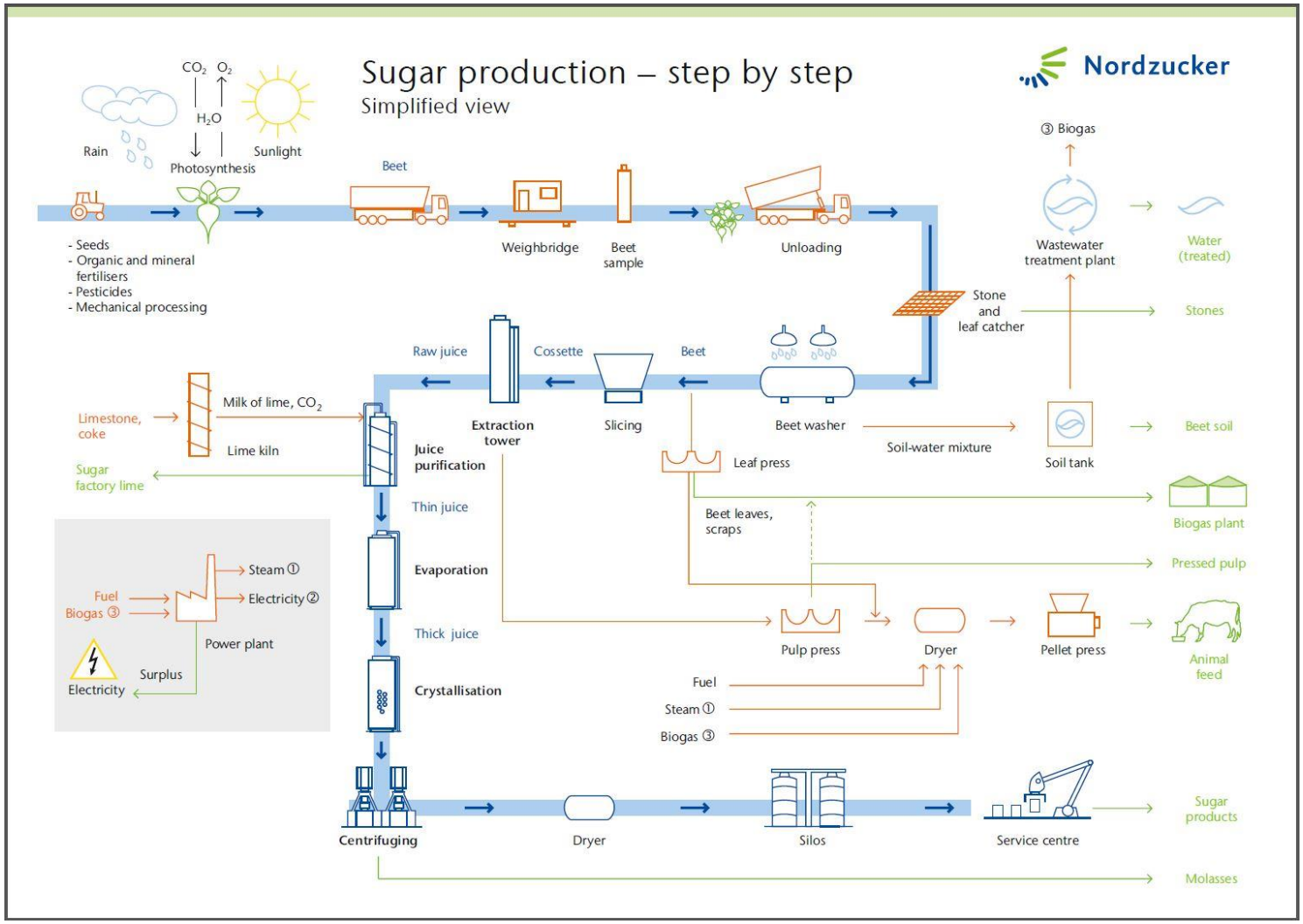

Figure 1 Sugar production – step by step. Source: Nordzucker (2017)

2.1.2 Volume of the sector

There is one sugar refinery, Arlöv, and one sugar factory, Örtofta, in Sweden, both owned by Nordic Sugar which is the only sugar producing company in Sweden, Figure 2. The refinery and factory is situated in the South of Sweden in Skåne.

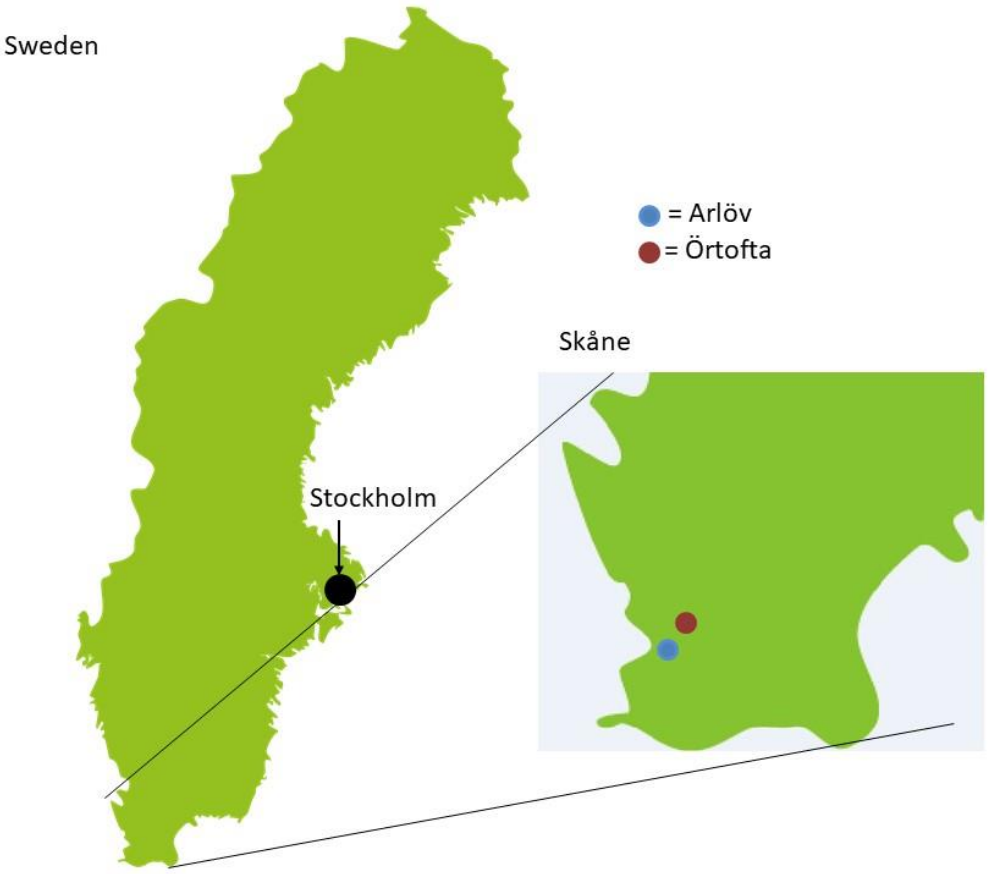

Figure 2 Map Örtofta and Arlöv in Skåne, Sweden

Since 2009, Nordic Sugar has been part of the German-based Nordzucker group, but has been manufacturing sugar for the Northern European market for more than 100 years. The sugar beets are locally produced, and some raw sugar is imported. Nordic Sugar has a total of 1,500 employees, of whom 330 work in Sweden. The employees at both Örtofta and Arlöv mostly work in production, such as machine operators, process operators and service engineers, where they work with electrical maintenance and automation or at the laboratory. Örtofta is one of the largest and most efficient sugar-producing facilities in northern Europe. The yearly production of sugar at Örtofta is 382,000 tonnes/year, Table 2. (Nordic Sugar, 2017)

Table 2 Yearly production in Örtofta. Source: Nordic Sugar (2017)

Yearly production Örtofta	
Products	Produced amount at Örtofta, tonnes/year
Sugar	382,000*
Molasses	58,000
Molassed sugar beet pellets (Betfor®)	74,000
HP-Pulp (HP-Massa®)	69,000

*One part is delivered to Arlöv

In Arlöv many different special products are manufactured for a wide range of applications, mainly for the food industry, Table 3. Some examples of special products are vanilla sugar, icing sugar, syrup, cube sugar, liquid sugar and nib sugar. They produce various sugar solutions which are developed in close cooperation with the customers and are delivered to daily basis to customers all over Sweden. About 80% of the products from Örtofta and Arlöv are sold to the industry market and about 20 % to customers.

Table 3. Yearly production in Arlöv. Source: Nordic Sugar (2017)

Yearly production Arlöv	
Products	Produced amount at Arlöv, tonnes/year
Sugar solution	146,000
Syrup	31,000
Cube sugar	7,800
Special products	11,000
Fractional sugar	23,000
Molasses	250

2.1.3 State of the sector

The EU sugar beet industry is preparing for one of the largest changes in its history which is the end of production quotas on 1 October 2017. When the EU regulation expires in 2017, it can mean that the sugar prices will fall within the EU with declining profits of sugar companies as a result. For the last 50 years the market for sugar beets has been regulated with quotas and minimum prices. EU production quotas and protective duties have been intended to prevent competition from imports of cheaper cane sugar cultivated outside the EU. This means that sugar prices in the EU today are almost twice as high as the world market price. A review shows that EU quotas and protection contributed to significantly increased profits for those companies in which sugar production is included. In just two years around 2013, for example, the operating results for the German Nordzucker increased from 78 million to 188 million euro (SVT, 2017).

In the summer of 2016 Nordic Sugar and the beet growers agreed upon a technical framework which will regulate the sugar beet production for the next four years. In autumn 2017 the market completely controls the demand for Swedish sugar, which means that the sugar production will compete with Europe in a new way.

For 30 years a factory in Köpingebro in Sweden has been producing fiber products from sugar beet intended for human consumption but in 2016 the factory was shut down. Examples of products produced in the factory were dietary fibre supplements made from sugar beet pulp. The reason behind the closing lies in the change of the human fiber market. (Nordicsugar, 2017)

The total sugar production from sugar beets has decreased with 38 % between 2011/12 and 2015/16 in Sweden, see Table 4. At the same time sugar consumption has remained relatively constant since the 1960s in the Nordic countries (Nordicsugar, 2017).

Table 4 Total sugar production from sugar beet in tonnes 2011/12-2015/16. Source: Comitesucre (2017)

Total sugar production from sugar beet, tonnes						
Country	2011/12	2012/13	2013/14	2014/15	2015/16	Average 2011/12-2015/16
Sweden	416,860	365,869	377,700	382,000	257,764	345,833

2.1.4 Typical size of the companies

Sweden produces approximately 2% of the total EU sugar production on a 5-year average 2011/2012-2015/2016 (Comitesucre, 2017). The length of the beet campaign at the sugar beet factory in Sweden was 118 days on average for 2011/12-2015/16 slightly above average for the 28 EU countries in
Table 5, 114 days.

The daily processing capacity at Nordic Sugar Örtofta is around 18,500 tons of beets. During the production season Nordic Sugar Örtofta receives and processes around 2 million tons of sugar beets. Every day 600 truckloads of beet are delivered. Around 1,500 beet growers sell their beets to the plant. Nordic Sugar Örtofta employs around 140 people, plus 70 seasonal workers during the production season. The daily refinery capacity at Nordic Sugar Arlöv is around 1,000 tons raw sugar, this sugar is delivered from Nordic Sugars beet sugar factory in Örtofta and some raw sugar is imported. Nordic Sugar Arlöv employs around 155 people. (Nordic Sugar, 2017)

Table 5. Number of sugar beet factories and daily beet slicing capacity by production year and length of the beet campaign Sweden, in total and average for the 28 EU countries. Source: Comitesucre (2017)

Sugar beet factories comparison different countries							
Country	Number of sugar beet factories and daily beet slicing capacity by production year, average 2011/12-2015/16						Length of the beet campaign, average 2011/12-2015/16
	< 5,000 tonnes	5,000-8,000 tonnes	8,000-12,000 tonnes	12,000-15,000 tonnes	>15,000 tonnes	Total	Days
Sweden	-	-	-	-	1	1	118
Total EU28	15	31	23	14	22	105	-
Average EU28	-	-	-	-	-	-	114

2.1.5 Distinctive facilities of the sector

Nordic Sugar Arlöv is a sugar refinery that is running all year round.

Nordic Sugar Örtofta is a sugar factory that only runs part of the year during the production season from mid-September to mid-January. The production period is linked to the cultivation season for sugar beet. During the production season the facility operates around the clock, seven days a week. During the time of year when there is no production on the site the key activities are focused on overhauling and maintaining the production equipment, installing any new facilities as well as on other improvement projects. According to Jensen and Dahlgren (pers. comm., 2017) at Nordic Sugar Örtofta, the non-production period could be shorter than it is today. There is no surplus on staff after the production season. But there might be a possibility that staff can be hired of the factory to do other things. This could for example create broader skills among the employees. In time this could

be possible just before the production season or just after the season. The process equipment is available from where the sugar beet enters the factory to the dryer. In the pre-treatment part of the factory there is great wear of the process equipment, so the reparation time cannot be that much shorted here. The storage facilities are utilized today but for a short period it could be used for other purposes.

The technologies utilized at Nordic Sugar Örtofta are simple inorganic technologies which for example involve water, lime, carbonic acid and filtration processes. For example, high-pressure processes would not fit in (Jensen and Dahlgren, pers. comm., 2017). Temperatures around 150°C and 200°C are ok, but for example pyrolysis around 350°C would not work. Acid hydrolysis is also not ok because the process today is at a high pH.

In February 2018 Nordic Sugar spread the news in the media that they plan to discontinue operations in Arlöv and move all its production to the site in Örtofta (Skånska Dagbladet, 2018). It means a billion investment but also staff reduction. An efficiency study conducted by Nordic Sugar shows that there are substantial savings and efficiency improvements to be made if all the production is gathers by the plant in Örtofta.

2.1.6 Degree of innovation

Historically a lot of resources have been put into research and development within the sugar industry in Sweden. But today a lot of the research and development activities have been moved from Sweden to other countries such as Denmark and Germany. The sugar industry is a mature industry. Water treatment and biogas production are examples of techniques that have been developed as research and development projects and are now common technologies within the industry´s operations. Energy savings have always been in focus within research and development. A lot of focus has also been on utilization of residuals; development of dried fibres for human consumption and hard-pressed pulp as two examples. The usage of fossil fuels is high today; this is one of the biggest challenges for the sugar industry.

Örtofta has invested in lowering the environmental footprint by delivering all surplus heat from the sugar production to the local district heating network. This gives major environmental gains in terms of reduced carbon dioxide emissions of up to 8,500 tonnes a year. The amount of surplus heat delivered corresponds to the annual consumption of 3,000 single-family houses. Recently around 20 million euros were invested in a new steam dryer and a new boiler plant. This is a venture that reduces the factory's natural gas needs by 30 %. At the same time, they reduce CO_2 emissions by around 32,000 tonnes / year. (nordicsugar.se)

Nordic Sugar has become more and more involved in research projects the last couple of years, also in the Swedish organization. A lot of the research projects they are involved in is into biobased products and processes, and the aim of the involvement from Nordic Sugar is to find a value chain improvement.

There has been different smaller projects and pilot studies at Nordic Sugars sites in Denmark to use the dryer for different biomasses, for example alfalfa and wood chips, before the sugar beet

campaign (Jensen and Dahlgren, per. com., 2017). There has also been a study on producing pellets from other fibres than sugar beet fibres.

2.1.7 Miscellaneous

The European Committee of Sugar Manufacturers (CEFS) has initiated a life cycle assessment of European beet sugar production where a multiple of environmental aspects has been investigated (Spoerri and Kaegi, 2015a, b). For Örtofta Sugar factory a similar life cycle assessment was performed by (*Unpublished source*). In this the climate impact was assessed, as well as contribution to eutrophication. The latter was measured as phosphate emissions-equivalents in freshwater systems and as nitrate emissions–equivalents in marine water systems. Also, the non-renewable energy total use (NREU) was investigated. Results were presented with different allocation principles, and the following figures refer to unallocated result. For climate impact and phosphate emissions sugar beet cultivation and sugar production contributed with 50% each to the carbon footprint. For nitrate emission the contribution from the sugar beet cultivation was 90% of the total. For NREU 75% of the contribution came from the production.

2.2 Opportunities IBLC

2.2.1 Sector related residues

2.2.1.1 Biomass residues within the supplying agricultural sector

The average yield for sugar beet tops in Sweden is around 2.5 tonnes dry matter per hectare (Jordbruksverket, 2014). Today the majority of the sugar beet tops is left in the field and are ploughed into the soil. If all sugar beet tops in Sweden were harvested around 80,000 tonnes dry matter beet tops would be generated theoretically. Sugar beet tops have high water content at harvest, which makes them difficult to preserve as silage. It is therefore an advantage to use sugar beet tops as fresh material, for example as substrate (feedstock used for production of biogas) for biogas production. The material is mainly available at harvest in September to November. Different harvesting and transport chains for sugar beets and beet tops were theoretically evaluated in a study by Kreuger et al. (2014). In the most economically feasible harvest chain only 55% of the available beet tops was harvested to minimize machine waiting times. If around 55% of the sugar beet tops in Sweden were harvested around 44,000 tonnes dry matter beet tops would be generated.

2.2.1.2 Biomass residues from the agro-industry's processing operations

All biomass residues from the Arlöv and Örtofta refinery factories are utilized today, Table 6. Nordic Sugar doesn't want to use the word biomass residues; since they are all utilized today they see the residues as co-products.

The molassed sugar beet pellets consist of approx. 90% dried beet fibres and about 10% molasses. It can be stored for a long time without changing nutritional content. Molassed sugar beet pellets are used as feed material in the feed industry and as feed for feeding ruminants, horses, sheep and pigs. When fed to horses, the pellets must be soaked first. It can also be used as a silage agent. Molassed sugar beet pellets are manufactured during the beet campaign. The manufactured product is available throughout the year.

HP Pulp is primarily used as feed for ruminants and is an excellent complement to home-grown silage and grain. HP Pulp must be ensiled before use. All manufacturing and sales of HP Pulp is done during the beet campaign.

Molasses is used as feed material and as an individual feed for ruminants, horses and pigs. It is also a good binder for pelleting and binds dust. Molasses is also used as a silage agent and as a substrate in biotechnological production. Molasses is produced during the beet campaign in September - December. The product is available throughout the year.

The beet leaves and scraps are used as substrate to feed the biogas plant.

Table 6. Co-products from Arlöv and Örtofta. Source: Nordicsugar (2017)

Biomass residues from Arlöv and Örtofta	
Products from Arlöv and Örtofta	Produced amount, tonnes/year
Molassed sugar beet pellets (Betfor®)	74,000
HP-Pulp (HP-Massa®)	69,000
Molasses	58,250

2.2.2 Potential synergies & benefits

The time of year when there is no production on the sugar industry production site it may be possible to utilize the site for other types of production. But since the flow of material during the production season for sugar beet is so large it must be a large flow of material otherwise it will be hard to get a profitable production. In some parts of the production line there are several smaller machines instead of one large, there might be an opportunity to use only one of the smaller machines if it is a smaller material flow. There are several boilers in parallel and in the juice cleaning there are a number of filters running in parallel. The other parts of the production are large flows.

If Nordic Sugar can utilize the production site better for example with IBLC the profit will increase. An improved value chain can create conditions for Nordic Sugar Örtofta to be able to convince the farmers to continue to grow sugar beets (Jensen and Dahlgren, pers. comm., 2017). Even if the sugar price would fluctuate it would be possible to give a good price to the farmers for the sugar beets. Increased profitability can be a driving force towards to sugar beet growers to compensate for a lower sugar price.

One possibility is also to increase today's biogas production (only operating during the sugar producing period), by adding more biomass residuals. This will increase the volume of digestate. This can improve the economy by extracting phosphorus, nitrogen and potassium from the digestate, which allows for the design of new fertilizer products optimized for agriculture. Another opportunity

is to expand the production of pellets production of other material than sugar beet fibres in a pellet plant and protein drying in drum dryers prior to the sugar beet campaign.

2.2.3 Market developments

Nordzucker is a company that with many years' experience of campaigns lasting 120, 125, 130 days or longer or shorter, their maintenance and investment can be adapted to the campaign period that is needed depending on the new opportunities that arise. (Nordzucker, 2017)

Two examples of projects that Swedish Nordic Sugar is involved in are STEPS and Farm2Furan Furans of agricultural surplus. STEPS (Sustainable Plastics and Transition Pathways) is a research programme with a vision of a future society in which plastics are sustainably produced, used and recycled in a circular economy. Nordic sugars role in STEPS is to deliver biomass into the process of producing bioplastic. The sugar production will be viewed from a life cycle perspective. The purpose of the project Farm2Furan is to develop a value chain based on side streams from agriculture and food production to produce key basic chemicals in the context of the future biorefinery.

Nordic Sugar Örtofta is not interested in selling bioplastic products, but they are interested in utilizing their industry site to produce biocommodities for bioplastic products and to utilize their biomass residues for bioplastic production (Jensen and Dahlgren, pers. comm., 2017). For example Nordic Sugar is interested in using co-products from the sugar industry as the main raw materials for PLA (polylactic acid, biodegradable biomaterial) production in Sweden in a system based on industrial symbiosis. They have together with different actors applied for research funding for a project where all processing steps from raw material to a final prototype of a PLA-based product are included. PLA is a commercial product but there are great possibilities for innovation along the production chain.

Nordic Sugar are experts in their own markets, but they don´t know the bioplastic market for example (Jensen and Dahlgren, pers. comm., 2017). That is also one reason why they are involved in different research project with other industries, to network and create new businesses. Nordic Sugar have great knowledge in logistics and large flows with biomass, this is a valuable knowledge they can utilize to create new business with new partners.

2.2.4 Non-technical barriers

In an interview with Jensen and Dahlgren (pers. comm., 2017) they raised the issue that there is a misunderstanding regarding the first generation of bioplastics. In a period of about 10-15 years we should be able to base our production of bioplastics on the carbohydrates that are available now (for example in sugar beets). If we want to develop a compounding industry we have to do that. But today every resource is put into transforming raw material from the forest (non-available carbohydrate today) into bioplastics. If we do not utilize the available carbohydrates for bioplastics perhaps we will not have available bioplastics until 10-15 years. It is good that money is invested in raw materials from forest to bioplastics, but in parallel we should use existing available carbohydrates such as sugar beet. We could produce the first generation bioplastics and later on when the forest based bioplastics is available we just change the raw material and get the second generation bioplastics. By starting to produce the first generation bioplastics based on Swedish

arable crops as sugar beets a market is established and a demand is created. There is a prejudice barrier in the political system; it is a misunderstanding which causes the green shift to take much longer than it could have done. For example, we could get started with PLA from sugar beet

When a market is deregulated, as just happened to the sugar market, price falls and price pressure often occur. But at the same time a deregulation can also lead to new markets and niches, which will probably also occur in the sugar sector.

There are many uncertainties at the moment when it comes to the non-technical barriers in the sugar industry due to the end of production quotas on 1 October 2017. One possible scenario is a lower sugar price, with a result of a decrease in the number of growers. The strategy for Nordzucker in 2016 was “Shaping the transition”, due to the end of production quotas (Nordzucker, 2017). The Chairman of the Supervisory Board at Nordzucker thinks that Nordzucker is in a position of financial strength and is well prepared for the transition towards the new EU market without sugar quotas and minimum beet prices.

If the policy makers in Sweden would support the utilization of sugar and sugar beet pulp to produce a first generation of bioplastics and building blocks the beet area can be increased and the product value per hectare may increase in comparison with other countries. This would make it possible to keep a good price to the farmers and build a stable ground for the future production. The sugar production site would then be utilized in a more efficient way and the biobased products would reach the market faster. This technique will also be useful for second and third generation processes when they become available. (Jensen, pers. comm., 2017)

3 Vegetable Oil extraction

3.1 Profile of the vegetable oil extraction sector

3.1.1 Production

The average area with rapeseed per year between 2012 and 2016 was 102,537 hectares, see Table 7*Table 7*. The cultivation of winter rapeseed has doubled in recent years; the average area between 2012 and 2016 was 78,404 hectares. Half of the area is in Skåne (the most southern county in Sweden). In the same period the cultivation of spring rapeseed has decreased from 44,448 hectares in 2012 to 7,616 hectares in 2016. Stockholm, Uppsala and Västra Götaland are the counties in Sweden with the largest cultivated area of spring rape. The cultivation of turnip rape and linseed only constitutes a small part of the arable land in Sweden, but has been significant in the past in Sweden.

The standard harvest for winter rapeseed was 3,642 kg/ha in 2016 as average for Sweden. The corresponding number for spring rapeseed was 1,834 kg/ha (Jordbruksverket & SCB, 2016). In the last five years, an average of about 330,000 tonnes of oil crops was harvested in Sweden each year, see *Table 8*.

Table 7 Area of oil seed crops in Sweden in hectares. Source: Jordbruksverket, 2012; 2013; 2014; 2015; 2016

Area of oil seed crops in Sweden in hectares						
Crops	2012	2013	2014	2015	2016	2012-2016
Winter rapeseed	62,477	77,617	79,841	88,076	84,008	78,404
Spring rapeseed	44,448	49,284	14,734	4,584	7,616	24,133
Total rapeseed	106,925	126,901	94,575	92,660	91,624	102,537

Table 8 Calculated amount of oil seed crops in Sweden in tonnes. Source: Jordbruksverket, 2012; 2013; 2014; 2015; 2016

Calculated amount of oil seed crops in Sweden in tonnes						
Crops	2012	2013	2014	2015	2016	2012-2016
Winter rapeseed	222,369	288,509	290,405	318,147	304,295	284,745
Spring rapeseed	82,554	91,838	27,219	8,591	12,296	44,500
Total rapeseed	304,924	380,347	317,624	326,738	316,591	329,245

Oil is the main ingredient in rape seed; it is expressed as raw fat and amounts to about 45%. It also contains 55% raw protein and crude fibre. The rape seed that is cultivated today has a low content of erucic acid and glucosinolates. The moisture content, in the seed, must not exceed 9% in order to be stored.

Products from rapeseeds are oil (used for food purposes and for technical use) and rape cake and rape flour (used for animal feed to ruminants, pigs and chickens).

The vegetable oil is extracted by either cold pressing or hot pressing. The cold pressing of oil seeds means that the seed is crushed and the oil is mechanically pressed under low temperature. During

the hot pressing of rapeseed the oil is pressed at higher temperature, typically 90°C. The pressed oil is refined and more oil can then be extracted from the filter cake by use of solvents. Most rape seed oils are hot pressed in Sweden, a system overview of the process at AAK Karlshamn is presented in Figure 3.

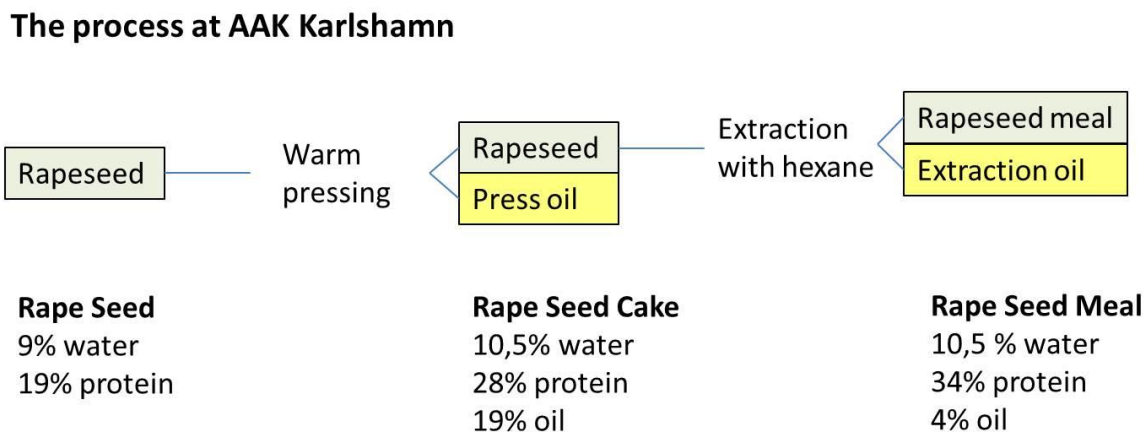

Figure 3 System overview of rapeseed pressing and extraction process at AAK Karlshamn. Source: Holmqvist pers. comm. (2017)

3.1.2 Volume of the sector

In Sweden the import of oil crops was higher than the export on average between 2012 and 2016, Table 9. In total, Sweden imported about 230,000 tonnes rapeseeds and vegetable oils and fats from rape seed per year (Fediol, 2017). The corresponding export was around 50,000 tonnes per year.

FEDIOL represents the European Vegetable Oil and Protein Meal Industry and produces statistics on the associated industry. The Swedish production of rapeseed constitutes only less than 2 % of the total production in EU, Table 9. The Swedish crushing of rapeseeds constitutes just above 1% of the total production in EU. The import of rapeseed oil, 200,000 tonnes, was higher than the Swedish production, 123,000 tonnes, on average between 2012 and 2016.

Total consumption of rapeseed oil for both food and technical purposes in Sweden was 294,000 tonnes per year on average between 2012-2016, Table 10. About the same amount of rapeseed meal is used in animal feed. One ton rapeseed gives approximately 0.4 ton rapeseed oil and 0.6 ton rapeseed flour.

Table 9 Production, import and crushing of oil seed in 2012-2016, in 1 000 tonnes. Source: Fediol (2017)

Production, import and crushing of oil seed in 2012-2016 in, 1 000 tonnes								
Crop	Production of oilseed		Imports of oilseed		Export of oilseed		Crushing of oilseed	
	Sweden	Total EU-28	Sweden	Total EU-28	Sweden	Total EU	Sweden	Total EU-28
Rapeseed	318	21,323	32	3,291	23	175	293	23,863

Table 10 Production, import, export and consumption of vegetable oils and fats in 2012-2016, in 1 000 tonnes. Source: Fediol (2017)

Production, import, export and consumption of vegetable oils and fats in 2012-2016, 1000 tonnes					
Crops	Production of crude vegetable oils and fats		Imports of vegetable oils and fats	Export of vegetable oils and fats	Consumption of vegetable oils and fats
	Sweden	Total EU-28	Sweden	Sweden	Sweden
Rapeseeds	123	10,203	200	29	294

AAK is a global company with around 20 production sites all over the world and around 3,000 employees. Their main business is food. AAK is organized in three business areas; Food Ingredients, Chocolate & Confectionery Fats and Technical Products & Feed. The cosmetics unit in Chocolate & Confectionery Fats is a growing business. The products from AAK are used as ingredients for the food industry (bakery, confectionery and dairy products), chemical industry, pharmaceutical industry, cosmetics, animal feed and environmentally-friendly lubricants (AAK, 2017). AAKs vision is to be the first choice for value-adding vegetable oil solutions. Almost all rapeseeds harvested in Sweden are delivered to AAK in Karlshamn, Figure 4.

Figure 4.Karlshamn´s location in Sweden

3.1.3 State of the sector

The rapeseed crop sector is in a sharp rise. Winter rapeseed is sometimes associated with some cultivation uncertainty, since it is important to establish the crop in field on time in the late summer.

Most of the food industry sectors follow the pattern of a declining staffing force. The number of employees was halved in the oil and fat industry sector in Sweden from 2008 to 2011, primarily in companies with more than 500 employees. This is partly due to the fact that some companies in the oil and fat industry started producing other things than oil and fat. At the same time the number of

companies in the fat and oil industry was 48 companies in both 2008 and 2011. The other food industry in Sweden, covering several of the processed agricultural products, on the other hand, grew in both the number of companies and in the number of employees during the period 2008 to 2011. (Jordbruksverket, 2012)

The oil and fat industry in Sweden is a sector with high profit figures (SCB, 2017). The neighbouring countries are Sweden's largest export markets. Denmark is the largest recipient country in terms of value, followed by Norway and then Finland.

The prerequisite for obtaining profitability in the rapeseed press process is based on the availability of both rapeseed oil and rapeseed press cake/rapeseed meal. The rapeseed press cake profit depends on the market price of rapeseed oil and vice versa. The need for rapeseed in compound feed is greater than can currently be produce in the country (Holmqvist, pers. comm., 2017). The great demand for the protein flour from rapeseed has during several years been the part that has affected the price of rape seed the most. Since 2007 there is a close connection between the price on vegetable oil and the price on fossil oil.

3.1.4 Typical size of the companies

The number of employees at AAK Sweden has not varied that much between December 2012 and December 2016, around 450 employees. The company had an economic turnover of approximately 650 000 Euro in 2016, an increase from December 2012 with around 63,000 Euro Table 11 (Allabolag, 2017). The profit went up from 2012 to 2013 and down 2014 and 2015, then up again 2016. Maybe there were large investments at AAK Sweden in 2015 that affected the profit of the year in 2015.

Table 11 Company facts on AAK. Source: Allabolag (2017)

	Company facts on AAK					
Facts	2012-12	2013-12	2014-12	2015-12	2016-12	2012-2016
Number of employees	456	440	448	454	451	450
Economic turnover (Euro)	589,980	586,251	631,960	627,105	652,905	617,640
Profit for the year (Euro)	20,331	42,434	34,667	13,796	51,110	32,468

AAK does not want to comment on the specific amount of rapeseed that is delivered to their production site in Karlshamn (Holmqvist, pers. comm., 2017). However, the production doesn't cover the company's total need and therefore imported seeds are also used.

Ecobränsle is a company that produce RME in their own factory in Karlshamn. In 2016 around 15,000 tonnes Swedish rapeseed oil was used for production of RME at Ecobränsle. From one ton rapeseed the RME yield is just below 100%, but in the process methanol is also added. In 2014 around 35,000 tonnes Swedish rapeseed oil was used for production of RME, in 2015 around 25,000 tonnes and 2016 only around 8,000-10,000 tonnes. The decline was due to a tax levied on RME in 2015. (Lorentzen, pers. comm., 2017)

Rapeseed oil is a large bulk product in the world market. Nevertheless, more and more Swedish farmers are investing in processing capacity for locally produced rapeseed oil. Here are examples of some locally pressed rapeseed oil: Nygård Gävleborg, Nyborg Stockholm, Julita Sörmland, Sänkdalen Östergötland, Stockuts Västra Götaland, Olivia Västra Götaland, Gunnarshög Skåne and SoilOil AB Skåne.

The Swedish company, Binol (www.binol.com), which has lubrication, engine and saw chain oils based on rapeseed oil. Binol was owned by AAK but was acquired by Quaker Chemical cooperation 2014.

3.1.5 Distinctive facilities of the sector

The production of rapeseed oil and rapeseed meal at AAK Karlshamn is a year around production. There is no seasonal variation. There are storage facilities at the site, but there is no possibility to store other materials in this facility since it is a year around production at the site.

Examples of type of machinery that is available on the site is a crusher, if capacity is fully utilized today or not is no information that AAK wants to reveal (Holmqvist, pers. comm., 2017). In the crusher the rapeseeds are mechanically pressed in expellers after a preheating step in indirectly heated conditioners. After the crusher the pressed cake will be further treated in the extractor (another example of machinery in the production process), since it might still content up to 19 % of oil).

AAK treats the meal further in a unique heat treatment process, which reduces the rumen digestibility without reducing the intestinal digestibility for ruminants. Very little soymeal is used for feeding bovines in Sweden today, much because of this process. (Holmqvist, pers. comm., 2017)

3.1.6 Degree of innovation

The rapeseed oil and rapeseed meal industry is a mature industry. As one example the production of fats and proteins for fodder is something that has arised from a need to take care of the residuals.

The vegetable oils is an agricultural product that is chemically most similar to mineral oils and therefore have a great potential as biological raw materials to replace the mineral oils in industries such as for biomaterials and chemicals. Already today vegetable oil is competing successfully with mineral oil in many technical applications. (Svenskraps, 2017)

The vegetable oil industry has put a lot of effort into delivering formulations with an improved nutritional profile to the food industry. Raw materials and innovative processes are in constant development with a clear cost impact. (Fediol, 2017)

3.2 Opportunities IBLC

3.2.1 Sector related residues

The total volume of straw from oilseed crops in Sweden is around 740,000 tonnes per year. This corresponds with 3.1 TWh in total energy production per year. The energy content in MWh per tonne dry matter is 5.0, with a water content of 16%. (Börjesson, 2016) There are a lot of nutrients in rape straw. From Swedish trials it was shown that winter rapeseed left 70 kilos of nitrogen per hectare as crop residues. The estimated content of phosphorus was 15 kilos and 340 kilos of potassium. (Svenskraps, 2017) A very small amount of rape seed straw is utilized in Sweden today, the most part is ploughed back into the soil. The utilization is as litter for animals.

Only small amounts of biomass residual are produced in the vegetable oil production at AAK since the rape seed meal is utilized as well. Small amounts of rape husks are separated from the rape seeds in the process at AAK Karlshamn. The specific amounts are nothing that AAK want to spread information about. Smaller amounts of bio oil are also produced. Both the rape husks and the bio oil are incinerated today. (Holmqvist, pers. comm., 2017)

The largest single import of oil crops consists of pressurized residues from vegetable oil production, so-called oil cakes and meal. About 400,000 tonnes of oil cakes and meal are imported annually to Sweden. (Jordbruksverket, 2017)

3.2.2 Potential synergies & benefits

Since there are no large amounts of biomass residues from the rape seed oil production and it is a year around production at the site there are no great opportunities for establishing a future IBLC at AAK Karlshamn. To become a supplier of biocommodities is not of interest for AAK Karlshamn (Holmqvist, pers. comm., 2017). AAK will not start producing rape seed press cake for food purposes, but it might be interesting for other non-food applications.

3.2.3 Market developments

At Lund University researchers are currently trying to convert the press-cake from rapeseed to human food, for an example as a protein substitute for meat. The press-cake from rapeseed contains around 30% protein, in comparison, meat contains 20 % protein. It also contains toxic substances such as glucosinolate. By using advanced membrane filtration methods, the researchers expect to extract these substances and then a whole new field of application opens up. In addition to the successful removal of the harmful substances, there is an off-flavour in the residual product which must be neutralized. (Lund University, 2017)

Rapeseed straw is not utilized to any significant extent in Sweden today. It contains macromolecules of the type lignin and hemicellulose which can be used as raw materials in the manufacture of renewable plastic materials. Researchers at KTH Royal Institute of Technology are working on developing a method for extracting the key elements from the rapeseed straw. The goal is to produce

a raw material and, based on it, create a renewable plastic that can be as good as oil-based plastics to eventually substitute the oil-based plastics. (KTH, 2017)

Rapeseed plants are flexible and can adapt to different uses. There is room for such development.

Vegetable oil from oil crops has been used primarily in the food industry in the past, but the growing bioenergy market has been an important factor in rapidly rising prices and demand for vegetable oils.

3.2.4 Non-technical barriers

There are opposing views on whether crop based commodities should be used for biofuels and/or biochemicals. The pro side claims that it is a way to keep arable land in cultivation as well as in readiness to produce both fuels and food. Increased demand affects the farmers' decisions in the crop production. However, the pro-side claims that one positive side effect can be that the product, rapeseed oil, can be used as food for a major food crisis and temporarily replaced with fossil fuels. The opponents on the other hand claim that there will be a competition for the raw materials. They also state that the biofuel industries are very favored by todays EU regulations.

If there would be a possibility or a market opportunity to produce some kind of protein concentrate from rape seed for food purposes it would not be possible with today's legislation (Holmqvist, pers. comm., 2017). Only protein isolate is approved for food today, selling a rapeseed cake or concentrated protein product for food today is prohibited as long as the protein concentration is not at least 90%. The difference between concentrate and isolate is the content (concentration) of protein. In a concentrate the protein content is around 70% and in an isolate around 90%.

In the beginning of 2018 the European Parliament voted in favor of the Renewable Energy Directive (RED II). A key decision made in the voting was to remove biodiesel made from palm oil from the list of biofuels counting towards EU renewables targets from 2021. The rules endorsed by the EU are not final. The European Parliament, the executive European Commission and EU national governments must now negotiate a final draft of the legislation and vote to approve it in a so called trialogue.

The attitude of the industry is that they are not interested in becoming a supplier of biocommodities, this has a negative effect on the possibility to establishing a future IBLC in this sector.

4 Grain Production

4.1 Grain production in Sweden

4.1.1 Production

4.1.1.1 Primary production

The primary grain processing chain production's main products are for human food consumption, animal fodder and industry applications like ethanol, biogas and alcohol beverage, Figure 5. The primary grain feedstocks are mainly wheat, barley, oats but also rye and triticale.

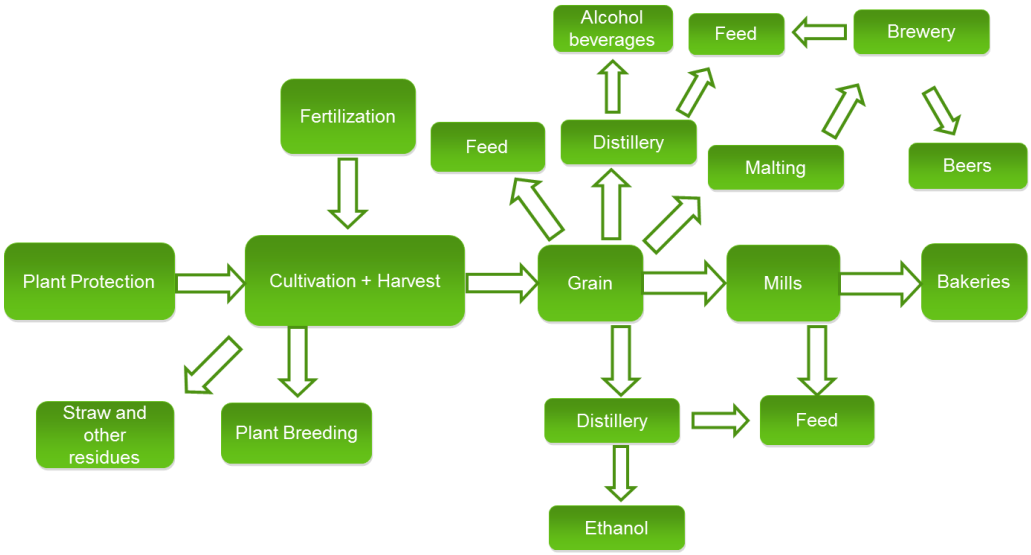

Figure 5. Schematic description of grain processing chain.

4.1.1.1 Processing industry production

For foods, mostly wheat and rye are used in flour production. For feeds, barley, oats, triticale and mixed grains are used as well as a large proportion of wheat. The by-products are bran and husks. The largest proportion of barley used in foods is brewing barley for the brewing industry with residues like malt grout pellets. A significant amount of wheat is used in ethanol production for biofuel and alcoholic beverages.

4.1.2 Volume of the sector

Table 12 shows, in average between 2012 and 2016, the total arable land (excluding pastureland) in Sweden was 2,595,797 ha and the total area used for the most common grains (see Table 12) were 999,940 ha. Wheat was the largest grain crop, sown on 412,185 ha or 41 % of total area with common grains. Slightly less than 80 % of the sown wheat was winter wheat. Barley is the second

largest grain crop and oats were the third. The sum of areas sown with remaining common grains were on average about 6.5 % of total area common grains (Jordbruksverket, 2017).

Table 12 Crop area for most common grain crops in Sweden (Jordbruksverket, 2017)

Crop area in Sweden (ha)						
	2012	2013	2014	2015	2016	Average
Total arable land excl leys and pasture	2,608,274	2,604,531	2,596,527	2,590,053	2,579,602	2,595,797
Total area with grains	1,000,240	984,491	1,034,378	991,776	988,815	1,011,307
Winter wheat	283,567	209,860	379,907	395,241	375,007	328,716
Spring wheat	84,804	116,353	75,282	64,710	76,192	83,468
Rye	22,027	25,127	27,130	23,649	16,650	22,917
Winter barley	9,131	13,701	13,357	15,699	19,179	14,213
Spring barley	364,687	378,867	321,924	311,779	308,154	337,082
Oats	196,240	200,581	164,895	168,055	180,869	182,128
Triticale	23,884	23,059	38,309	-	-	28,417
Mixed seed (grain)	15,900	16,943	13,574	12,643	12,764	14,365

Between 2012 and 2016, the total annual grain harvest was approximately 5.5 million tonnes, Table 13. The largest harvest obtained was winter wheat, averaging at 2.3 million tonnes, or 41.8 % of total grain harvest. The next three largest grain crops (spring barley, oats and spring wheat) were together averaging at 49.7 % of total grain harvest (see
Table 12) (Jordbruksverket, 2017).

Table 13 Total harvest of different grain crops in Sweden. (Jordbruksverket, 2017)

Total harvest in Sweden (tonnes)						
	2012	2013	2014	2015	2016	Average
Total grain harvest	5,055,900	4,985,200	5,775,400	6,162,400	5,466,700	5,489,120
Winter wheat	1,933,800	1,319,000	2,750,800	2,984,800	2,502,100	2,298,100
Spring wheat	355,500	549,600	335,600	315,600	339,500	379,160
Rye	139,900	142,000	173,600	149,200	101,600	141,260
Winter barley	60,300	78,100	85,800	96,100	110,300	86,120
Spring barley	1,641,400	1,862,000	1,488,400	1,576,200	1,427,600	1,599,120
Oats	731,200	851,500	665,900	744,700	771,500	752,960
Winter triticale	140,400	111,700	226,400	231,300	148,700	171,700
Spring triticale	-	-	-	12,500	10,000	11,250
Mixed Seed	53,400	71,300	48,900	52,000	55,400	56,200

Grain is cultivated in most parts of Sweden, but the largest productions are in the counties of Skåne, Västra Götaland, Östergötland and Uppsala, all of which is in a range of south to middle of Sweden (see map in annex). In total 60 % of the grain cultivated area is located in these regions.

In average around 200 000 tonnes are used for seeds on the farm and 2,300,000 tonnes are used as fodder (Table 14). Approximately 745,000 tonnes are used by industries, e.g. Absolute Vodka and Agroetanol, where Agroetanol used most of that volume. In Table 14, the grain balance during 2010-2014 is presented for all grains and in Table 15 different examples of each grain is presented under 2013/2014. The data on consumption and fodder in Table 14 is uncertain and should be analysed with caution as remaining products are labelled as fodder for simplicity. The storage capacity does not include storage at the farms (Eklöf, 2014).

Table 14 Total grain balance July-June 2010/11-2013/14, 1000 tonnes (Eklöf, 2014)

Total grain balance July-June 2010/11-2013/14, 1000 tonnes					
	10/11	11/12	12/13	13/14 prel.	Average
Incoming supply	619	432	405	447	476
Harvest	4,280	4,630	5,056	4,980	4,737
Import	335	342	362	430	367
Total asset	5,234	5,469	5,846	5,857	5,602
Food	863	895	892	975	906
Industry	716	737	817	710	745
Seed	192	196	199	199	197
Fodder etc	2,046	2,346	2,416	2,440	2,312
Export	985	892	1,074	900	963
Total use	5,234	5,496	5,398	5,224	5,338
Outgoing stock	432	405	447	633	479

Table 15 Total cereal balance July-June 2013/14, 1000 tonnes (Eklöf, 2014)

Total cereal balance July-June 2013/14, 1000 tonnes						
	Wheat	Rye	Barley	Oat	Triticale	Other
Incoming supply	172	14	145	66	5	2
Harvest	2,289	140	1,702	731	140	53
Import	208	9	31	8	89	17
Total asset	2,669	163	1,902	805	234	72
Food	505	124	221	41	0	1
Industry	673	0	30	0	110	4
Seed	85	3	68	100	5	3
Fodder etc	837	0	970	389	102	53
Export	396	24	454	190	0	10
Total use	2,496	151	1,743	720	217	71
Outgoing stock	173	12	159	85	17	1

In average between 2010/11-2013/14, 360,000 tons of grains are imported into Sweden (Table 14) In 2013/14, primarily wheat followed by triticale were imported (Table 15). Higher quality wheat (higher protein levels for human consumption etc.) is usually imported in variable amounts depending on the quality of the Swedish harvest. Barley is imported when domestic barley is not of

sufficient quality for malting, among other reasons (Eklöf, 2014). How imports have varied with different grains between 2000 and 2013 is illustrated in Figure 6.

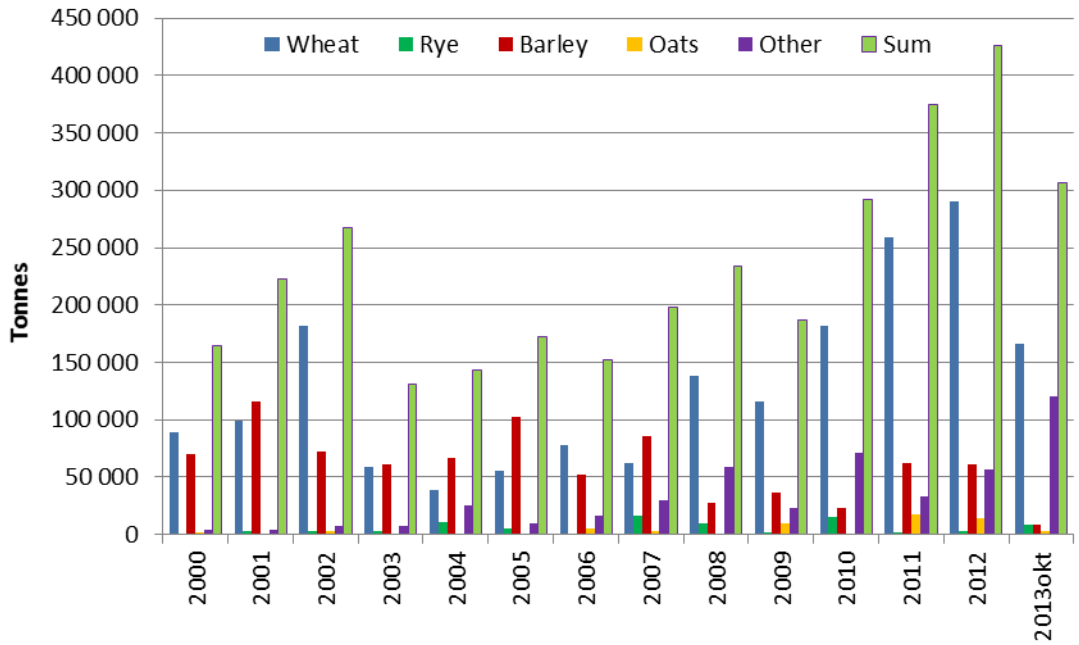

Figure 6 Import 2000-2013 (Eklöf, 2014)

As seen in Table 16, the average yield per hectare of the most common grains grown in Sweden is increasing over time, where the highest average was with winter wheat at 6,500 kg/ha (Jordbruksverket, 2017).

Table 16 Yield kg/ha for the most common grains in Sweden 2012-2016

Yield kg/ha for the most common grains in Sweden 2012-2016						
	2012	2013	2014	2015	2016	Average 2012-2016
Winter wheat	6,820	6,310	7,250	7,570	6,680	6,513
Spring wheat	4,290	4,800	4,530	5,000	4,540	4,428
Spring barley	4,560	4,980	4,710	5,200	4,760	4,570
Oat	3,820	4,370	4,170	4,610	4,450	4,094

Examples of end products of the grain chain industries are base products like flour, groats and flakes.

Table 17 shows grain chain industry's end products quantity in tonnes. The currently available data is from the period 2011-2015 (SCB, 2017).

Table 17 Deliveries from processed grains 2011-2015 in Sweden, tonnes (SCB, 2017)

Deliveries from processed grains 2011-2015 in Sweden, tonnes						
	2011	2012	2013	2014	2015	Average 2011-2015
Flour, grinded from regular wheat and spelt	335,323	326,887	264,821	260,930	379,566	313,506
Flour, grinded from mixed seeds of wheat and rye	106,061	122,077	121,059	114,627	134,654	119,696
Flour, grinded from barley	440	267	239	244	278	294
Flour, grinded from rye	0,0	48,163	50,456	49,786	52,418	40,165
Crushed groats and coarse flour incl. fine grouts from oats	4,084	75	16,557	18,785	25	7,905
Oats, processed to flakes	22,784	20,172	18,643	22,377	22,939	21,383

4.1.3 State of the sector

The largest number of farm enterprises is found in the area group 50.1-100 ha with 8,181 companies, followed by 30.1-50.0 ha with 7,458 companies, Table 18 (Jordbruksverket, 2017). Grain companies in Sweden have the follows the pattern fewer but bigger companies. In average, a farming company today has 43 ha arable land (Jordbruket i siffror, 2017) which is an increase of approximately 16 % from 2012 (Eklöf, 2014).

Table 18 Farm holdings in Sweden 2005-2016 (Jordbruksverket, 2017).

Farm enterprises in Sweden 2005-2016						
Size of holding	2005	2007	2010	2013	2016	Average 2005-2013
20,1-30,0 ha	7,583	7,122	6,603	6,022	5,413	6,549
30,1-50,0 ha	8,862	8,259	7,490	6,778	5,901	7,458
50,1-100,0 ha	9,569	8,957	8,205	7,368	6,807	8,181
100,1+ ha	6,099	6,165	6,456	6,605	6,690	6,403

4.1.4 Typical size of the companies

This section of the report focuses on the biggest companies in the sector. Lantmännen (LM) is a co-operative owned by approximately 25,000 Swedish farmers (in 2016). The corporate group is divided into several subdivisions. The division LM Lantbruk (LM Agriculture) is the core operation working with the primary production holdings, the farms, with selling commercial products (fertilizers, crop protection, etc.), seeds, animal fodder and more. As of 2017, the divisions Lantbruk and Maskin (Machine) is merged to one division. LM Lantbruk is also buying and selling the raw material (the grains). The number of employees at LM Lantbruk in 2016 was 766 (see Table 19), a decrease of 52 from previous year 2015. This division's economic turnover was €1.1 billion. LM Livsmedel (LM Food) is involved in the processing industry, producing, refining and developing grain-based products like flour, pasta, bread, breakfast products etc. This division's turnover 2016 was €1.46 billion with 6,610 employees (Lantmännen, 2016).

Svenska Foder is an agricultural company with a turnover of approximately €440 million and 329 employees. They are selling commercial products and raw material (grains) much like LM Lantbruk. The DLG-group owns 100 % of the shares in Svenska Foder.

Furthermore, there is a bigger group consisting of 18 private companies and co-operatives called Spannexgruppen (Spannex group). The organization acts as a whole sale dealer of products and raw material for the participating enterprises. The companies are Västerbotten Fodercentralen AB, Dalviks Kvarn AB, Värmlant AB, AB Johan Hansson, Fjällbacka Foder AB, Forsbecks AB, Buttle Foder & Spannmål, Varaslättens Lagerhus, AB Skene Valskvarn, Mörk och Söner HB, XL-Bygg Byggland Höör, Br Karlssons Foder AB, AB Hjalmar Möller, Karmegrens gårdsservice AB, Vallberga Lantmän, LT Lantmän, and Kristianstads Lagerhusförening (Spannex, 2018). Spannexgruppen has a turnover of approximately €300-400 million with approximately 400 employees over all the participating enterprises. Market share of each company within Spannexgruppen varies within the respective region and all companies are not working exclusively with grains and fodder (Von Sydow, pers.

comm., 2018). Swedish Agro is a subsidiary company to Danish Agro with a turnover of approximately €125 million and 137 employees.

Table 19 summarize the biggest companies in grain processing in Sweden.

Table 19 List of biggest companies regarding grain processing in Sweden

List of biggest companies regarding grain processing in Sweden		
Company	Turnover MEURO	Employees
Lantmännen Livsmedel[1]	1,460	6,610
Lantmännen Lantbruk[1]	1,119	766
Spannexgruppen[2]	300-400	400
Svenska Foder[3]	447	329
Swedish Agro[4]	125	137

Food & feed

The largest malting plant in Sweden is situated in Halmstad and has a production capacity of about 200,000 tonnes malt. A smaller proportion of barley and oats for food is composed of meals and flours which are grinded at the mills (Eklöf, 2014).

Ethanol

Presently in Sweden, fuel ethanol from grain is produced in a plant in Norrköping, LM Agroetanol, with a capacity of 230,000 m^3 ethanol per year. Ethanol production consumes about 600,000 tonnes grain per year, mostly wheat. The remains, besides draff, are carbon dioxide from the fermentation (Gundberg, 2017).

Milling

The milling industry in Sweden today is comprised of approximately ten production units which together have a turnover of approximately €151 million annually. The industry is effective with a low level of staffing. The economical margins are small but the processed quantities are very large. If the turnover in average is €100,000 per staff member, the equivalent figure in the milling industry is approximately ten times. (Svenska Kvarnföreningen, 2017). About 600 000 tonnes of grains are

[1] (Lantmännen, 2016)

[2] (Spannex, 2018)

[3] (Svenska Foder, 2017)

[4] (Swedish Agro, 2017)

grinded to flour for human consumption. The by-product is used mostly as animal feed (Svenska Kvarnföreningen, 2017).

4.1.5 Distinctive facilities of the sector

The two largest actors (Lantmännen and Svenska Foder) on the Swedish grain market have together close to 80 plants for grain delivery situated throughout Sweden. Most of them are strategically located near the main grain producing areas and there are fewer the further north in Sweden one come, see Figure 7 for location of Lantmännens 45 receiving plants (of which 25 have drying and storing capacity) in Sweden. In addition, there are 4 seed plants strategically placed near Eslöv, Skara, Skänninge and Klintehamn. Lantmännen has 2 breeding stations located at Svalöv and Lännäs. Lantmännen, in addition, has 3 research farms in Bjertorp, Nötcenter Viken and the Svalöv farm unit. Svenska Foder has its own facilities at around 30 other sites which includes feed factories, harbour facilities, seed plants, shops/storage terminals for receiving grains and sales/deliveries of animal feeds, seeds, fertilizers and chemical products Svenska Foder has seed plants in Kinne Kleva, Västergård and Bergsgården (outsourced operation). Seeds for Svenska Foder are produced by Skånefrö AB. Spannexgruppen has several facilities over the country, see figure 8 (Spannex, 2018).

During harvest period (normally July-October), the grain receiving facilities are utilized at 100 %, both storage and dryers. Usually, the dryers are not used between the beginnings of November to next year's harvest starts, but the storage silos are utilised as grain is received year round. The seed plants are used august to march at 100 %, then down to around 75 % of capacity (Jönsson, pers. comm., 2017).

Figure 7 Grain receiving plants for Lantmännen (Lantmännen, 2017).

Figure 8. Grain receiving plants and other grain facilities from enterprises collaborating under Spannexgruppen. (Spannex, 2018)

4.1.6 Degree of innovation

The level of innovation considering by-products/ side-streams can be considered as high. Many projects from Lantmännen are invested in using crop residues in alternative biobased products, but today most of the crop residues are used for feed, biogas industry or incineration (Pettersson, pers. comm., 2017). The sector is actively investigating in opportunities to increase the production effectiveness of its facilities.

There are many examples of already established benefits using raw material residues. For example, the oat mill in Järna is using the husk residues as burning material in their steam boiler in the process for oat groat production and excess steam and hot water are used as heating around Järna municipality. Not only does this reduce the factory CO_2 footprint, but it also reduces the transportation of residues to landfills and the transportation of fuel oil for the previous steam boiler which furthermore reduces the CO_2 footprint (Telge Nät AB, 2011; Ny Teknik, 2005).

During the ethanol production, a lot of CO_2 is produced which is utilized and refined in a nearby carbon dioxide plant in cooperation with AGA Gas AB (AGA, 2012).

LM Agroetanol has great experience in using the IBLC approach and is constantly working on increasing the added value of residues. All draff is used for fodder and the majority is exported. Not only is grain used as raw material but also food waste like expired bread and the like which was previously used mostly as animal fodder (Gundberg, pers. comm., 2017).

BIOAGRO Energy is a company located in Skåne in collaboration with Skånefrö AB and others. Their production is based on using dry biomass residues from agricultural production to create fuel pellets and district heating. The ashes can then be used as fertilizers (BIOAGRO Energy, 2018).

4.1.7 Miscellaneous

In a comparative study, two LCAs were established, where the first LCA compared three different scenarios in arable land use from a climate change perspective. The scenarios were cultivation of wheat used for production of bioethanol, carbon dioxide and DDGS (see abbreviation), cultivation of rapeseed used for production of RME, rapeseed meal and glycerine and fallow in the form of long-term grassland. The study concluded that the best use of arable land from a climate change perspective were cultivation of wheat for production of above-mentioned products. The second LCA compared the three protein feeds DDGS, rapeseed meal and imported soybean meal, where DDGS and rapeseed meal where to preferred instead of imported soybean meal from a climate change perspective (Karlsson & Sund, 2016)

4.2 Opportunities IBLC

4.2.1 Sector related residues

4.2.1.1 Sector related residues within the supplying agricultural sector

The biomass residues from primary grain production are mostly straw with smaller biomass components such as chaffs. The straw either stays on the fields and gets incorporated into the soil or is used for livestock bedding or feed. The availability in time of this biomass is limited due to the growing season, the harvesting period as well as the local storage capacity. Today, most of the straw residues are reintroduced to the soil to preserve soil humus content, but some are used as litter in animal production and a small part is used for incineration often in farm-level boilers and grain dryers.

Nutrient content in straw is estimated to 40 kg potassium, 4 kg phosphorus, 6 kg sulphur and 5 kg magnesium per hectare at a straw yield at 4 tonnes/ha (ATL, 2006). The amount of straw from gross grain production in Sweden is estimated to 3.8 million tonnes. Expressed as energy the straw is estimated to approximately 16 TWh per year. With consideration of ecological (leaving the straw to increase humus content etc) and techno-economic (harvest losses, limited harvest opportunities due to weather, straw as litter and fodder and more) Börjesson, 2016, estimates that the total, practical availability of straw is 3,600 GWh/year, and the regions with biggest available amount of straw lies in Skåne with 40 % (1,450 GWh/year) of total potential, followed by Östergötland and Uppsala (Uppland) with 15 % (500 GWh/year) each (Börjesson, 2016).

4.2.1.2 Sector related residues within the agro-industry's processing operations

Residues derived from the processing industry are mostly shell residues from milling and grinding of cereals and residues such as draff and marc from production of ethanol for industry/fuel, beer and other alcoholic beverages. Today the majority of these residues are used as animal fodder. The malt industry residue is approximately 13,000 tonnes malt sprout pellets, which today are used as raw material to fodder industry (Nowack, 2017). The draff from ethanol production is estimated to 190,000 tons per year (Gundberg, 2017). The biggest brewery in Sweden is Spendrups, and the company produces about 30,000 tonnes of marc per year (Spendrups, 2017).

Residues are produced during the cereal drying both at the local farms and at the silos from Lantmännen and other cereal buyers. The residues from Lantmännen's grain silos are estimated to 2,000 tonnes in the Skåne region and 9,000 tonnes in the middle of the country (Fredriksson, 2017). The deposits are used for incineration in Lantmännen's own facilities, other facilities and producing biogas. The volume from the local farms cereal dryers are much harder to estimate. Almost all of the residues that originate from grain drying are produced during harvest time and to somewhat extent the storage period directly after harvest time.

Comparing process industry's related residues to that of fodder and roughages, the logistics chain is easier to handle as the residues are already used for production today (Petterson, pers. comm., 2017).

4.2.2 Potential synergies & benefits

It is with each industry's core interest to maximize the production capacity of its facilities during the whole year. Therefore, many plants have few production dips, nowadays. Seed plants and grain receiving plants potentially have some surplus capacity, perhaps offering an interim storage of straw and other residues. There are examples of facilities moving its staff during high and lows in production, for example between seed facilities and grain receiving plants (Lööf, pers. comm., 2017). Many, and especially the bigger farms do not have the storage capacity to store their whole harvest and is therefore dependent on delivering some crop quantity during the harvest period.

It is also important to consider IBLC approach when planning for the location of future expansions of facilities and also adapt the building for different production and storage possibilities.

As most of the residues are already used today in some way other than landfills, the main focus in the IBLC approach is to further increase the added value of these by-products, both in the process industry and in the primary production. There are several examples of production focus in already established facilities.

It is also important to look at the synergy between companies both inside as well as outside the grain sector. For example, LM Agroetanol recently started cooperation with truck manufacturing company Scania, with the intent of delivering total solution for heavy transports to reduce emissions (Jordbruksaktuellt, 2016).

4.2.3 Market developments

Lantmännen is involved in a recently started project regarding developing bio composite material from oat husks used for furniture and coffins (Andersson, 2017). This can increase the added value of these residues even more than earlier mentioned and this could be a new market for LM.

Today, wheat bran is mostly used as animal fodder and to some degree as fibre addition in human food. A research team at Royal Institute of Technology (KTH) has found a way to extract polysaccharides from pollards, opening up for several, more environment-friendly fields of applications with bio-plastics like medicine capsules and protecting plastic layers around meat (ATL, 2017).

Lantmännen is involved in a project called Farm2Furan with the purpose to develop a value chain for production of chemicals within a frame for a future bio refinery based on agricultural raw materials and residues like husks, straw and brans (Moldin, 2017).

4.2.4 Non-technical barriers

Looking forward in time, there are several factors that play a role in the supplies of crop residues. Therefore, there are many uncertainties in the estimates in future potential for bio-production purposes. For example, the area of land for growing crops may decrease, yield levels, changes in the amount of straw relative kernels (straw/kernel-quota), other fields of applications and more (Börjesson, 2016). In Hjerpe et Al. (2012) model studying has shown that a decrease in farmland area by 30 % and maintaining the same production levels by 2050 is possible.

The volume of straw is determined by the amount of cereals produced which in turn is determined by the price. The prices for cereals are mainly influenced by global market prices and therefore dependent on variation from countries with larger influence. The type of crop that is produced is therefore to some extent controlled from a market demand standpoint. As the sort of crop varies, so does the amount of straw, which in itself adds fluctuations in the amount of straw available for processing. The weather plays a significant role as well on the management and storage of straw.

The EU has formed a burden-sharing policy, the Renewable Energy Directive (RED)5, where 20 % of total energy needs to be produced from renewables and 10 % of transport fuel comes from renewable sources by 2020. Due to a recent proposal, the total energy produced from renewables should be 35 % by 2030 but also a reform on which crops that are classified as renewables. This proposal may have an influence on primary crop production to biofuels, but also has the potential to benefit the production from grain sector residues.

[5] https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive

5 FEED AND FODDER SECTOR

5.1 Profile of the feed and fodder sector

5.1.1 Production

Feeds and fodder for animals in Sweden derives from grains, green crops, protein crops, leys, and residues from different industries. The biggest proportion of feed are grains and mainly barley, wheat and oats. Protein crops are peas, broad beans, imported soybeans and rapeseed meal. Residues from sugar and vegetable oil production are also important feeds for fibre and fats and ethanol production residues are rich in proteins. Green crops are crops that are prematurely harvested and silaged (whole crop silage). Fodder mixtures are divided into two groups: complete feed and complementary feed. Complete feed must cover the animal's complete nutrient need and complementary feeds are premixes, concentrates and feed supplements (Jordbruksverket, 2017).

5.1.2 Volume of the sector

5.1.2.1 Volumes from the primary production

Leys and green crops comprise the largest group of crops in Sweden and were cultivated on 37% of agricultural land between 2010 and 2016 (Table 20). The average annual harvest of temporary grasses is 4.9 million tonnes. Looking at yield levels, here are some uncertainties about the statistics. Between 2010 and 2016, in average yield per hectare of temporary grasses is estimated to be 5,670 kg/ha, calculated as weight in hay, assuming 83.5% dry matter (DM),

(Jordbruksverket, 2017). These numbers includes all ley production in Sweden, but focusing on more high-intensity production in southern and middle Sweden, the yields are much higher. Trial material compiled and used in report 445 by Tidåker et.al, 2016 shows yield levels at 10,000 kg DM/ha with two harvests and 11,200 kg DM/ha with three harvests, effectively doubling the yield from the national average.

Table 20 Use of arable land 2010-2016 (Jordbruksverket, 2016)

Use of arable land 2010-2016 (ha)				
	2010	2015	2016	Average 2010-2016
Pasture and green crops	1,194,700	1,137,900	1,107,400	1,146,667
Sum total arable land incl ley and meadows	3,085,400	3,039,900	3,031,500	3,052,267

Table 21 Temporary grasses total harvest and yield (83.5 % DM) in Sweden (Jordbruksverket, 2017).

Temporary grasses total harvest in Sweden						
	2012	2013	2014	2015	2016	Average 2012-2016
Yield, kg/ha	5,320	4,960	5,950	6,240	5,880	5,670
Total harvest, tonnes	4,751,500	4,532,500	5,224,900	5,382,200	4,733,700	4,924,960

Protein crops grown and used as fodder in Sweden are peas and broad bean. In Table 22, yield per hectare and total harvest between 2012 and 2016 are presented (Jordbruksverket, 2017). The number of companies with animal production is presented in Table 23.

Table 22 Yields and total harvest of peas and broad beans 2012-2016 in Sweden (Jordbruksverket, 2017)

Yields and total harvest of peas and broad beans 2012-2016						
		2012	2013	2014	2015	2016
Yield, kg per hectare	Peas	2,730	3,340	3,220	3,710	3,680
	Broad beans	3,240	3,510	3,240	3,960	3,520
Total harvest, tonnes	Peas	35,100	40,800	46,500	83,100	92,700
	Broad beans	58,200	61,300	61,100	99,100	103,900

Table 23 Number of companies with animal production (Jordbruksverket, 2017)

Number of companies with animal production						
	2012	2013	2014	2015	2016	Average 2012-2016
Cows	16,314	15,712	15,035	14,624	14,221	15,181
Cattle	19,561	18,962	18,210	17,581	17,046	18,272
Sheep	9,263	8,869	8,951	9,110	8,724	8,983
Pigs	1,113	1,281	1,282	1,228	1,252	1,231
Poultry	4,766	5,020	4,898	3,920	3,484	4,418
Horses	N/A	16,595	N/A	N/A	15,358	15,977

The dairy cow population at present in Sweden is approximately 330,000 cows
Table 24). Daily consumption per cow is on average about 10 kg silage (DM basis) and 5-6 kg DM silage for young stock (Eriksson, 2017).

In Table 24, a number of animals is presented between 2012 and 2016 (Jordbruksverket, 2017). For convenience, certain animal groups are grouped together. Other cattle include cows for breeding calves, heifers, bulls, steers calves under 1 year of age, sheep includes lambs, rams and ewes, pigs

includes boars and sows for breeding, slaughter pigs over 20 kg and piglets under 20 kg, poultry includes both for slaughter and egg production. All animal groups except other cattle and poultry show a decline in numbers in the presented time period. Poultry shows some increase and other cattle are almost unchanged. Due to the recent crisis in dairy cow production, one can argue that an amount of dairy cows has been moved to other production and affecting the numbers.

Table 24 Number of animals in Sweden 2012-2016 (Jordbruksverket, 2017)

Number of animals in Sweden 2012-2016						
	2012	2013	2014	2015	2016	Average 2012-2016
Dairy cows	347,969	344,021	344,339	339,823	330,833	341,397
Other cattle	1,152,324	1,152,505	1,148,780	1,140,235	1,158,791	1,150,527
Sheep	610,534	576,769	588,757	594,753	578,174	589,797
Pigs	1,363,364	1,398,875	1,377,530	1,356,027	1,354,286	1,370,016
Poultry	14,760,985	16,540,365	16,173,528	17,856,775	18,752,274	16,816,785

5.1.2.1 Volume of the processing industry

There is a substantial amount of grains used in feed production as well. As mentioned in the grain sector chapter, an average of 2,300,000 tons grains are used and processed as fodder (Table 13). Grains mainly used in feed processing are barley, wheat and oats.

Lantmännen's 7 feed mills in Sweden are located in: Åhus, Falkenberg, Lidköping, Klintehamn, Kimstad, Västerås and Holmsund (Figure 8), all situated close to harbours. Feeds, feed supplements and additives are produced here for dairy and beef cattle, pig, poultry, reindeer, sheep and horses. These 7 units produce about 1.1 million tonnes of feed yearly. This is composed of 430,000 tonnes grain and 700,000 tonnes other feed materials, including feeds in organic farms and oil plants (Lantmännen, 2017).

Figure 8 Lantmännens feed mills in Sweden (Lantmännen, 2017)

5.1.3 State of the sector

The number of animal farms has been steadily decreasing (Table 23) and so has the number of animals

Table 24) (Jordbruksverket, 2017). Land use for grass production has been maintained by the usage of horses when cattle numbers have decreased. Sweden has a very high status of animal welfare legislature which is unique. The regulations influence production forms in Sweden. All farm animal groups, pig, poultry and not least dairy cows, have undergone crises during the last fifteen years which has greatly affected production. Smaller units have been forced into closing and larger operations with modern housing have been established (Hermansson, pers. comm., 2017).

In Sweden animal production is often associated with on-farm crop production. On-farm produced grain that is sufficient to cover all or part of the farm's feed requirements offsets the effects of price surges in the grain market, at least in the short term. Those animal producers that are most directly affected by increases in grain prices are those buying complete feeds and those producing their own grain but are in areas which have not supported normal harvests and need to complement with more grain than normally (Lööf, pers. comm., 2017).

Grass producers without animals have specialized in horse feeds amongst others. These operations are often close to the segment such as for example around the district Mälaren (Stockholm area and west of Stockholm) where much of the horse husbandry is situated. (Andersson, pers. comm., 2017).

5.1.4 Typical size of the companies

The two largest companies for feed production in the market are Lantmännen and Svenska foder. Lantmännen produces 900,000 tonnes feed of which half of the raw material is from grains (Szabó, pers, comm., 2017). The latest feed factory in Sweden was built in Kalmar, which produces about 270,000 ton yearly. In this feed factory about 400 different feed recipes are produced, which in practice means that recipes and production change every hour. Another example of a factor is Lantmännen's feed factory in Holmsund (north of Sweden) which processes about 30,000 tonnes of grain in feed production (Hermansson, pers. comm., 2017). The feed produced in Holmsund is shipped by bulk tanker as far north as to northern Norrbotten and even to Finland. One of Lantmännen's largest customer group are reindeer herders who often need to complement their feeding to the reindeers during the winter months. (Thomas Ruuth, pers. comm., 2017) A third example of factories is Svenska Foder's feed mill in Åhus (southern Sweden). Svenska Foder's yearly production is around 500,000 tons feed for cattle, pig, horse and sheep, corresponding to 25 % of the total market. Other producers are Swedish Agro, approximately 200,000 tons or 10 %, and Vallberga Lantmän, approximately 100,000 tons, or 5%. The remaining 15 % is divided between KLF, Johan Hansson, Teknosan, Västerbotten Fodercentral AB and more, including a large number of local feed mills.

5.1.5 Distinctive facilities of the sector

In perspective of idle time and surplus capacity, the fodder factories in LM have an even production a yearly basis with no seasonal highs or lows. The work schedule is 4 to 5 shifts per day with an idle time of around 20-30 hours per week dedicated to cleaning the factories (Jönsson, pers. comm., 2017).

Lately, the prices for feed grains have generally been low and this has helped maintain animal production ventures, which are struggling. The price for feed grains is steered by developments in the global grain market and how the harvest is for Sweden (Jeppsson, pers. comm., 2017). New types of grains have been developed, which can be used both for mills and feeds. Previously feed grains had a much greater yield. Due to seed development, this difference is no longer decisive which leads to a more diverse market benefitting producers who have a surplus over their own production needs and can sell on the general market.

5.1.6 Degree of innovation

Innovations are being made in limiting the need of import of protein crops in feed production. Between 2007 and 2009 around 240,000 tonnes of soy were imported to Sweden. From a time period perspective over ten years there has been a reduction from 300,000 tonnes. About 40 % of imported soy is used in feed production for cattle, about 40 % for poultry and 10-15 % for pigs. Remaining part is other animals like horses, cats and dogs (SLU, 2017). Alternative resources to protein are draff from ethanol production, soy beet pulp, rapeseed meal and pulses like peas and broad bean. Draff is an excellent protein source in feed mixing, but the quality of draff is too uneven for Swedish feed industry (Gundberg, pers. comm., 2017). Studies have shown that domestic-grown

rapeseed meal can replace soybean meal while maintain or increase milk yield in dairy cows (Gidlund H., 2017).

Innovation in grass as feed is mainly focused to decrease the need for protein supplements production and therefore also decreasing the need of imported protein. Animal advisers are actively working with farmers to increase the usage of grass to dairy cows e.g. increasing digestibility of roughage to decrease the need of supplementary feed.

5.2 Opportunities IBLC

5.2.1 Sector related residues

Residues produced from primary production (mainly grains) can be considered as the same as for the grain chain sector. Also, residues sugar industry and vegetable oils in form of molasses, sugar beet fibres, HP Pulps, rape seed meals and cakes (see sugar industry and vegetable oil sectors).

The amount of by-products from grain processing industry facilities from LM is considered low, around 2 %, which is stored at the factories and then reused in the fodder production (Jönsson, pers. comm., 2017).

Residues from leys in primary production are mainly in form of losses during harvest, storage and transport between storage to feeding platform. During harvest of leys, the DM losses is estimated to be between 3-10 % with silage roughages and 17-30 % with hay (Grovfoderverktyget, 2017).

Residues derived from other processing industries like ethanol or malt production (see grain sector) are today already used as feed.

5.2.2 Potential synergies/benefits

An upcoming project where RISE JoL (formerly JTI) will investigate the profitability of using discarded silage bales for biogas production. The same company is looking into combining traditional cultivation system with energy crops to increase profitability of the farms (JTI, 2017).

There is some amount of area in Sweden that cannot be used for traditional grain crops but could be suitable for leys. Today, some locations in Sweden have crop producing farms with fields that has low to no production (farrows and meadows). With increased value of products of these unused fields, there is a potential that the biomass availability would increase without affecting any other production areas. Consequently, increasing the profitability for the primary producers and availability of biomass for IBLC.

By using leys as a break crop in the crop rotation on farms, several benefits will emerge and increase crop production profitability in the long round. From a climate perspective, growing ley for biogas production is positive in several factors by increasing coal assimilation and reducing the use of fossil fuels (Tidåker *et. al,* 2016) and therefore has a positive effect on environment.

If the number of animals continues to decrease, consequently the demand for feed and also raw material for feed production will decrease. One can speculate that as animal numbers are decreasing, the surplus capacity in feed plant may increase, opening up for future IBLC use. Previously abandoned fodder plants has been successfully utilitized for other applications for example, Gyllebo Gödning is today using a feed plant for producing organic fertilizers (Lööf, pers. comm., 2017).

Morover, by offering different depositions for feed grain if animal production is decreasing, the primary production can continue. For example, the ethanol production has kept the need for producing feed grains (Eklöf, 2014).

5.2.3 Market developments

Just as straw from grains, grasses could broaden the choice material available for lignocellulosic ethanol processing and other bio applications. Research is ongoing but for the moment no official reports are published.

Grasses and whole crop silages are used as fodder, but there is potential in these products as a bio gas substrate. Today, most of the bio gas industry uses sewage sludge, food waste and manure as substrates. But studies have shown a net energy (energy exchange minus energy usage in production) of 28 MWh/ha for grass and 33 MWh/ha from wheat whole crop silage (Prade *et.al.*, 2015).

5.2.4 Non-technical barriers

Many by-products from other industries are already being used in feed production. One can argue that there is competitiveness in the market presently which may be a barrier for future biomass uses. One can speculate however, with a future surplus capacity of feed grains, the availability of biomass is increasing with a potentially decreasing animal production. Other non-technical barriers of primary production of feed grain are the same as in the grain sector.

6 SUMMARY ANALYSIS OF THE COUNTRY

Table 25. Summary Sugar industry sector.

Sector Sugar industry	
	Profile
Production	• About 2 million tons of sugar beets are produced every year in Sweden, the majority is cultivated in the southern part. • The sugar production starts in the field with the sugar beets and ends with a diversity of products, including sugar products, feed products (molasses, beet pulp), sugar factory lime, stones, beet soil and water.
Volume of the sector	• There is one sugar refinery, Arlöv, and one sugar factory, Örtofta, in Sweden, both owned by Nordic Sugar which is the only sugar producing company in Sweden. • Örtofta is one of the largest and most efficient sugar-producing facilities in northern Europe with a yearly production of sugar of 382,000 tonnes/year.
State of the sector	• For the last 50 years the market for sugar beets has been regulated with quotas and minimum prices, in October 2017 the EU regulation expired. • In autumn 2017 the market completely controls the demand for Swedish sugar, which means that the sugar production will compete with Europe in a new way.
Typical size of the companies	• Sweden produces around 2% of the total EU sugar production on a 5 year average 2011/2012-2015/2016 • During the production season Nordic Sugar Örtofta receives and processes around 2 million tons of sugar beets and the daily refinery capacity at Nordic Sugar Arlöv is around 1,000 tons raw sugar.
Distinctive facilities of the sector	• Nordic Sugar Arlöv is a sugar refinery that is running all year round and Nordic Sugar Örtofta is a sugar factory that only runs part of the year during the production season from mid-September to mid-January. • Just before the production season or just after the season there is a possibility to utilize some parts of the factory as the storage facilities and the drum drier.

Degree of innovation	• The sugar industry is a mature industry, historically a lot of resources have been put into research and development within the sugar industry in Sweden. • Nordic Sugar has become more and more involved in research projects the last couple of years, also in the Swedish organization, the projects is in into biobased products and processes, and the aim of the involvement from Nordic Sugar is to find a value chain increasement.
Miscellaneous	• For Örtofta Sugar factory a life cycle assessment of the beet sugar production was recently performed where a multiple of environmental aspects has been investigated.
	Opportunities for IBLCs
Sector related residues	• If all sugar beet tops in Sweden were harvested around 80,000 tonnes dry matter beet tops would be generated theoretically • All biomass residues from the Arlöv and Örtofta refinery factories are utilized today.
Potential synergies & benefits	• The time of year when there is no production on the sugar industry production site it may be possible to utilize the site for other types of production. • Some parts of the production line are only adapted to the large flow of biomass, but in some parts of the production line there are several smaller machines instead of one large.
Market developments	• Nordic Sugar Örtofta are involved in projects regarding bioplastics, they are interested in utilizing their industry site to produce biocommodities for bioplastic products and to utilize their biomass residues for bioplastic production. • They are also involved in a project that will develop a value chain based on side streams from the sugar industry for the production of key basic chemicals in the context of the future biorefinery.
Non-technical barriers	• When a market is deregulated, as just happened to the sugar market, price falls and price pressure often occur, but it can also lead to new markets and niches, which will probably also occur in the sugar sector.

Table 26. Summary Vegetable oil extraction sector.

Sector Vegetable oil extraction	
	Profile
Production	• In the last five years, an average of about 330,000 tonnes of oil crops was harvested in Sweden each year. • Most rape seed oils are hot pressed in Sweden, the rapeseed is pressed to oil at higher temperature, it is then refined and more oil can then be extracted from the filter cake by use of solvents.
Volume of the sector	• AAK is the owner of the only large-scale processing plant for oilseeds in Sweden. • Total consumption of rapeseed oil for both food and technical purposes in Sweden was 294,000 tonnes per year on average between 2012-2016.
State of the sector	• The rapeseed crop is in a sharp rise. • The oil and fat industry in Sweden is a sector with high profit figures.
Typical size of the companies	• AAK had an economic turnover of approximately 650,000 Euro in 2016. • The production of rapeseeds in Sweden doesn't cover AAKs total need and therefore imported seeds are also used.
Distinctive facilities of the sector	• The production of rapeseed oil and rapeseed meal at AAK Karlshamn is a year around production, there is no seasonal variation.
Degree of innovation	• The rapeseed oil and rapeseed meal industry is a mature industry. • The vegetable oils are an agricultural product that is chemically most similar to mineral oils and therefore have a great potential as biological raw material to replace the mineral oils in industries such as for biomaterials and chemicals.
	Opportunities for IBLCs
Sector related residues	• The total volume of straw from oilseed crops in Sweden is around 740,000 tonnes per year. • Only small amounts of biomass residual are produced in the vegetable oil production at AAK since the rape seed meal is utilized as well.
Potential synergies & benefits	• Since there are no large amounts of biomass residues from the rape seed oil production and it is a year around production at the site

	there are no great opportunities for establishing a future IBLC at AAK Karlshamn. • To become a supplier of biocommodities is not of interest for AAK Karlshamn.
Market developments	• There are research projects investigating rapeseed straw used as raw materials in the manufacture of renewable plastic materials and to convert the press-cake from rapeseed to human food.
Non-technical barriers	• The attitude of the industry is that they are not interested in becoming a supplier of biocommodities; this has a negative effect on the possibility to establish a future IBLC in this sector.
Sector Grain	
Profile	
Production	• Primary production is grains where the mostly common grown crops are wheat, barley and oats • Process production are mostly flour and animal feeds
Volume of the sector	• In average, 5.5 million tonnes of grains are produced where most commons grains are grown on 1 million hectares. • Around 300,000 tonnes of wheat flour are produced and 120,000 tonnes of wheat flour mixed with rye. About 2.3 million tonnes of grains are used as feed
State of the sector	• The number of farm companies is decreasing but each farm is getting bigger • The average land used by each farm is 43 ha, an increase of around 16 % since 2012
Typical size of the companies	• The biggest agricultural company is Lantmännen which is owned by 25,000 members, followed by Svenska Foder.
Distinctive facilities of the sector	• The two biggest companies have together around 80 receiving plants, where 45 is Lantmännen's and 30 is Svenska Foder's. • The facilities high production period is during harvest, but the storage silos are receiving grains all year round.
Degree of innovation	• Lantmännen has a history of investing and developing residue usage mostly by increasing the added value of side chains in processing production

	• One example is the usage of oat husks from groat production for incineration in boilers, where excess energy is used to heat the local house holdings
Miscellaneous	• A study using LCA shows that cultivation of wheat for production of ethanol and by-products were better fitted usage from a climate change perspective than cultivation and production of rape seed for RME production.
	Opportunities for IBLCs
Sector related residues	• Straw from gross grain production is estimated to 3.8 million tonnes per year, or 16 TWh/year. The practical potential usage for bioenergy from straw were estimated to 3,600 GWh/year • Residues from drying were around 9,000 tonnes from Lantmännens receiving facilities in the middle of Sweden
Potential synergies & benefits	• There is some surplus capacity at seed plants and receiving facilities and personnel are moved between production facilities • Benefits can be made by increasing the added value further from residues and side chains. There is already today synergies between facilities in and outside this sector
Market developments	• Projects are researching the use of bran and husks in production of biobased furniture and other bioplastics.
Non-technical barriers	• There are many uncertainties while estimating potential bioenergy potential, for example changes in straw/kernel-quota and decreasing land used for growing crops • Recent proposals in EU-regulations points that primary crops used in production of bioenergy should not be classified as renewable. This may open for future usage of residues in these productions

Table 27. Summary sector Fodder

Sector fodder	
	Profile
Production	• Feed and fodder consists of mixes of different crops like barley, wheat and oats, whole crop silages, protein crops like rape seed, peas and broad beans, and grass as roughages
Volume of the sector	• Temporary grasses are produced in quantities of 4.9 million tonnes per year in average, and leys and green crops are grown on 1.1 million h/year

	• About 2.3 million tonnes of grains are used as feed
State of the sector	• The number of animal farms is decreasing, and all animal groups except poultry are decreasing in number of animals
Typical size of the companies	• Lantmännen produces 900,000 tonnes of feed yearly where about half is from grains. Svenska Foder produces 500,000 tonnes of feed
Distinctive facilities of the sector	• The fodder factories seem to be in production all year round with little down time. • Previously, focus in specialized feed grains has grown on farms with animal production, usually locking in the usage of these crops to only feed. Nowadays, it is possible to maintain high yields of crops used in other applications like human consumption, which opens up sales market for the farmer in other areas than just feed
Degree of innovation	• There seems to be a focus on research in using domesticly grown protein crops to decrease the need of import. • Focus on increased grass proportion for dairy cows to decrease the need of grains and other crops as supplement
Miscellaneous	
	Opportunities for IBLCs
Sector related residues	• Residues from grain productions are the same as in grain sector. There are no biomass residues from feed production as the by-products are being reused • Grass production residues are losses during harvest and transportation between storage and feeding place. Losses in DM varies between 3-30 %
Potential synergies & benefits	• Using grass as break crop in grain dominant production may benefit grain production and profitability on farm level in the long run • If number of animals and animal producers continue to decrease, there is potential of using grass and feed crops for other applications, for example in the bioenergy industry
Market developments	• Studies are showing that grasses have potential of being used in production of biogas, ethanol and other bio applications.
Non-technical barriers	• The non-technical barriers of feed grains are the same as mentioned in the grain sector

- There may be competition from feed industry using feed products in the bioenergy production, but biomass availability may increase if the need for feed to animals decreases

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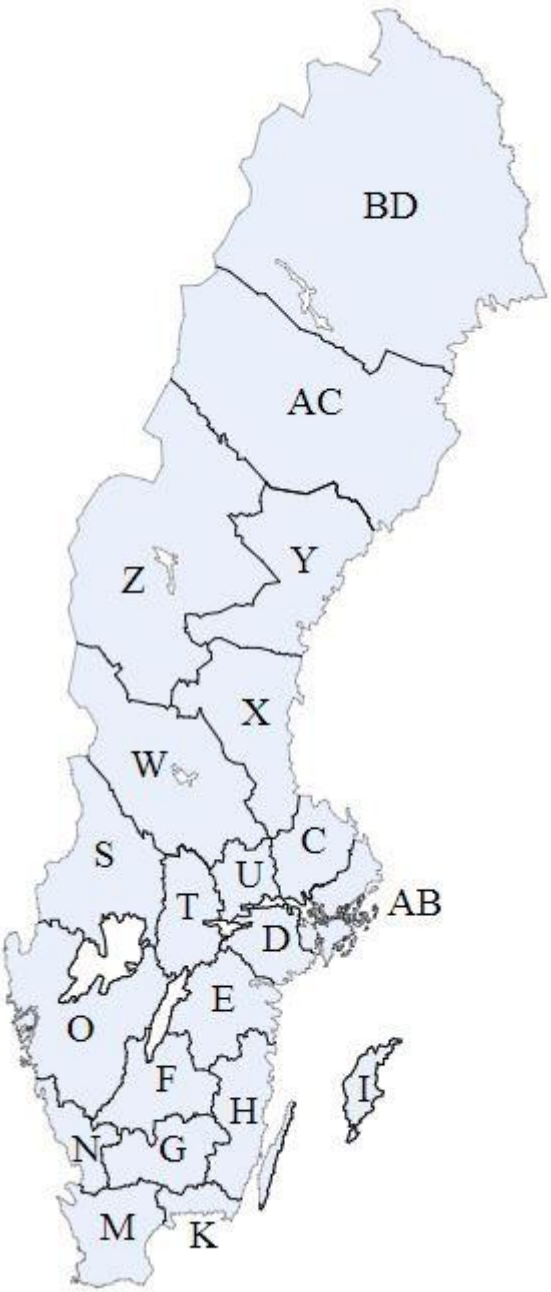
County	Letter
Blekinge county	K
Dalarnas county	W
Gotlands county	I
Gävleborgs county	X
Hallands county	N
Jämtlands county	Z
Jönköpings county	F
Kalmar county	H
Kronobergs county	G
Norrbottens county	BD
Skåne county	M
Stockholms county	AB
Södermanlands county	D
Uppsala county	C
Värmlands county	S
Västerbottens county	AC
Västernorrlands county	Y
Västmanlands county	U
Västra Götalands county	O
Örebro county	T
Östergötlands county	E



AGROinLOG

INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors

D6.2.4 Country Report Ukraine

Project AGROinLOG "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe"
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ABBREVIATIONS

UCAB: Association "Ukrainian Agribusiness Club"

SSSU: The Statistics Service of Ukraine

UABIO: Bioenergy Association of Ukraine

IBLC: Integrated biomass logistics centre

IFC: The International Finance Corporation

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

SPANIS 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

The report analyses the four sectors of the Ukraine's economy: grain chain, vegetable oil extraction, sugar industry, and feed and fodder. Each sector chapter consists of two main parts: a general sector description and a part concerning sector's interest from the IBLC concept of view. The grain chain and vegetable oil extraction sectors generate significant amounts of by-products and residues, during the primary production of respective crops, as well as during the later stages of industrial processing. These residues can be used as feedstock for production of solid biofuels (e.g. straw pellets). The demand for solid biofuels has also been growing in Ukraine in the recent years. In the vegetable oil extraction sector exists a constant surplus in processing capacities, which constitutes a potential opportunity for IBLC. Logistics seems to be the main obstacle for further development of this market. Another obstacle is the general low awareness of the possibilities and benefits offered by handling of biomass.

The sugar industry sector also generates residues and by-products, which can be used as biomass feedstock – primarily sugar beet press and molasses. The first, in particular, is used for production of biogas, and the second one for the production of bioethanol. There are some sugar producers in Ukraine, which have experience of using biofuels (biogas, solid biofuels) to power sugar plants. However, those are still isolated cases which rely exclusively on their own supply of biomass and its processing into biofuels. The sugar beet press is very difficult to transport, as it spoils fast. Molasses on the other hand, can be stored and transported much more easily. There also currently exists a surplus in production capacities at distilleries in Ukraine, which in theory could be used to process molasses into bioethanol.

The feed and fodder sector doesn't seem to offer any biomass related residues, but does also have a significant surplus in processing capacities. These can be used for physical processing (dehydration, granulation etc.) of grain and vegetable biomass feedstock generated by other sectors into solid biofuels.

See Chapter 6 "Summary analysis of the country" for a more detailed summary on every sector.

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1 INTRODUCTION

This desk-study was written as a part of the AGROinLOG project "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe" and is written within the scope of the Task 6.2 "Basic analysis of targeted agricultural sectors". This report aims at providing an actual overview of the state of a selected number of sectors, as well as with their specifics with respect to the IBLC related topics. The following sectors of the Ukrainian agricultural industry are considered: the grain chain, the sugar industry, the feed and fodder and the vegetable oil extraction. Another goal is to determine, whether there is potential in all or in some of the selected sectors for implementation of the IBLC concept. Therefore, each sector chapter effectively consists of two parts: an overview and an assessment of IBLC opportunities.

The four sectors of the agricultural industry were selected primarily because they are (to a various extent) well developed in Ukraine in comparison to others, and also because they either yield significant amounts of biomass residues and by-products, or are known to have idle production/processing/storage capacities, or both. These, from the IBLC concept point of view, may offer opportunities for potential synergies.

This report is based primarily on the analysis of the available literature, the overview of which is provided in the Annex A, publicly available statistical information, as well as some proprietary information which UCAB as an association of agri-businesses has, additionally it has been also complemented by the feedback received from selected stakeholders – these were the companies and organizations also interviewed for the Task 7.2. Among these stakeholders were represented agricultural producers, in addition to other organizations, such as for example sector-specific associations.

Ukraine differs from other European countries in that Ukraine has many agricultural companies that control a very large land area. Figure 1 illustrates the distribution of companies by the size of the land they work with.

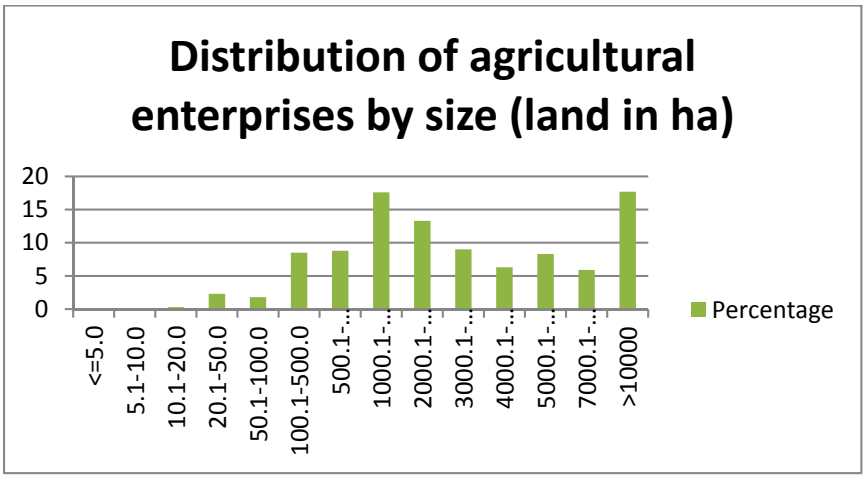

Figure 1. Distribution of agricultural enterprises in the Ukraine, by size of agricultural land as of November 1, 2015. Source: SSSU, 2015

As figure 1 illustrates, most of the agricultural enterprises work (not own) with a land bank over 1,000 ha. About 17 % of agricultural enterprises work with land banks of over 10,000 ha.

Another important issue is the number of employees in each sector. Although, this information should be provided in the 4th subsection of each chapter, the State Statistics Service of Ukraine doesn't provide specific sector information, but rather the aggregated data for the agricultural industry as a whole. The approximate shares of each sector may then be implied from respective sector sizes. So in 2015 there were 560,300 persons officially employed in agriculture, forestry and fishing. With the following distribution among the enterprises by size.

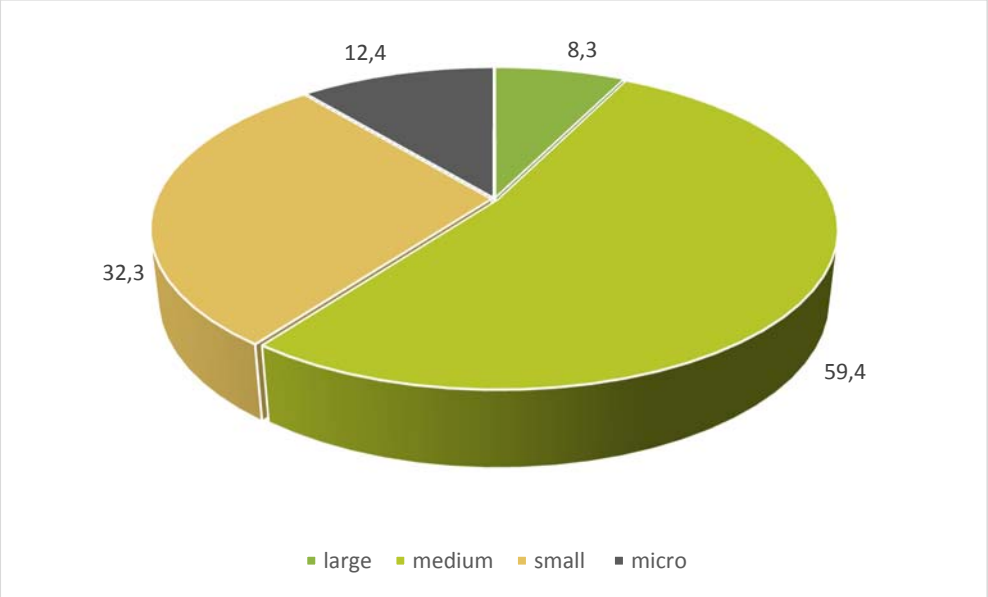

Figure 2. Share of enterprises (%) by size category for employees number. Source: SSSU, 2015.

Figure 2. illustrates that large enterprises employ only about 8.3 % of people working in the agricultural sectors, whereas mid-sized enterprises employ roughly 60 %.

The most significant challenge that has come up during the work on this report, is, undoubtedly, the lack of relevant statistical information. Unfortunately, on the industry-level often no data regarding the residues and by-products is being gathered at all. Some enterprises may be aggregating their own statistics about their operations, but in most cases they are extremely reluctant to share this information for whatever the reasons may be. Most likely, they are afraid that information will leak and it might compromise their businesses or benefit their competitors.

GRAIN CHAIN

2.1. Profile of the grain sector

2.1.1. Production

Understandably, the exact input products, as well as the precise processing technology used vary from grain crop to grain crop. The input products required for production of grain crops usually are: seeding materials, fertilizers, plant protection products, specialized agricultural equipment, fuel and lubricants. Main stages in grain crops production are pre-sowing tillage, seeding, applications of fertilizers, application of plant protection products. Then, harvest, storage and, possibly, processing.

In the case with grain crops, residues occur on the stages of harvesting or processing. This sequence of production stages might be different for various crops. The final products are the respective grains, which may be consumed, exported or processed into other products, but certain by-products are produced as well. For such grain crops like wheat and barley there are possible by-products, which are generated during harvesting: stubble and straw.

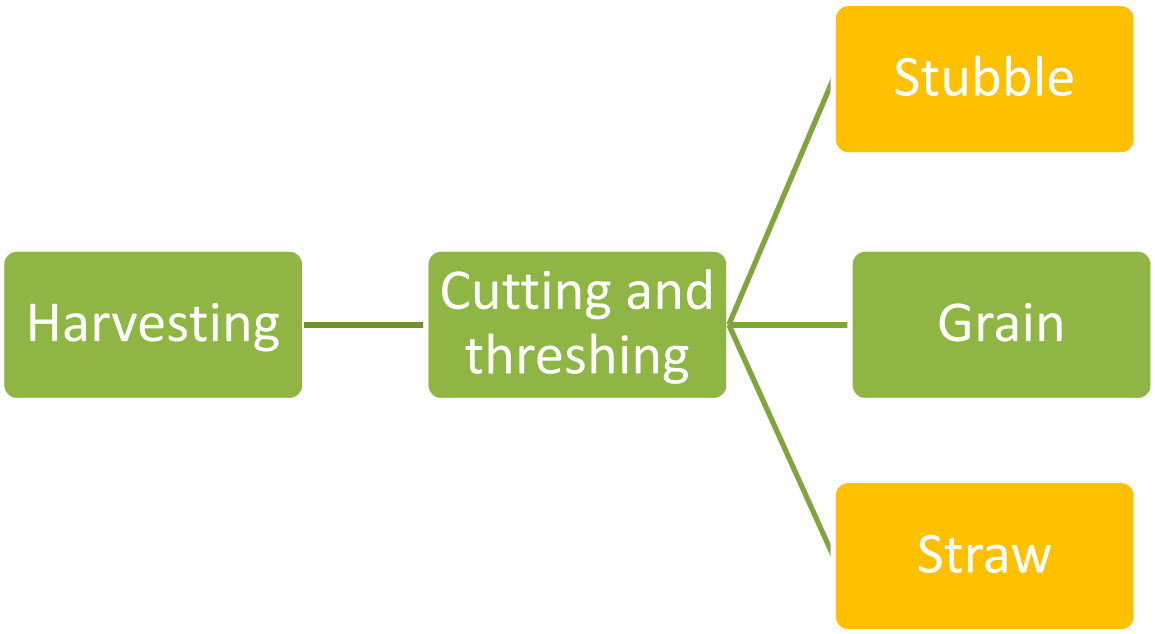

Figure 3. Generalized scheme of by-products generated by harvesting of main grain crops.
Source: UCAB, 2018.

During harvesting, when wheat-ears are cut, stubble is being left on the field. After that, wheat-ears are being threshed inside a combine harvester and grains are being separated. Whereas straw is being thrown back onto field. For barley the harvesting process is the same. For corn, harvesting process is more complex.

Most by-products, in terms of their ration to total mass, are generated by corn. In case with corn crop there is, of course, final product in form of corn grains and various by-products: leaves, stalks, corncobs, and cornhusk. By-products are generated by the process of corn threshing, when grain is separated from the rest. Usually, corn threshing is performed directly in the field by a combine harvester. The grain usually accounts for 35-40 % of total mass. (UABIO 2016: 15) The figure below illustrates different harvesting techniques for corn.

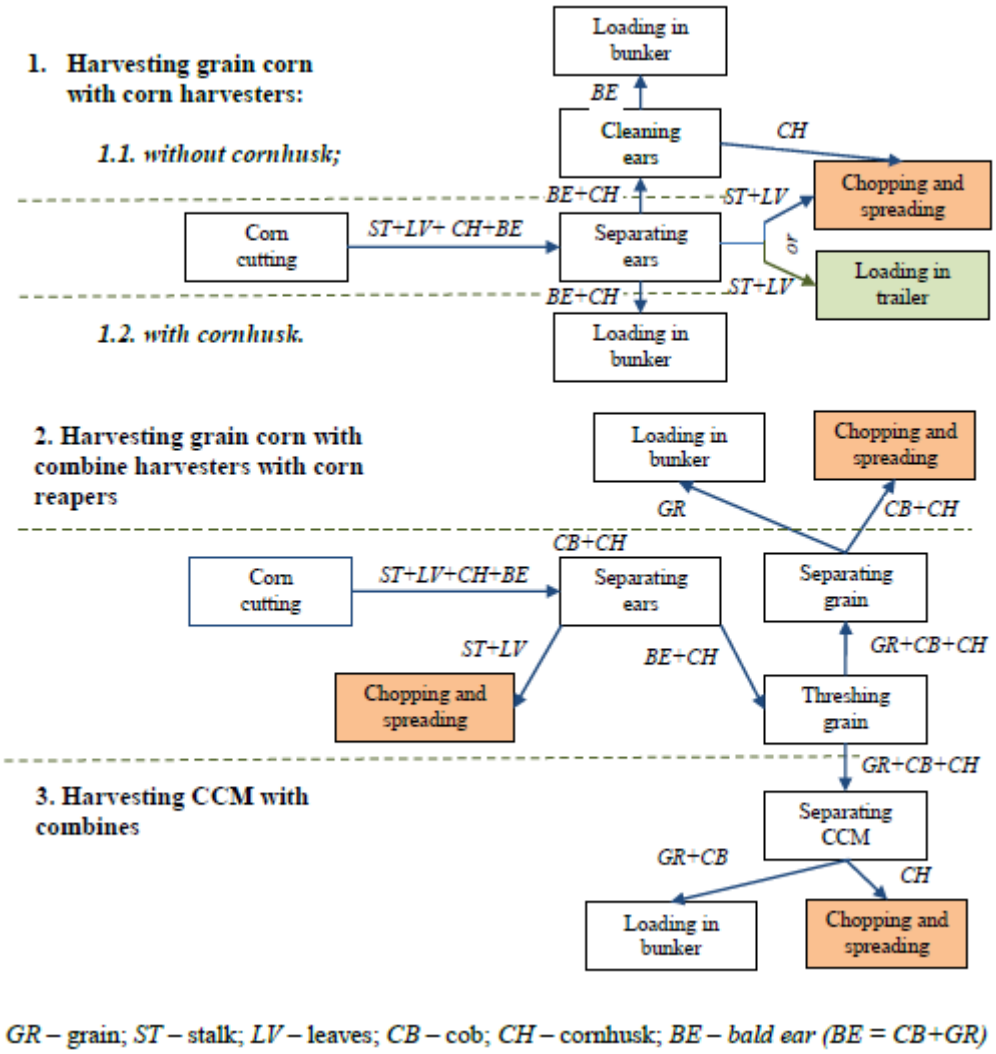

Figure 4. Harvesting techniques for corn.
Source: UABio Position Paper, N16, 2016

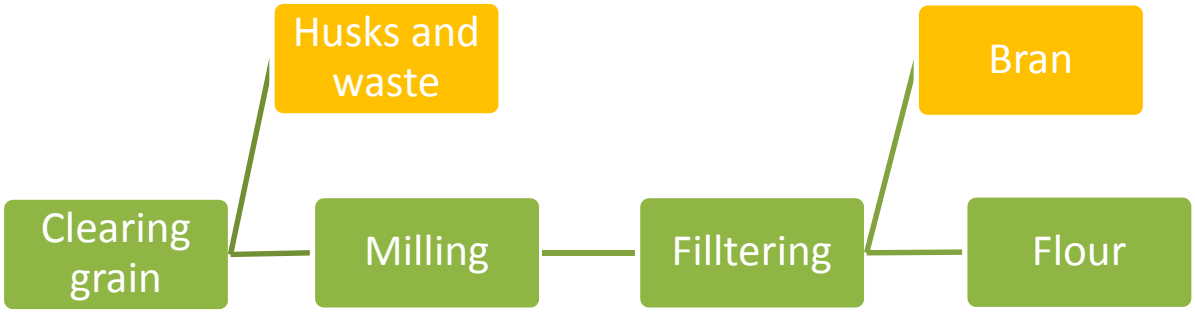

Figure 5.Generalized scheme of processing grains into flours.
Source: UCAB, 2018

The grain crops then are used in agro-processing industry, mainly for the production of flours and groats. The main by-products four-grinding and groats production are bran and husk. Bran is usually further used in food and baking industry, or for production of mixed feeds for farm animals, as bran is highly nutritious. Whereas husk is either wasted or, in some cases, used for production of biofuels.

2.1.2. Volume of the sector

According to the recently published data by the SSSU for the year 2016, the production of grain crops (including leguminous crops) totalled a little more than 51 million tonnes. Grain crops also constitute the biggest sown areas under agricultural crops. According to the official statistics that area was equal to 14.4 million hectares (excluding the area occupied by the Russian Federation - Crimea and the eastern parts of the Donbas region)[1)] in 2016.

The main grain crops produced in Ukraine are wheat, corn and barley. Among those corn has a leading position. In the marketing year 2016/17 Ukrainian agricultural producers produced 28 million tonnes of corn. In second position is wheat. In the 2016/17 marketing year 26 million tonnes of wheat were produced. The third in line is barley. In the marketing year 2016/17 in Ukraine more than 9 million tonnes of barley were produced.

[1)] If not specified otherwise, all data provided by the SSSU from the year 2014 and on doesn't cover these territories.

Table 1. Historical production volumes for wheat, corn, barley, 2007 – 2017, in million tonnes. Source: SSSU, 2017.

Historical production volumes (wheat, corn, barley), in 2007 – 2017, million tonne			
Marketing year	Wheat	Corn	Barley
2016/17	26.0	28.0	9.4
2015/16	26.5	23.3	8.2
2014/15	24.1	28.4	9.0
2013/14	22.2	30.8	7.3
2012/13	15.7	20.9	6.9
2011/12	21.4	22.8	8.3
2010/11	16.5	11.9	8.4
2009/10	20.8	10.4	11.8
2008/09	25.8	11.4	12.6
2007/08	13.9	7.4	5.9

Concerning the number of companies in the grain sector, the SSSU provides data for 2015 meaning it may be different today. In the recent years a trend for scaling in the grain crops sector has been observed, which results in a slight decrease in the total number of agricultural enterprises, but at the same time a higher average number for an enterprise's land bank. In Ukraine, under the term 'land term' is understood not the quantity of land legally owned by an enterprise, but the total sum of arable land it cultivates. Given that the moratorium on selling agricultural land is still in force, most agricultural producers cultivate land they rent, but do not own. In 2015 there were 34,505 companies, large and small, operating in the grain and leguminous crops sector. The largest share of them was growing wheat: 23,562 companies. On the second place are the companies growing corn – in 2015 there were 13,136 companies. The third biggest category are the companies growing barley: 12,774. The following figures 3-8 below illustrate the geographical spreading, or rather geographical intensity of the three main grain crops production in Ukraine, as well the processing of the respective grains.

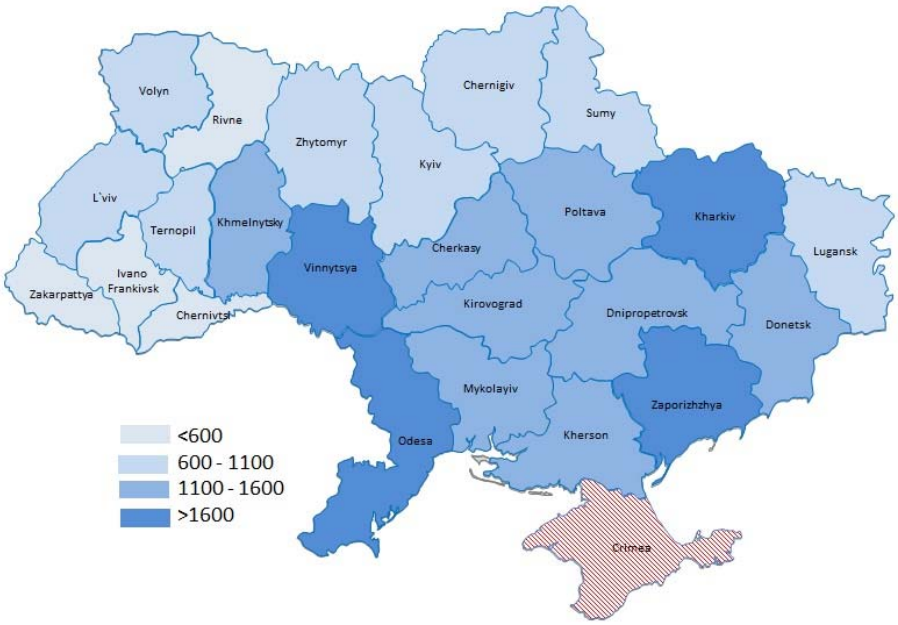

Figure 6. Gross production of wheat in 2016 in different regions, in '000 tonnes.
Source: UCAB based on the SSSU data (2017).

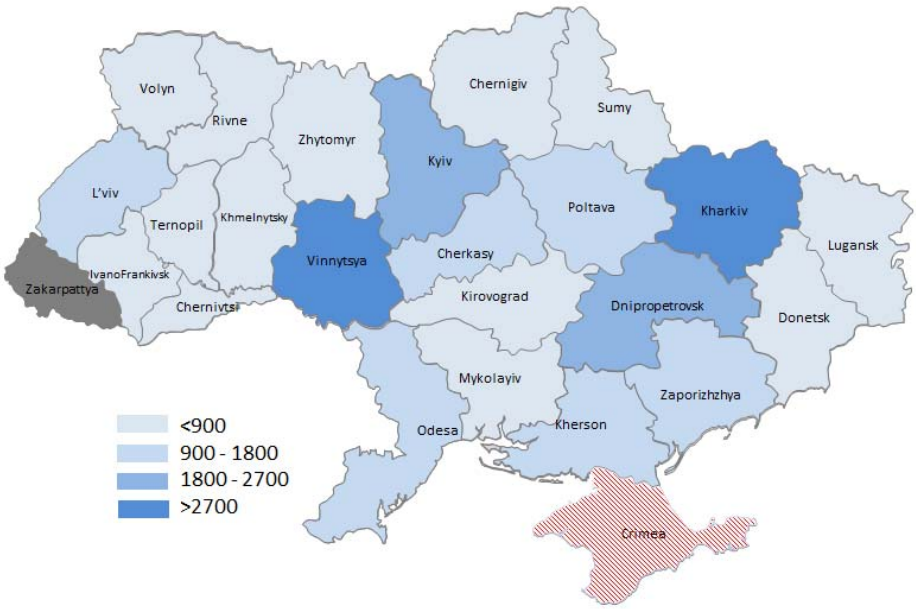

Figure 7. Gross processing of wheat in 2016 in different regions, in '000 tonnes.

Source: UCAB based on the SSSU data (2018).

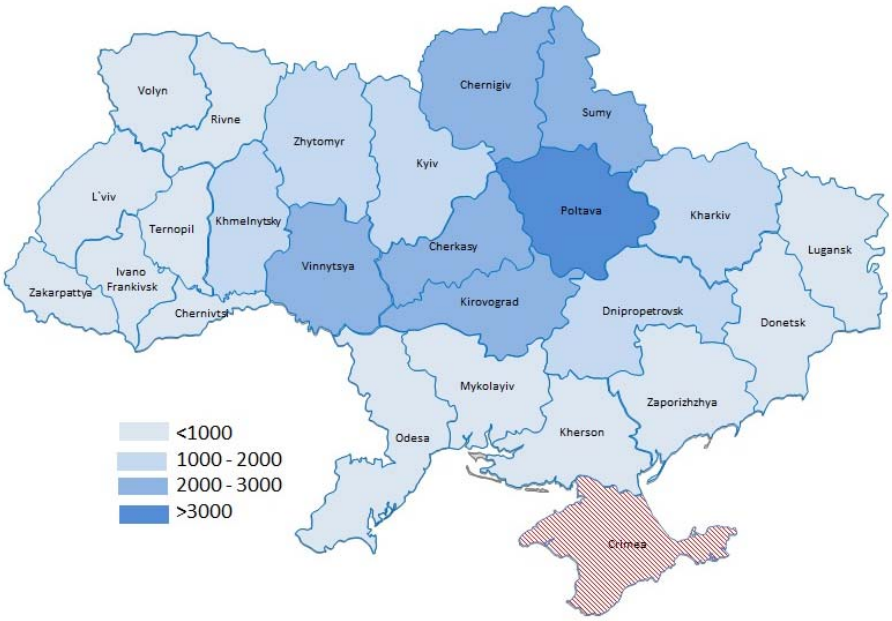

Figure 8. Gross production of corn in 2016 in different regions, in '000 tonnes.
Source: UCAB based on the SSSU data (2017).

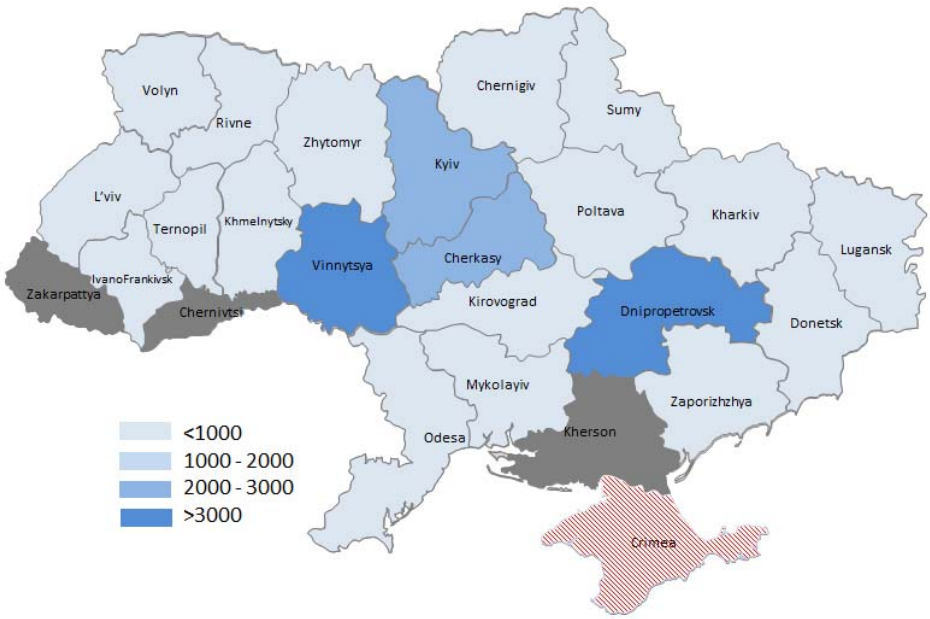

Figure 9. Gross processing of corn in 2016 in different regions, in '000 tonnes.

Source: UCAB based on the SSSU data (2018).

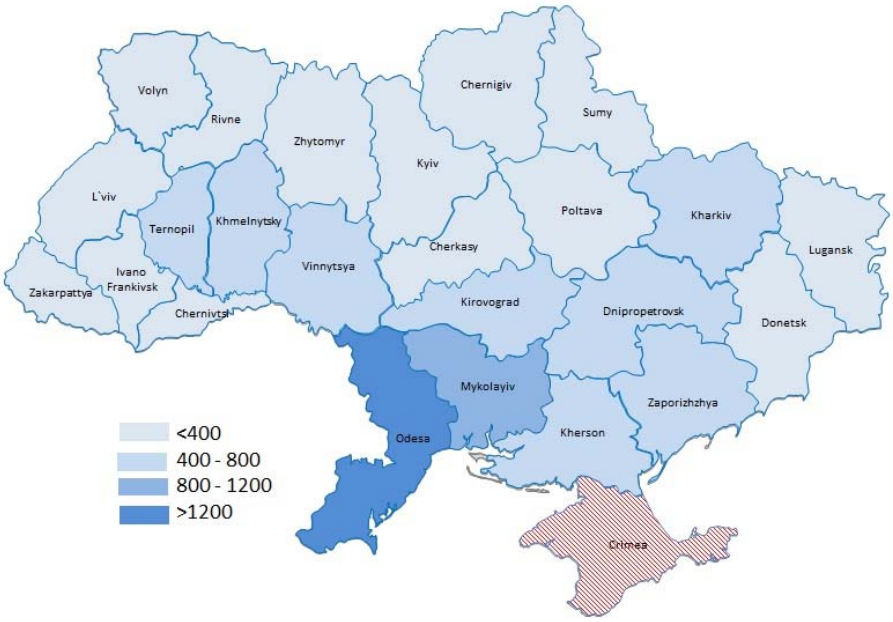

Figure 10. Gross production of barley in 2016 in different regions, in '000 tonnes.
Source: UCAB based on the SSSU data. (2017)

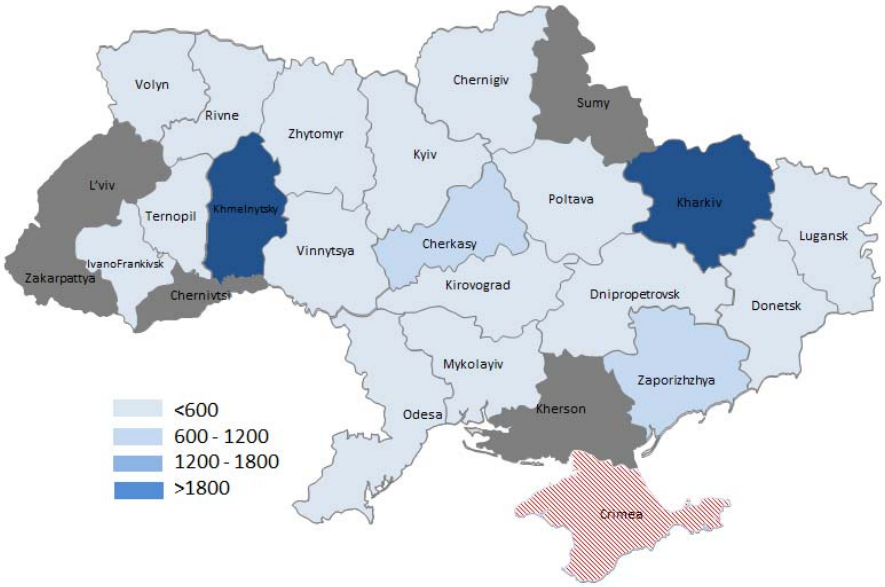

Figure 11. Gross processing of barley in 2016 in different regions, in '000 tonnes.

Source: UCAB based on the SSSU data. (2018)

Let's now take a look a little farther down the value chain, namely the processing stage for the three main grains. According to the most recent data – again, focusing on the 2016/17 marketing year – 3.79 million tonnes of wheat, 0.68 million tonnes of corn and 0.43 million tonnes of barley went into industrial production in Ukraine. These amounts accounted for 14.5 %, 2.42 % and 4.77 % of total

production volumes of wheat, corn and barley respectively. The rest of the respective commodities was mostly exported or domestically consumed.

The end-products produced by grain industries are flours, groats and other ground products, as well as grain corns processed into flakes, crushed or finely chopped. Only data covering the time period 2013-2015 is currently available on the SSSU website.

Table 2. Volumes of end-products produced by the Ukrainian grain chain industries. Source: SSSU (2016)

Grain chain industries grain products			
Product, in tonnes	2015	2014	2013
Wheat flour, wheat-rye flour	1,068,778	1,126,082	1,265,140
Flour from other grain crops	75,651	90,490	156,903
Groats and ground products from wheat	47,431	41,749	36,875
Groats from other grains and cereals	146,692	170,450	154,101
Grain crops' corns processed into flakes, crushed, finely chopped	24,833	17,892	22,232

2.1.3. State of the sector

Although the Ukrainian soil is considered to be very suitable for agriculture and is one of the most productive in the world, the Ukrainian agricultural yields fall behind in comparison to those in other European countries due to a lack of financing, outdated equipment and the underdeveloped technology. Nonetheless, as from 2016 the grain sector (including the leguminous) has achieved the highest yields in Ukrainian history, averaging at 4.61 tonne per ha. Table 1 presents an overview of the average yields in the grain sector for a ten-year period.

Table 3. Historical average yield for grains & leguminous.
Source: SSSU, 2017.

Historical average yield (grains & leguminous), yields for wheat, corn, barley in 2007 – 2016, tonne/ha				
Year	Average yield	Wheat	Corn	Barley
2016	4.61	4.2	6.6	3.3
2015	4.11	3.8	5.7	3.0
2014	4.37	4.0	6.1	3.0
2013	3.99	3.3	6.4	2.4
2012	3.12	2.8	4.8	2.1
2011	3.70	3.2	6.5	2.3
2010	2.69	2.6	4.5	2.4
2009	2.98	3.0	5.0	2.4
2008	3.46	3.6	4.7	3.0
2007	2.18	2.3	3.9	1.3

Table 4. Receipt for processing by grain chain industries of wheat, corn, barley. Source: SSSU, 2017.

Receipt for processing by grain chain industries of wheat, corn, and barley in 2012 -2016, in million tonnes.			
Year	Wheat	Corn	Barley
2016	24.8	26.5	6.7
2015	21.2	28.2	6.2
2014	19.4	28.7	6.3
2013	17.2	30.5	3.9
2012	16.3	25.7	4.7

Concerning the state of the sector, the SSSU provides data on total amounts of different agricultural crops raw stuff the processing industries have received for processing. The changes in how much of raw commodities actually were sent for processing each year can provide some impression on how the sector – certain segments of it – is doing. As the table above illustrates, the processing of wheat has been steadily increasing during the last 5-year-period, as well as that of barley, whereas processing of corn has first experienced an upswing, but then started to decline and in 2017 may have return to the levels of 2012.

2.1.4. Typical size of the companies

Diagrams showing the number of companies separated into categories by gross production for the three major grain crops is presented below.

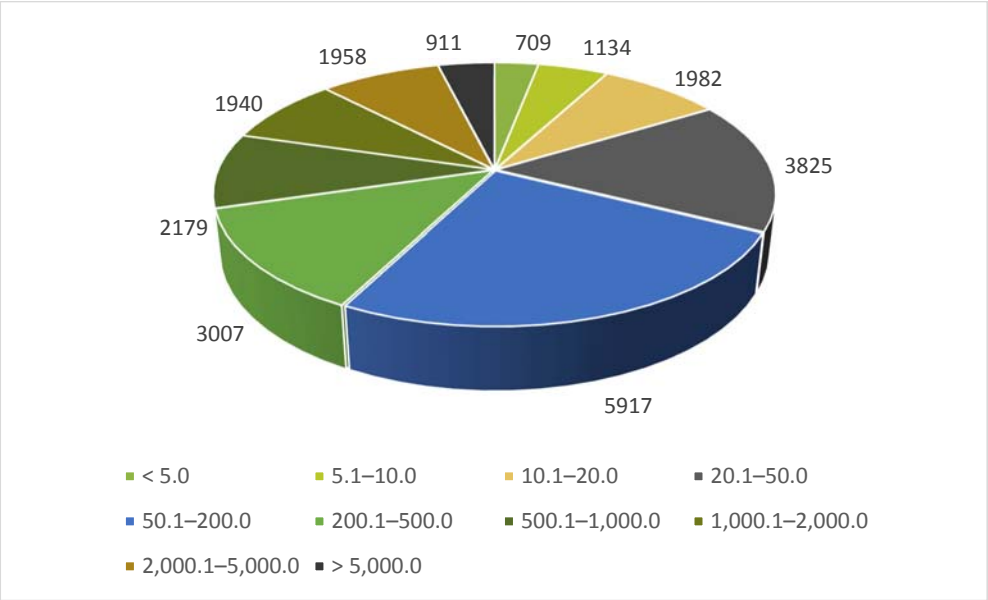

Figure 12. Number of companies growing wheat by gross production (in tonnes). Source: SSSU, 2015.

As we can see from the diagram above, the most numerous categories of wheat producers are enterprises producing between 50.1 – 200 tonnes per year (5,917 enterprises), 20.1 – 50 tonnes

(3,825) and between 200 – 500 tonnes (3,007). These three categories of agricultural enterprises - 12,749 producers - are producing a little bit over 50 % of all wheat.

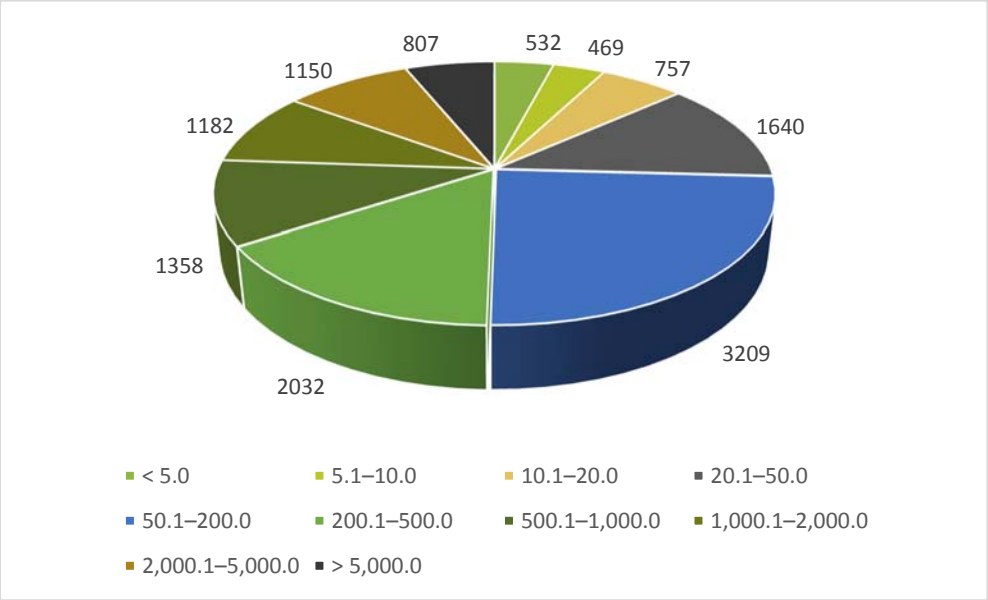

Figure 13. Number of companies growing corn by gross production (in tonnes). Source: SSSU, 2015.

In comparison to wheat production, the production of corn is shifted to the side of bigger producers. The three main categories are the ones producing between 50.1-200 tonnes (3,209), 200.1-500 (2,032) and 500.1-1,000 tonnes (1,358).

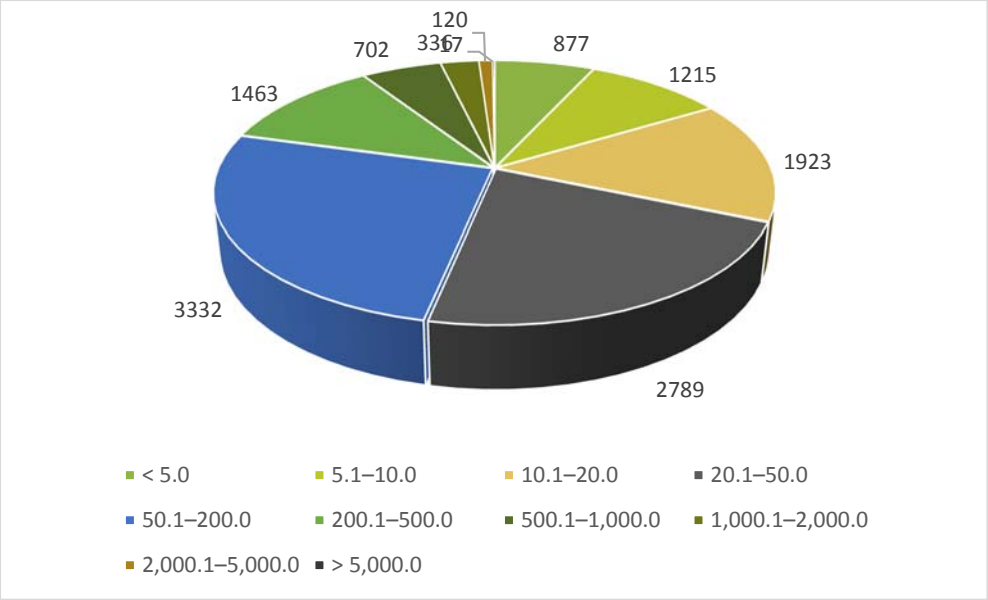

Figure 14. Number of companies growing barley by gross production (in tonnes). Source: SSSU, 2015.

And the barley production is dominated by small agricultural producers. The most numerous categories are the ones with gross yearly production between 10.1-20 tonnes, 20.1-50 tonnes and 50.1-200 tonnes.

2.1.5. Distinctive facilities of the sector

Grains are mainly processed into flours. Unfortunately, the exact data on industries processing grains into flours is available only for 2014. In that year 15 biggest companies produced about 42 % of total production volume. The biggest grain processing facilities are located in Central and Eastern parts of the country.

Table 5. The top 15 flour producers in Ukraine, 2014. Source: UCAB.

Top 15 flour producers, production share (%)		
Rank	Year	Share
1	KYIVMLYN	6,0%
2	NOVOPOKROVSKYI COMBINAT KHIBOPRODUKTIV	5,0%
3	DNIPROMLYN	4,7%
4	VINNYTSKYI COMBINAT KHLIBOPRODUKTIV № 2	3,8%
5	TOV "COMBINAT KHIBOPRODUCTIV "TALNE"	3,7%
6	DP "CULINDORIVSKYI COMBINAT KHIBOPRODUKTIV"	2,6%
7	TOV COMERZIYNO-VYROBNYTCHA FIRMA "ROMA"	2,5%
8	TOV "TORHIVELNA COMPANIYA "UROZHAY"	2,4%
9	PAT "LUHANSKMLYN"	2,4%
10	PAT "CROLEVETSKYI COMBINAT KHLIBOPRODUKTIV"	2,0%
11	TOV "ENLIL"	1,7%
12	DOCHIRNE PIDPRYEMSTVO "DP AGROSERVIS 2000"	1,5%
13	TOV "KHMELNYTSK-MLYN"	1,4%
14	PAT "VINNYTSYA-MLYN"	1,4%
15	COLECTYVNE PIDPRYEMSTVO "BILOTSERKIVKHLIBOPRODUKT"	1,3%
Total		**42,4%**

2.1.6. Degree of innovation

The SSSU does not provide any specific industry-level innovation index. The application of innovative technologies probably varies from company to company. When considering innovations in the segment of biomass production, innovation capacities are rather low. Currently, a large part of the crop residues are left in the field to waste. In some cases, crop residues are burned on the field, although this practice is prohibited by law. There are various reasons for that: some farmers consider it as an additional fertilizer, some simply do not have means to collect it from the fields. This is especially the case with corn, because the dominant method of grain harvesting is "the cobs threshing by combine in the field, shredding and spreading truncated mass"[2)] by using combine harvesters with corn reapers. Although there is technology on the market (combine harvesters) that

[2] Dragnev, Zheliezna, Geletukha (2016), p. 13

would allow harvesting corn with cobs, and following stationary threshing and collecting of cobs.[3)] However, that technology is more expensive and therefore it is hardly used.

Grain chain processing industries generate a substantial amount of residues, which can be used as biomass. This issue is discussed later in the report (see Section 2.2.1.). But it is unknown whether these industries have any experience of handling biomass.

2.1.7. Miscellaneous

The grain chain sector in Ukraine has some sustainability issues, which are getting sounded in public more often nowadays. The first one is common for the whole agricultural industry, namely crop rotation and soil deterioration, meaning that agricultural producers in pursuit of highest possible gains can be short-sighted and tend to ignore crop ration. This of course has a negative effect in the long run on the soil quality. The issue is also intensified by the fact that most of arable land is rented. The second issue is the one concerning stubble. What should be done with, should be left in the field, should be tilled into the soil? Although it is illegal[4], in Ukraine stubble will be often burned in the field, which possess significant environmental hazard as well as strengthens soil deterioration, as it destroys the useful bacteria in the soil. The first issue cannot be directly related to the IBLC concept, whereas the second one is relevant, as stubble potential is a very potent source of agricultural biomass. It is unclear, whether are sustainability issue farther up the grain chain.

2.2. Opportunities IBLC

2.2.1. Sector related residues

The grain sector generates a variety of residues and by-products, which can be used directly as feedstock for biomass production or pre-processed into secondary products. Almost on every tage of the grain chain – crop harvesting and further crop processing - residues are produced. Among the primary residues are for example wheat straw, corn stems, sunflower husks etc. These represent a cheap and at the same time rich in lignocellulose feedstock for bioenergy generation.[5)]

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[3] See ibid.

[4] See Art. 77-1 in the Code of Ukraine on Administrative Offenses, Art. 16. 22 in the Law of Ukraine “On the Protection of Atmospheric Air”, Art. 27 in the Law of Ukraine “On Flora”, Art. 36 in the Law of Ukraine “On Fauna”

[5] See Dam van, J.E.G., Elbersen, W., Ree van, R. (2014) Setting Up International Biobased commodity trade chains, p. 55

Grain crops residues are often used for the production of solid biofuels. Production of briquettes and pellets, which are becoming a popular energy source (fuel for boilers) in rural areas, which is a segment that is developing rapidly.[6]

As for available residues, the Bioenergy Association of Ukraine in one of their recent research papers[7] estimate that only about 3 % of residues from production of grain crops is being currently used for biomass, based on other estimate that on average 70 % of agricultural residues are being left in the field. Although, as was stated by a stakeholder, the issue of stubble left in the field is a complicated one[8]. Because stubble left in the field provides positive fertilizing effect. So there is obviously a conflict of interests and it is not clear at the moment in which case grain crops stubble would generate a higher utility.

The data on residues and by-products generated by the agro-industry at the moment this country report was writtenwas available for the time frame 2013-2015. The data is published for the three groups and is represented in the table below.

Table 6. Volumes of by-products and residues produced by the Ukrainian grain chain industries. Source: SSSU, 2016.

Grain chain industries by-products and residues			
Category, in tonnes	2015	2014	2013
Bran, waste and other residue from corn	48,059	38,904	51,370
Bran, waste and other residue from wheat	404,440	405,762	447,579
Bran, waste and other residue from other grain crops	31,343	38,326	41,723

As can be seen in table 4, in 2015 the Ukrainian grain chain producing industries generated in total 0.48 million tonnes of bran and other residues. Unfortunately, the official statistics do not specify the shares of separate by-products.

Most of these residues are further processed or used as feed for farm animals. Unfortunately, there is no data available that would allow to make precise statements about what part of these residues is further used and what part is wasted.

2.2.2. Potential synergies & benefits

The IBLC concept assumes that possible synergies may arise through the seasonality effect: meaning e.g. that some industry facilities are underused during specific time period of the year, and thus can be used for storage or processing of biomass. Accordingly, the first step in order to identify such

[6] See Kalnitskaya, J. (2013): Business opportunities in the bio-based economy in Ukraine, p. 34

[7] See UABIO (2017): Report "Comprehensive analysis of the Ukrainian biomass pellets market", p. 64

[8] See Section 2.1.7

synergies is to identify seasonality patters in grain chain industries. The table below illustrates the production volumes of flour and groats for each month for the year 2016.

Table 7. Production volumes of flour and groats in each month of 2016. Source: SSSU, 2017.

Production volumes of flour and groats in Ukraine in 2016 by month					
Month	Flour	Groats	Month	Flour	Groats
January	132,536	18,148	July	148,531	24,624
February	160,795	28,678	August	175,684	33,016
March	166,721	26,795	September	180,625	35,047
April	164,317	24,900	October	180,018	30,836
May	130,778	19,496	November	176,143	34,262
June	132,073	20,137	December	180,227	34,474

As we can see from table 5, the most productive month of the grain chain industry is September, for flour production and groats production alike. To see a pattern, let's convert the numbers above into indices, while setting the September outputs to 100.

Table 8. *Production indices of flour and groats for 2016, Sep = 100.* Source: UCAB, 2017.

Production volumes of flour and groats in Ukraine in 2016 by month					
Month	Flour	Groats			
January	73.38	51.78	July	82.23	70.26
February	89.02	81.83	August	97.26	94.20
March	92.30	76.45	September	100.00	100.00
April	90.97	71.05	October	99.66	87.98
May	72.40	55.63	November	97.52	97.76
June	73.12	57.46	December	99.78	98.37

There seem to be two low-intensity production periods, namely in January and in May-July. Especially production falls for groats – almost to half of the 'high-period'. It can be assumed that available biomass residues from the primary grain chain production, such as straw, sterns, husk etc., might be used during the 'low-intensity periods' in the grain chain industries for storage or, perhaps, mechanical pre-treatment – for example for grinding or crushing.

This synergy would result in increased volumes in production of biomass, which would lead to higher supply of biofuels and further stimulate ever growing demand for it.

It is difficult to say, whether there would be a significant positive effect on employment. But agricultural producers, small and big alike, most certainly will gladly welcome an alternative economic way of dealing with residues and by-products of primary agricultural production.

2.2.3. Market developments

The Ukrainian market for biomass made of residues of grain crops, primarily for straw pellets, has being developing rapidly in the recent years. In the first six months of 2016 Ukraine has produced

146,010 tonnes of grain straw-based pellets (about 175,000 tonnes during the whole 2015).[9] The average growth rate per year since 2013 was 35 %.[10] As of June 2016, there were 65 enterprises specializing in biomass production based on grain crops residues. Whereas production can be characterized as concentrated and specialized, meaning these producers are unequal. So from the total of 65 only 4 companies – Avers-Tech, Bioenergy-Vinnytsya, Win-Peleta and Creative-Agro – produce one third of the whole volume. Accordingly, production of grain-residues biomass is also unequally distributed though the geographic regions of Ukraine. It is concentrated primarily in the centre of the country, and also in the southern oblast of Odesa.

The UABIO estimates the average load factor of producers of this type of biomass to be 0.3-0.4.[11] This means that producers are anticipating higher demand in the future, and there is potential to significantly and in short term increase production volumes if needed.

Logistics and the lack of infrastructure seems to be indeed one of the major barriers on the way connecting biomass suppliers-producers-buyers. These three groups of market actors already seem to have developed a certain interest in using biomass, first and foremost as fuel for bioenergy, though unable to find appropriate models of cooperation.

2.2.4. Non-technical barriers

Unfortunately, only a small share – about 30 % - of the mentioned above residues is used as biomass for bioenergy generation, whereas the rest is used as animal feed, soil fertilizer or even simply – illegally – burnt in the field.[12] Grain stems collection requires specialized equipment, which is often not available.

A survey conducted by the IFC from 2015, has shown that the obstacles most mentioned for implementing biomass/bioenergy projects are "the large initial investment requirements and the lack of government support"[13]. Although about 13-14 % of the surveyed farms consider using biomass either as a solid biofuel or for biogas production (mainly for own consumption), only 2 % of the surveyed farms have moved to actually planning such an investment.[14]

Last but not least, is the very low awareness among agricultural producers about what they can do with available biomass, or respectively how could they be using their seasonally idle equipment.

There seem to be no any particular legal or political barriers for IBLC implementation at the time.

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[9] See Dam van, J.E.G., Elbersen, W., Ree van, R. (2014) Setting Up International Biobased commodity trade chains, p. 64

[10] See ibid.

[11] See ibid., p. 65

[12] See Kalnitskaya, J. (2013): Business opportunities in the bio-based economy in Ukraine, p. 34

[13] IFC: Survey findings (2015), p. 25

[14] IFC: Survey findings (2015), p.25

3. VEGETABLE OIL EXTRACTION

3.1. Profile of the vegetable oil extraction sector

3.1.1. Production

In Ukraine, vegetable oil is produced from the following three main oilseeds: sunflower, soybean and rapeseed. The absolutely dominant oilseed is the sunflower seed. Ukraine is the biggest sunflower oil producer in the world.[15]

Two main methods of production of sunflower oil do exist, these are the extraction by using chemical solvents and the extraction by pressing. The end products are refined and unrefined sunflower oils respectively. The primary feedstock is – of course – the sunflower seed. Regardless of which production method is used, sunflower seed has to be separated from husk, as the oil is primarily concentrated in the seed's core. At this stage of dehulling the first residue is produced – sunflower husk. Dehulling is usually achieved through the use of a centrifuge machine, where sunflower seeds are being smashed against each other and inner walls of a cylinder. Then husks are separated from kerns in a flashing machine (filtering machine), which consists of a number of vibrating sieves.After dehulling, the rest is processed and oil is extracted. Another residue is generated – oilcake. (The humidity level and other factors might vary depending on the production method).

The production stages for other vegetables oil are similar. In each case, there is some sort of seed/bean pre-treatment, which generates some residues. As well as there are leftovers after the actual extraction.

[15] See e.g. http://www.fao.org/faostat/en/#data

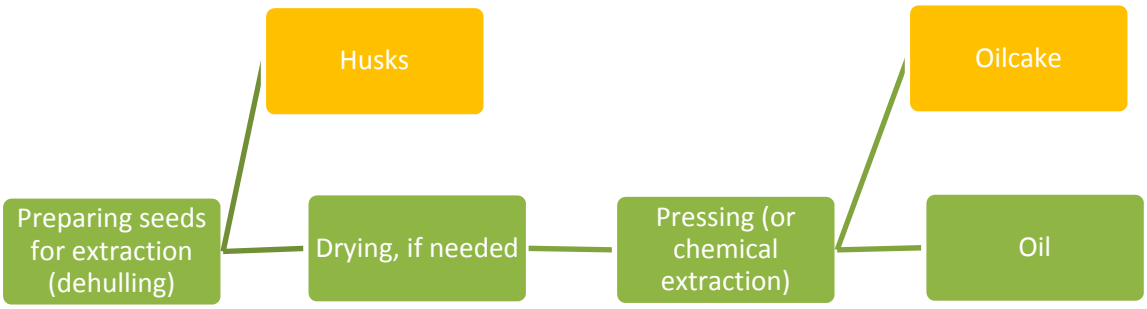

Figure 15. Generalized scheme extracting sunflower oil.
Source: UCAB, 2018

3.1.2. Volume of the sector

Ukraine produces various kinds of vegetable oils. In 2016 Ukraine produced 5.2 million tonnes of vegetable oil. The three main types are sunflower oil, soybean oil and rapeseed oil, with other kinds having insignificantly marginal shares in production. Let us take a closer look on the production of specific vegetable oil and the respective oilseed.

Sunflower and sunflower oil

The sown area of agricultural land under the sunflower was equalled to 6 million ha in 2016. The amount of sunflower seeds produced during the year 2016 was equal to 13.6 million tonnes. The largest part - 9.1 million tonnes[16)] or 67 % - was used for sunflower oil production. Actually, about 96 % of all sunflower seed (if we consider a marketing year instead of a calendar year) are processed into sunflower oil. In the calendar year 2016 Ukraine produced 4.9 million tonnes of combined refined and unrefined sunflower oil (0.5 and 4.4 million tonnes respectively). This accounted for around 95 % all vegetable oil produced.

Soybean and soybean oil

The sown area covered by soybean was equalled to 1.8 million ha in 2016. In this year the produced quantity of oil equalled 4.3 million tonnes. Only 664,392 tonnes of soybean went into soybean oil production, or 16 %, which is a considerably smaller amount in comparison with the sunflower seed.

[16] Based on the SSSU data and the UCAB own calculations

Ukraine produced 168,240 tonnes of soybean oil in 2016 which has accounted for a little bit more than 3 % of the country's total vegetable oil production.

Rapeseed and rapeseed oil

The harvest area under rapeseed was 449,000 ha in 2016, with a total harvest of 1.1 million tonnes. From that amount, 127,057 tonnes were used in the rapeseed oil production – making it 11 % of all rapeseed. Around 81,600 tonnes of rapeseed oil were produced. This accounted only for 1.5 % of Ukraine's vegetable oil production.

According to the SSSU, in 2015 there were 20,317 companies in Ukraine growing sunflower seeds. The following three figures show the geographical intensity of the production of the three main oilseeds in Ukraine.

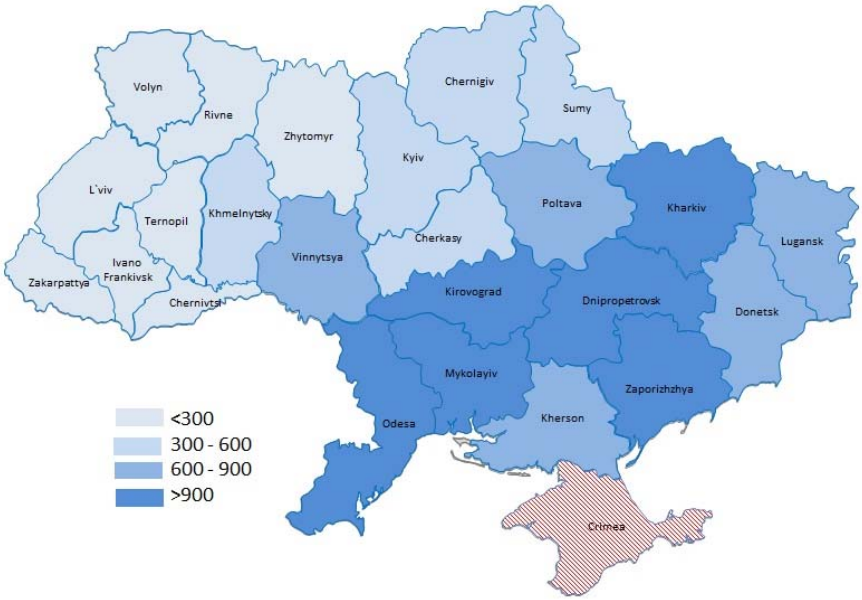

Figure16. Gross production of sunflower seed in 2016 in different regions, in '000 tonnes.
Source: UCAB calculations based on SSSU data, 2017

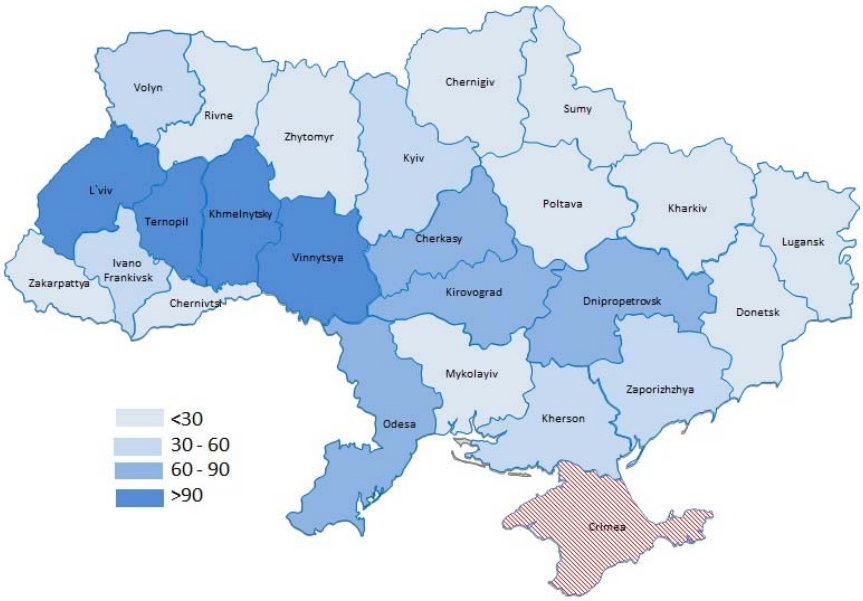

Figure 17. Gross production of rapeseed in 2016 in different regions, in '000 tonnes.
Source: UCAB calculations based on SSSU data, 2017

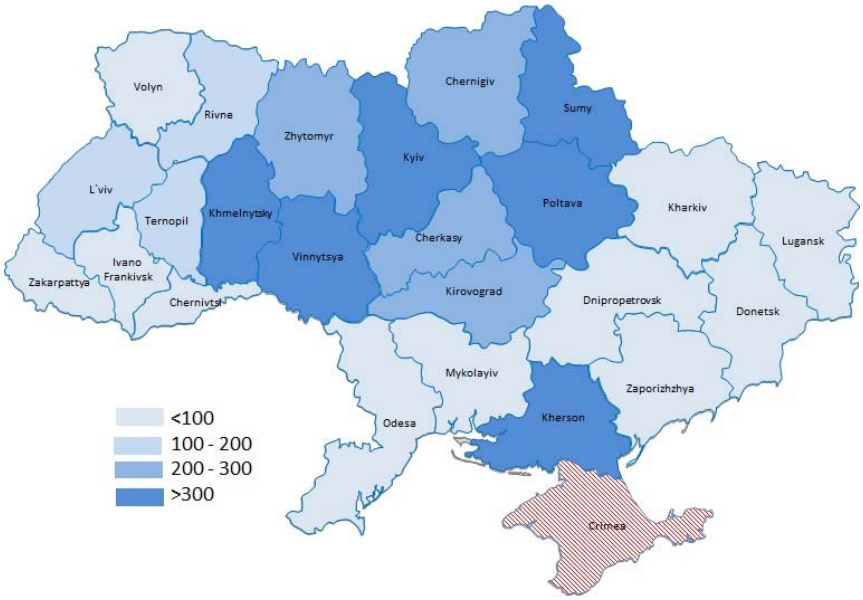

Figure 18. Gross production of soybean in 2016 in different regions, in '000 tonnes.
Source: UCAB calculations based on SSSU data, 2017

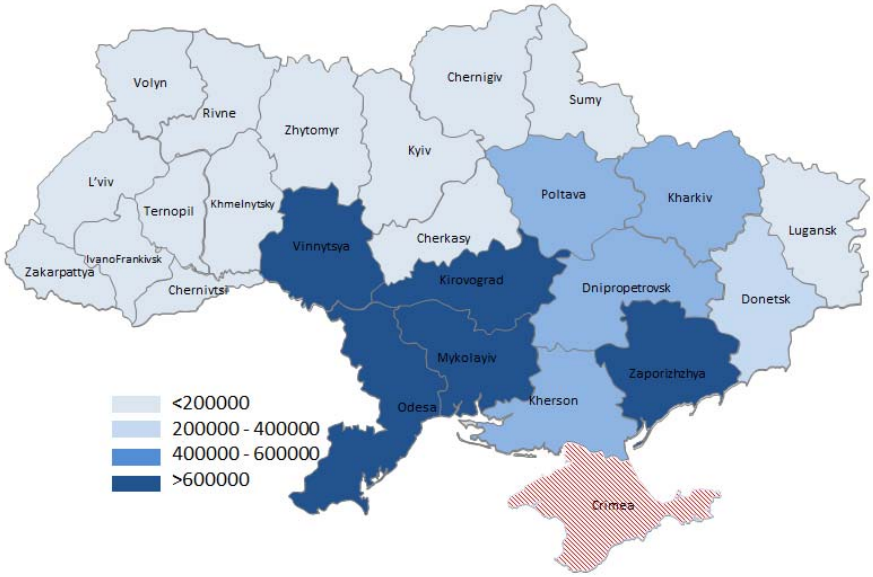

Figure 19. Gross production of unrefined sunflower oil in 2016 in different regions, in tonnes. Source: UCAB calculations based on SSSU data, 2018

3.1.3. State of the sector

There has been a significant increase in the quantities of sunflower seed produced – raising about 20 % from 2015 to 2016. It is difficult to assert unambiguously what exactly has driven the production up so much, but one of the likeliest reasons is a very high profitability in comparison to other cash crops, explained in turn by high prices for sunflower oil on international markets. Higher production of sunflower seed is also the result of the excess in domestic sunflower oil production capacities – sunflower oil producers to keep their facilities working were eager to offer higher prices for sunflower seed and drove the prices up for the crop. In the years before the amounts of sunflower produced were more or less the same. The productivity – average yield in ton per hectare – has grown only slightly.

Table 9. Historical average yields for sunflower, soybean and rapeseed in Ukraine, in 2007-2016 Source: SSSU.

Historical average yields, tonne/ha			
Year	Sunflower yield	Soybean yield	Rapeseed yield
2016	2.24	2.31	2.57
2015	2.16	1.84	2.59
2014	1.94	2.17	2.54
2013	2.17	2.05	2.38
2012	1.65	1.71	2.23

2011	1.84	2.10	1.60
2010	1.50	1.62	1.70
2009	1.52	1.40	1.65
2008	1.53	1.55	1.80
2007	1.22	-	-

The productivity levels of soybean and rapeseed have been steadily increasing over the last decade, averaging in 2016 at 2.3 and 2.6 tonne per hectare respectively.

Table 10. Historical processing volumes of oilseeds by industries in Ukraine, in 2010-2016 Source: SSSU.

Historical processing volumes, thsd. tonnes			
Year	Sunflower	Soybean	Rapeseed
2016	13140	1530	251
2015	10790	1410	241
2014	10070	1173	97.25
2013	10033	1104	4.89
2012	7974	910	5.02
2011	8080	640	0.46
2010	6697	500	0.52

Although processing volumes of soybean and rapeseed have been increasing over the recent years, the processing industries are still underdeveloped and account for 3% and 1.5% of total vegetable oil production in Ukraine. The processing volumes likely depend not so much on yields rates or production quantities of these oilseed crops, as on their prices on international commodity markets, as most of rapeseed and soybean producers in Ukraine are export-oriented.

3.1.4. Typical size of the companies

As was mentioned earlier, there were over 20,000 companies growing sunflower seeds in Ukraine in 2015. Those can be anybody from small farmers to huge agroholdings, the distribution of sunflower producers may vary drastically from year to year depending on various factors, like sunflower seed prices, crop rotation reasons etc. Whereas concerning the industries producing the sunflower oil, this sector, as will be shown in the next section, is clearly dominated by large producers.

3.1.5. Distinctive facilities of the sector

The Kernel Holding is Ukraine's leading vegetable oil (mainly sunflower oil) producer. The Kernel Holding produces 8 % of total sunflower oil produced in the world. The company has 8 vegetable oil

production plants. For the first seven months of the 2016/17 marketing year (September – March), Kernel has produced 0.93 million tonnes of unrefined sunflower oil.

Sunflower oil producing companies are concentrated in the Central, Eastern and Southern regions of Ukraine, such as Zoporizhska, Kharkivska, Donetska, Dnipropetrovska and Odes'ka Oblasts. An oblast is a primary administrative unit in Ukraine. Ukraine is divided into 24 oblasts. The closest English word in meaning would be province. Oblasts are further divided into districts. The table below represents the Ukraine's 15 biggest producers of unrefined sunflower oil.

Table 11. Top 15 biggest producers of vegetable in Ukraine. Source: UCAB, 2016

Top 15 producers of unrefined sunflower oil, production share (%)		
Rank	Year	Share
1	Kernel	27.2%
2	BUNGE	10.3%
3	Violiya	6.9%
4	Optimus Plus	6.5%
5	MHP	5.6%
6	Allseeds Black Sea	4.6%
7	Delta Wilmar	4.0%
8	Cargill	3.9%
9	COFCO-Satellite	3.5%
10	Polohivsky vegetable oil plant	3.2%
11	ADM-Illichivsk	2.2%
12	Kolos	1.8%
13	Gradoliya	1.7%
14	Agroproinvest	1.5%
15	Svativska oliya	1,3%
Total		**84.2%**

As we can see, the fifteen biggest producers account for nearly 85% of total production volume of unrefined sunflower oil.

3.1.6. Degree of innovation

In this sector, or better to say in certain segments of it, referring primarily to the big agricultural holding companies, which can afford better equipment and are constantly looking for way to optimize their costs, the degree of innovation might be considered high, at least above the average level in comparison to other sectors, as many sunflower oil producing companies install specialized equipment –granulators – for processing the sunflower husk into a solid biofuels in form of pellets and briquettes.[17] There also exists overcapacity in vegetable oil production industries, which in turn

[17] See Kalnitskaya, J. (2013): Business opportunities in the bio-based economy in Ukraine, p. 20

– at least partially – can be explained with the fact than new processing facilities are being built continuously, because producers want to work with efficient equipment (low costs – high yields), rather than with old facilities and machines, that today become redundant.

3.1.7. Miscellaneous

The vegetable oil sector industries have a lot of experience in handling biomass. The dominant vegetable oil industry – the sunflower oil production – uses sunflower husks to make pellets. The Ukrainian Bioenergy Association estimate that during 2015 the sunflower oil producing facilities used around 750,000 tonnes of sunflower husk for own needs in their own boilers, for instance to generate steam, heat or electricity, whereas the other half was either sold for pellets production or produced into pellets.

3.2. Opportunities IBLC

3.2.1. Sector related residues

Oil containing crops, such as sunflower seeds and rape seeds provide biomass for bioenergy production. The main by-product of sunflower oil production process is the sunflower husk obtained during the sunflower seed crushing. The quantity available per year in Ukraine is estimated at about 10 million tonnes.[18]

There are different ways to use sunflower husk for energy generation. Firstly, there is direct burning or burning combined with traditional carbon-based fuels. This is usually done in the sunflower seed processing plant to satisfy own energy needs. Secondly, approximately 70 % of all sunflower husk is used for the production of solid biofuel, such as pellets and briquettes[19]. The solid biofuel is often used at the plant as well for energy generation. The surplus is exported to the EU countries, as the local demand is still rather low[20].

The Ukrainian Association of Biomass in their latest report have analysed the production of pellets from sunflower husk[21]. According to this report, as of June 2016 there were 169 companies in Ukraine producing this kind of biofuel. Whereas 110 of them exclusively producing sunflower husk pellets, and the rest producing different kinds of biofuels too (e.g. based on wooden biomass, wheat straw etc.). In the first six months of 2016, total production was around 730,000 tonnes of sunflower husk pellets. These pellets are then sold on the market. But Ukrainian Bioenergy Association estimates the 'inner production' to be approximately just as big.

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[18] See Kalnitskaya, J. (2013): Business opportunities in the bio-based economy in Ukraine, p. 16

[19] See Kalnitskaya, J. (2013): Business opportunities in the bio-based economy in Ukraine, p. 16

[20] See ibid. p. 20

[21] [21] See UABIO (2017): Report "Comprehensive analysis of the Ukrainian biomass pellets market", p. 62

3.2.2. Potential synergies & benefits

There are no official statistics on the processing capabilities in the vegetable oil production sector, but according to an industry insider's statement, the surplus of processing capacity in the sunflower oil segment in Ukraine may be as high as 40 %. One reason behind such a high overcapacity may be the fact that in such estimates all kinds of processing facilities are accounted for - even the old ones and outdated, which might be just standing idle for years (See Section 3.1.6). Today, sunflower producers prefer to invest in new ones, with modern machinery, which have higher efficiency rates. Another possible reason behind such a high estimate for production capacities underused, might be related to big enterprises – agricultural holdings – which are building large facilities with high production capabilities, aiming perhaps for higher production in the future, as well at securing higher market share by "squeezing out" smaller producers. They do it by securing contracts for processing of large quantities at once. These surplus capacities offer an opportunity of processing biomass into solid biofuels.

3.2.3. Market developments

The vegetable oil sector – especially the sunflower oil – is in good shape, and is likely to stay that way. Higher production of sunflower oil is going to drive sunflower seed production up. The sector's main biomass product is the sunflower seed husk. This market for sunflower husk-based biofuels is but yet to be developed in Ukraine. It is constrained by a low demand, poor infrastructure (or even absent sometimes) and high logistics costs. The currently active green tariff, as well as ever increasing awareness among consumers and producers alike, would likely lead to an increasing market in the future.

Vegetable oil market is a growing and promising market. Higher production volumes of sunflower can be expected in Ukraine in the next years. For one, the prices for oilseeds and vegetable oil prices remain high on international markets. Another reason lies in the already mentioned surplus processing capacity, because of which vegetable oil industries try to stimulate domestic sunflower production by offering higher prices and signing long-term contracts. Of course, more sunflower means also higher biomass production (by-products and residues).

Similar to other sectors considered above, seasonal availability of sunflower husk, as well as of sunflower oil production residues poses an issue for biomass production, meaning it might be challenging if not impossible in certain cases to organize an uninterrupted production of biomass[22].

[22] See http://s2biom.alterra.wur.nl/doc/S2biom---T932---SCS-Ukraine---report.pdf p. 18 (Accessed 10.08.2017)

3.2.4. Non-technical barriers

No other barriers could have been identified, which had not yet been mentioned in this chapter.

4. SUGAR INDUSTRY

4.1. Profile of the sugar industry

4.1.1. Production

In Ukraine, sugar is being produced from processing of sugar beet. Along the chain of sugar production different by-products are generated. A tonne of sugar beet yields on average 17 % of its mass in sugar[23]. First, the sugar beet is divided into roots and haulm, then tops of roots are cut off. During the actual industrial processing sugar beets are first grinded and clear water is added. The mass is called diffusion juice, which is then cleared of beet grinds and further processed. The sugar beet grinds (shavings), also called sugar beet press or sugar beet pulp, is a by-product. Often, it is used as feed for farm animals. The diffusion juice is further processed into final product sugar, and another by-product – molasses. The procession of diffusion juice is a multi-stage process on consists of cleaning (defection, saturation, saturation and filtering) operations and thickening (evaporation of diffusion juice and further cleaning of resulting syrup) operations.

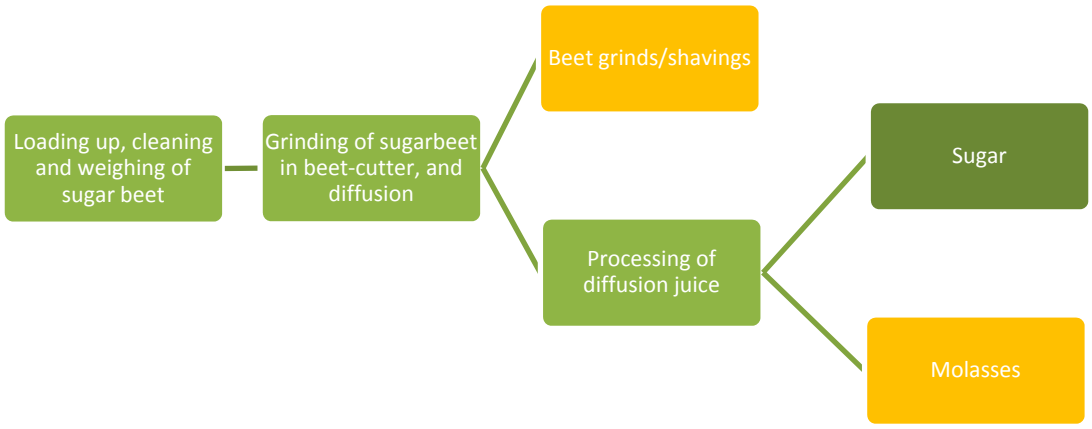

Figure 20. Generalized scheme of sugar production.
Source: UCAB, 2018

[23] http://agravery.com/uk/posts/show/cukrovij-burak-so-z-nogo (Accessed on 17.10.2017)

4.1.2. Volume of the sector

After the break down of the Soviet Union, the Ukrainian sugar industry experienced a massive decline. In the early nineties Ukraine was growing over 42 million tonnes of sugar beet, which then was processed at almost 200 sugar factories into 5 – 5.2 million tonnes of sugar[24]. Last year's production of sugar beet in Ukraine amounted only 14 million tonnes. From this amount, 12 million tonnes of sugar beet were processed into 1.7 million tonnes of white sugar[25]. The reasons for this decline seem to be obvious. For one, it is the fact that all of these sugar plants were operating with outdated Soviet-era equipment and were unable to produce a quality product at a competitive price – before they were supplying the domestic market of the Soviet Union. On the other hand, the inability to attract foreign direct investments - due to the unstable political situation, underdeveloped governmental institutions or weak security guarantees for private property - prevented purchasing modern technology and corresponding know-how. However, in the recent years the situation in the sugar producing sector has started to improve.

The raw material base for the Ukrainian sugar industry is composed of sugar beet. The sown area under the sugar beet was 292,000 ha in 2016.

According to the data published by the SSSU, in 2015 there were 808 companies growing sugar beet. As of the end 2016, there were 42 active sugar production plants.

The following figure illustrates the production of sugar beet in Ukraine's regions. The figure illustrates, sugar beet is mainly grown in the central part of Ukraine.

[24] Ткаченко, Н.М., Кравченок, І. Й (2014): Цукрова промисловість України: минуле і сучасне; шляхи відновлення галузі, p. 8

[25] Бондар, В.С. (2017): Тенденції і перспективи цукрового ринку України, In: Цукрові буряки, №1, 2017

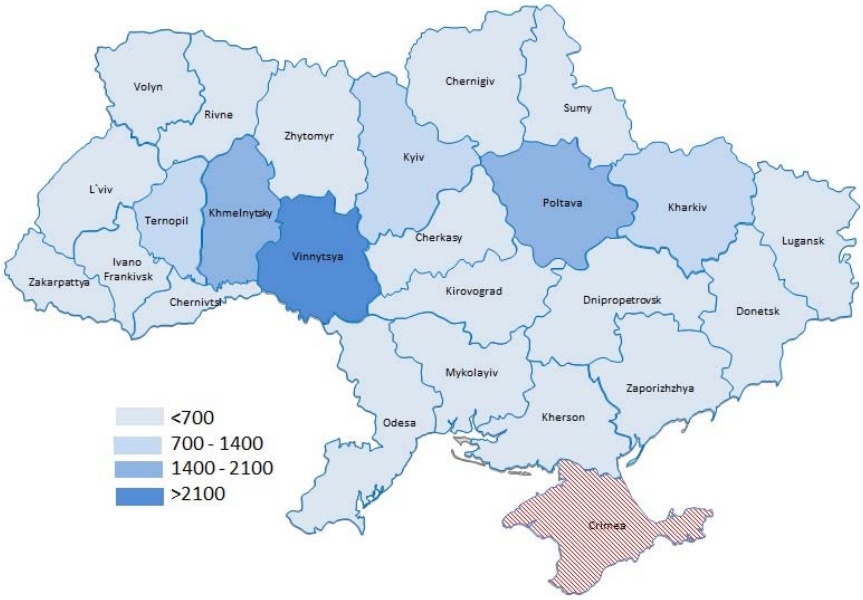

Figure 21. Gross production of sugar beet in 2016 in different regions, in '000 tonnes.
Source: UCAB calculations based on the SSSU data, 2017

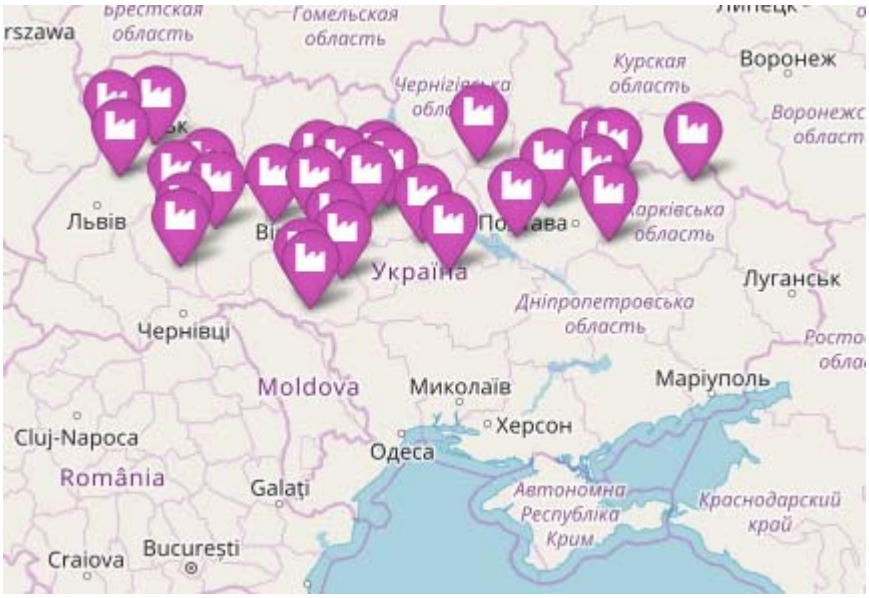

Figure 22. All active sugar production plants as of the end 2016

Source: http://ukrsugar.com/uk#map (Accessed: 25.05.2018)

4.1.3. State of the sector

Ukrainian sugar sector, sugar beet production and production of crystalline sugar both, during recent year have been rather sporadic and trendless.

Table 11. Sugar beet production in Ukraine, 2010-2016. Source: SSSU, 2017

Sugar beet production in Ukraine (million tonnes)	
Year	Production
2016	14.01
2015	10.33
2014	15.73
2013	10.78
2012	18.43
2011	18.74
2010	13.79

As the table above illustrates, the sugar beet production in during the recent years has been up and down, while peeking in the years 2011, 2012. Since then, production has plummeted sharply two times – in 2013 and in 2015. This may indicate, that the production decrease in 2015 was not brought about (to the full extent) by the political and military turmoil of 2014. The high variation in sugar beet production volumes probably can be explained primarily by the variations in the world sugar prices.

Table 12. Historical average yields of sugar beet in Ukraine. Source: UCAB, 2016

Historical average yield (Sugar beet), tonne/ha	
Year	Average yield
2016	48.2
2015	43.6
2014	47.7
2013	39.9
2012	41.1
2011	36.3
2010	27.9

Whereas the consistently growing yield rates of sugar beet in Ukraine, as shown by the figure above, would indicate, that agricultural producers of this crop have been employ new technologies and more efficient production methods.

Table 13. Sugar beet sugar balances. Source: SSSU, 2017

Sugar balances, 2012 – 2016, in million tonnes			
Year	Production	Export	Consumption
2016	1.99	0.50	1.42
2015	1.45	0.15	1.52
2014	2.0	0.04	1.55
2013	1.26	0.16	1.68
2012	2.14	0.17	1.71

The production of sugar has been following a similar pattern with the sugar beet. There have been two drops in production during the recent years – 2013 and 2015. Taking into account that virtually

all of sugar beet goes into production of sugar, the production of sugar has been simply mimicking that of sugar beet. The exports of Ukrainian sugar have dropped significantly in 2014, probably because of lower production in 2013, but then were growing steadily. Domestic consumption of sugar has been staying relatively on the same level.

Figure 13 shows that there were two significant drops in sugar prices on the world markets, which is consistent with drops in production of sugar beet and, accordingly, sugar.

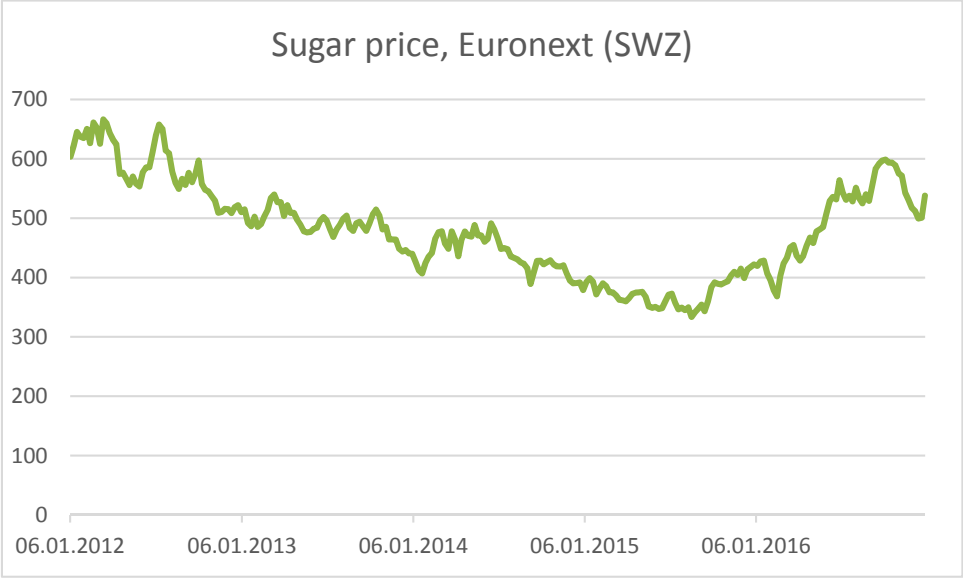

Figure 23. Sugar price, Euronext (SWZ), covering 2012-2016, USD/tonne. Source: UCAB visualization based on the Barchart.com data, 2017

4.1.4. Typical size of the companies

Over the last years agricultural holding companies (big producers) have pushed small and medium size producers aside, controlling about 80 % of the sugar market in Ukraine[26].

At the end of 2016 a total of 42 sugar producing plants were operating in Ukraine[27].

The Ukrainian National Association of Sugar Producers estimates the daily sugar production capacity in Ukraine at 23,100 tonnes[28]. The sugar plants operate up to three months per year, given the seasonality of sugar beet production and the fact that sugar beet cannot be stored for longer periods of time cheaply enough. If the sugar production plants would operate whole year long, the maximum production would be around 8 million tonnes (today it is about 2).

[26] Бондар, В.С. (2017): Тенденції і перспективи цукрового ринку України, In: Цукрові буряки, №1, 2017
[27] National Association of Sugar Producers, http://www.ukrsugar.com/uk/post/virobnictvo-cukru/pusk-cukrovih-zavodiv-stanom-na-08092016 (23.03.2017)
[28] http://www.ukrsugar.com/uk/post/v-ukraini-vze-virobleno-bilse-900-tis-t-cukru (18.10.2017)

For the biggest part of the year, the sugar production facilities are standing idle.

4.1.5. Distinctive facilities of the sector

Sugar producing facilities are located mainly in the Central and Western regions of Ukraine, such as the Poltava and Vinnytsya regions[29]. Some of the biggest producers in the sugar industry are: Astarta, Galsagro, Cygnet, ED&F, and Pfeifer&Langen.

As was mentioned in the previous paragraph, there is indeed a major overcapacity of sugar producing plants, substantiated by seasonal availability of sugar beet. Although, it is doubtful that these facilities during their idle times can be used for biomass processing, for example for grinding and shredding, because starting a sugar plant, as well then shutting it down is a long and energy consuming process No mentioning of such cases in Ukraine has been found in the literature.

Two possible technical barriers may responsible. First, sugar beet has a rough hard texture, whereas grain or sunflower straw not. The equipment might be appropriate for the task.

Secondly, big facilities are usually complex systems, and it is unclear, whether only an intermediate unit of a production chain can be launch independently – it may seemly be too costly to use sugar plants for external biomass processing.

4.1.6. Degree of innovation

Again, as Ukrainian statistics agency does not compose any kind of an industry innovation index, it is rather difficult to make any accurate statements on the sector's degree of innovation. At this moment the sector, as a whole, does not appear to be particularly innovative. Although, the potential for innovation for processing of sugar by-products and residues into bioenergy is being recognized by industries[30].

In 2016, there already were sugar producing plants, which were running on biofuels. For example, the Uzynskyy sugar plant was using pellets, and Globynskyy sugar plant was supplying up to 50 % of its energy needs by using biogas[31]. This last plant is a part of the Astarta, an agricultural holding company and the biggest sugar producer in Ukraine. Biogas is being produced by the situated nearby biogas plant, which in turn uses the sugar-beet pulp produced by the sugar plant. The biogas facility had to be situated in the immediate proximity because sugar beet pulp deteriorates very fast – it cannot be stored for too long or transported for long distances[32].

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[29] See Kalnitskaya, J. (2013): Business opportunities in the bio-based economy in Ukraine, p. 20

[30] See Ibid.

[31] http://agravery.com/uk/posts/show/energetika-astarti-ak-cukrovomu-zavodu-zaroblati-na-biogazi (18.10.2017)

[32] See ibid.

As noted by the head of the Ukrainian Association of Sugar Producers, Andriy Dykun, many other sugar producers are showing interest in producing biogas or bioethanol from by-products of sugar production, but these projects are yet on the planning phase[33].

4.1.7. Miscellaneous

As was mentioned before, there is some experience with biomass handling in the sector, although, as of today, these are isolated cases and not a mass phenomenon.

Although, there is a significant potential for biomass in the sector. For one, as was mentioned, sugar production generates various biomass by-products; as well as sugar plants, given the recent rise in natural gas prices, may be among the biggest consumers of biofuel.

4.2. Opportunities IBLC

4.2.1. Sector related residues

Sugar production yields various by-products, which can be used for biomass production - sugar beet press (about 0.2 tonnes per one tonne of sugar) and molasses (about 0.25 per one tonne of sugar[34]). Sugar beet pulp is suitable for biogas production by means of anaerobic digestion whereas molasses can be used as feedstock for bioethanol[35]. This type of production is not widespread though, because sugar beet pulp deteriorates very fast, so it must be transported rapidly to a biogas production facility, in order to be fitted for processing. In short – logistics is the problem. Installing equipment for biogas production in a facility itself or in the immediate proximity is one possible solution, as proved by the Globinsky sugar factory[36].

Given the fact that in Ukraine during 2016 was produced about 2 million tonnes of sugar, it can roughly be estimated a total amount of residues of 0.4 million tonnes of sugar beet pressed pulp and 0.52 million tonnes of molasses.

4.2.2. Potential synergies & benefits

Sugar plants are operating usually 3-4 months per year. Whether there exist potential synergies is hard to tell. Not least because the process of starting and shutting down is time-consuming and energy-intensive. In Ukraine, traditionally sugar producing companies rely primarily of own supply of sugar beet. In order to keep a high soil quality, there have to be crop rotation on regularly basis. This

[33]http://www.ukrsugar.com/uk/post/v-ukraini-planuut-viroblati-biopalivo-z-vidhodiv-cukrovih-zavodiv?sec=novini-ukraini (18.10.2017)
[34]http://agravery.com/uk/posts/show/energetika-astarti-ak-cukrovomu-zavodu-zaroblati-na-biogazi (18.10.2017)
[35] See http://s2biom.alterra.wur.nl/doc/S2biom---T932---SCS-Ukraine---report.pdf (Accessed 10.08.2017), p. 16
[36]http://pzp.astartakiev.com/2-uncategorised/48-vp-globinskij-tsukrovij-zavod-tov-tsukoragroprom (17.10.2017)

results in that mainly sugar producing companies end up producing as well other cash crop, which they then sell. This means availability of grain crops biomass (like stubble) close to a sugar producing plant. It is not known whether there are any cases in which sugar producing facilities are used for grain biomass.

Another opportunity for IBLC may lie in the production of bioethanol from the molasses – a by-product of sugar production. Bioethanol is currently produced at separate private and governmental distilleries, which current under-utilization is estimated to be as high as 50 %[37]. Molasses can easily be stored for longer periods as well as transported.

Production of biogas or bioethanol of sugar production residues has a potential to play an important role in improving Ukrainian energy sufficiency, especially given the fact that government does not subsidize natural gas consumption anymore, as well as the rapid deterioration of Russian Federation – the supplier of natural gas.

4.2.3. Market developments

It could be premature to talk about industries of the sugar sector entering new markets, in the sense of supplying biomass or biofuels to external consumers since industries' experience of handling biomass is yet limited to using self-produced biofuels (pellets, biogas) in sugar production in order to minimize energy costs.

The development of this trend to scale which would allow entering new markets is obstructed by several barriers. For one, as was shown previously in this chapter, by unstable dynamics on the sugar markets, meaning that uncertain relation of long-term profitability and dramatically fluctuating price make it a difficult investment decision.

Logistics is the main technical barrier.

4.2.4. Non-technical barriers

Sugar industries, on their way of embracing renewable energy, in particular biomass, are facing non-technical barriers as well. Of course, first of all one should name a cautious attitude of the industry towards biomass. Although the topic is slowly gaining popularity nowadays but there are yet not a lot of practical examples – or success stories – one can rely upon.

Of course, many companies still don't know, or don't completely recognize possible benefits of working with biomass or as a part of something like an IBLC.

And last but not least, industries in this sector, as in many others, tend to be quite isolated and their corporate strategy being built upon the goal of becoming self-sufficient. In this case, this "independence" might stimulate a plant to process the biomass by-products for one's own energy needs.

[37] See Kalnitskaya, J. (2013): Business opportunities in the bio-based economy in Ukraine, p. 33

5. FEED AND FODDER

5.1. Profile of the feed and fodder sector

5.1.1. Production

As feed and fodders for farm animals in Ukraine are used primarily residues and by-products of major crops, specialized technical agricultural crops, as well as concentrated and mixed fodders. Combined feeds are a homogeneous and complex mixture of various refined and grinded feed components. There are three possible stages of processing – physical (e.g. shelling, grinding, pressing, granulation), chemical (e.g. acid or alkaline treatment) and biological (e.g. soldering, fermentation).

5.1.2. Volume of the sector

The SSSU publishes data on the feed and fodder consumption distribution by all types of agricultural producers in fodders units, which measure total nutrition value of fodders. This is a somewhat archaic measure, which doesn't allow making accurate statements about the volumes of different feed and fodder types consumed. Nonetheless, the biggest part of nutrition value in 2016 was provided by mixed and concentrated fodders – 14,445,000 tonne fodders units or 47.4 % of total values[38]. On the second place there were coarse fodders (15.7 %), followed by the rich fodders (27,6 %) and lastly others – 9.1 %.

Because the data on the feed and fodder consumption is archaic and difficult to interpret it is better to turn to production. In Ukraine, in 2016 were produced 6,231,562 tonnes of combined and concentrated feed.

The fraction of grain crops in the production of concentrated and mixed feeds (prepared feeds) is about 65-70 %. The three major grain crops which are used in concentrated and mixed fodders production are corn, wheat and barley. In the previous year (2016) 1,092,000 tonnes of corn (or 4 % of corn produced), 476,000 tonnes of wheat (2 %) and 64,000 tonnes of barley (1 %)[40].

The sown area of agricultural land under the specialized cultures equalled 1,932,000 ha in 2016.

As of green feed, in 2016 Ukraine has produced 6,967,800 tonnes of corn 6,431,900 tonnes of perennial and 2,289,600 tonnes of annual weeds. Mainly in the southern and central regions.

[38] See Нікішина, О. (2015): Вітчизняний ринок комбікормової продукції, In: Вісник КНТЕУ, № 2, ст. 134
[40] The UCAB's calculations

5.1.3. State of the sector

In the recent years, the feed and fodder has been demonstrating negative dynamics. The figure below illustrates the production output of prepared feeds for farm animal in Ukraine for the time period 2011 – 2016.

Table 14. Prepared feeds for farm animals, 2011-2016, in million tonnes. Source: the SSSU, 2017

Production prepared feeds for farm animals	
Year	Output
2016	6.23
2015	6.71
2014	6.82
2013	6.75
2012	6.36
2011	6.15

As we can see, the production output has been declining since 2015. In this data it is already accounted for the annexed Crimea and separate regions of the Donetsk Oblast. Ukraine produces combined feeds for farm animals exclusively for domestic consumption. Taking this into account, it seems obvious that the reason of the decline in production output of prepared feeds is related to the decline in livestock's herd.

Table 15. Number of livestock and poultry, 2014-2016, in '00 0 tonnes. Source: the SSSU, 2016

Number of livestock and cattle in Ukraine, 2014-2016 (in '000 tonnes)				
Year	Cattle	Pigs	Sheep and goats	Poultry
2016	3,750	7,079	1,325	203,986
2015	3,884	7,351	1,371	213,336
2014	4,398	7,764	1,500	220,636

The table above illustrates a drop in the livestock during last years. This corresponds with the decrease in production output of prepared feeds for farm animals.

5.1.4. Typical size of the companies

There are about 440 producers of concentrated and mixed fodders in Ukraine. Whereas 350 producers with maximum production capacity less than 75 tonnes of combine and mixed feeds per day and about 90 producers with higher production capacity up to 1,150 tonnes per day[42].

It is impossible to say how many of them are producers of green fodder (specialized feeder plants), as these are usually grown by the livestock owners themselves.

[42] See Нікішина, О. (2015): Вітчизняний ринок комбікормової продукції, In: Вісник КНТЕУ, № 2, ст.139

5.1.5. Distinctive facilities of the sector

It is common that large vertically integrated agribusinesses produce mixed feed and fodder. About 70 % of all mixed and combine fodders is produced by such companies. Some of the biggest producers are the MHP, Ukrlandfarming, and Complex Agromars[44]. Usually, that such agribusiness produce combined feeds to supply their own needs, using primarily their own input materials. They do not advertise themselves as feed and fodder producers and are not market oriented. But in the case, unfortunately there is no detailed information on production capacities, so it impossible to estimate availability of surplus capacities.

5.1.6. Degree of innovation

The degree of innovation must be rather low judging by the fact that Ukraine does not export prepared feeds and fodders, it is plausible to assume, that the industries are not competitive in comparison to their foreign counterparts, which in turn can be due to either a higher price or a significantly lower quality.

5.2. Opportunities IBLC

5.2.1. Sector related residues

Actually, the feed and fodder sector is in a certain way a competitor sector for the biomass industry. For once, green feeds, which can either be given to farm animals directly or can be used as a feedstock for combined and mixed feeds production, come in two types: specialized plants that are grown specifically as fodder (e.g. fodder beet or vetch), or crops residues, as well as residues of other agricultural industries (e.g. residues of sugar production etc.). The feed and fodder sector generates no biomass related residues.

5.2.2. Potential synergies & benefits

There is a processing capacity (physical processing – grinding, granulating etc.) surplus in the feed and fodder sector. The current underuse of production facilities is estimated at the level of 20-40 %[46]. Following the recent decline in the production output of combined and concentrated feeds the underuse of production facilities today may be even higher.

Considering the fact, that the production of concentrated fodders shares some similar stages with the production of solid biomass, such as for example dehydration and granulation, this surplus capacity may be potentially of interest for an IBLC project.

[44] See See Нікішина, О. (2015).
[46] See ibid, ст. 135

5.2.3. Market developments

As we have seen, the production output of combined and concentrated feeds has been falling in the recent years, while following the decline in livestock numbers, as well the tendency of big agribusiness to producer their own feeds and not buy them on the market – demand is low The underused facilities in the sector probably would fit for processing of vegetable biomass. Many agricultural holding companies tend to supply themselves with feed and fodder, there are not many of independent producers, though the exact number is not known. It is possible, that the situation will develop similarly to the sugar sector, as when big integrated companies try to use all the secondary feedstock they produce.

5.2.4. Non-technical barriers

Non-technical barriers are the same as in all the other sectors.

6. SUMMARY ANALYSIS OF THE COUNTRY

Table 16. Summary of the grain chain sector

Grain chain sector	
	Profile
Production	• By-products potentially suitable as biomass feedstock are generated during grain production, as well as during grain processing by industries. • Main by-products during crops production: leaves, stalks, stubble, corncobs etc. During industry processing into groats and flours following by-products are generated: bran and husk.
Volume of the sector	• In 2016 total production of grain crops (including leguminous crops) was around 51 million tonnes. • Grain crops have the biggest sown areas among agricultural crops – 14.4 million hectares. • Main grain crops produced in Ukraine are corn, wheat, barley. In the 2016/2017 marketing year was produced 28, 26, and 9 million tonnes respectively. • 34,505 agricultural companies producing grain crops in 2015. • In the 2016/2017 marketing year 3.79, 0.68, and 0.43 million tonnes of wheat, corn and barley respectively went into industrial processing.
State of the sector	• In Ukraine, average yield rates fall behind in comparison to those in other European countries. Nonetheless, there have been improving in the recent years. • During the last 5-year-period processing quantities of wheat and barley have been steadily increasing, whereas processing of corn has experienced a slowdown.
Typical size of the companies	• In terms of gross production, about 50 % of all wheat are produced by small and medium-sized enterprises. • Corn production is dominated by medium-sized and big enterprises. • And most of barley is being produced by small agricultural producers.
Distinctive facilities of the sector	• Top 15 grain processing companies are listed. • These companies account for 42 % of all grain procession. • Biggest facilities are located in Central and Eastern parts of the country.
Degree of innovation	• The degree of innovation in the grain chain sector is rather low, which results in substantial amounts of residues generated during primary production, as well as during industrial processing gone unused (or used inefficiently).

Miscellaneous	• The primary production in the grain chain sector has sustainability issues, particularly concerning topics like crop rotation, soil deterioration and stubble, which is often left and burned in the fields.
	Opportunities for IBLCs
Sector related residues	• The grain chain sector, specifically the primary production segments, generates a lot of residues, which can be used as biomass feedstock for production of solid biofuels. • It is estimated, that currently about 3 % of residues are used as feedstock for biofuels, whereas 70 % go "wasted" on the fields. • The grain chain processing industries generate about 0.5 million tonnes of residues (such as bran), most are used as feed for farm animals.
Potential synergies & benefits	• Two low-intensity (production falls almost by half) production periods for grain chain industries have been identified: January and May-July. • These seasonally underused facilities may offer opportunities for IBLC.
Market developments	• The Ukrainian market for solid biomass produced of grain crops residues has been developing rapidly in recent years. • Average growth rate in total production output was 35 %. • Production is primarily concentrated in the centre and the south of Ukraine. • Logistics seem to be indeed the most important barrier.
Non-technical barriers	• Low awareness. • Mentioned lack of initial investment requirements as well as the lack of government support. • When considering stubble left in the field as a biomass residue, it should keep in mind the positive fertilizing effect that it provides for the soil. There is obviously a conflict of interests.

Table 16. Summary vegetable oil extraction sector

Vegetable oil extraction sector	
	Profile
Production	• Vegetable oil is produced from the three main oilseeds: sunflower, soybean, rapeseed. • The dominant oilseed is the sunflower – Ukraine is the biggest sunflower oil producer in the world. • The sunflower oil produced either through mechanical extraction or chemical extraction. • Main residues: sunflower husk, sunflower oilcake.
Volume of the sector	• In 2016 total production of vegetable oil was 5.2 million tonnes. • About 96 % of sunflower seed produced in Ukraine are used for sunflower oil production – about 13 million tonnes of sunflower. • Soybean and soybean oil: 4.3 million tonnes of soybean produced in 2016, only 0.7 million tonnes went into production of soybean oil. Total production of soybean oil was 168,240 tonnes. • In 2016, 1.1 million tonnes of rapeseed were produced in Ukraine, thereof 127,057 tonnes were used for rapeseed oil production – resulted in 81,600 tonnes of oil.
State of the sector	• Average yields of sunflower have been going up and down in the recent years. For soybean and rapeseed – steadily increasing. Since 2015 there have been a significant (around 20 %) in production volumes of sunflower. Due to high profitability of this crop.
Typical size of the companies	• Concerning the primary production (oil seeds production), in the sector many thousands of companies are active, ranging from small to large. • The processing industries are primarily large companies.
Distinctive facilities of the sector	• The Kernel Holding is producing 27 % of sunflower oil in Ukraine, which is equal 8 % of total world supply. • 15 biggest companies are producing around 85 % of sunflower oil.
Degree of innovation	• In comparison to other sectors analysed in this report, the vegetable oil sector may be considered the most innovative.
Miscellaneous	• The sector already has experience of handling biomass, mostly in form of producing solid biofuel – pellets – from sunflower husk. • It is estimated that about 750,000 tonnes of sunflower husk is used for sector's own energy needs.
	Opportunities for IBLCs
Sector related residues	• Sunflower husk produced per year is estimated to be at about 10 million tonnes.

	• It is either used for production of pellets or exported (mainly to the EU country). • In 2016, there were 169 producing pellets.
Potential synergies & benefits	• The surplus in processing capabilities of the vegetable oil sector is estimated to be as high as 40 %. • That big a surplus offers an opportunity for an IBLC. • Energy generation from sunflower husk offer a viable alternative to natural gas imports from Russia and a way to minimize the country's dependence on it.
Market developments	• The vegetable oil sector is demonstrating positive dynamics. The markets for sunflower oil and for sunflower seed are likely to continue to grow in the future. • Despite the green tariff, the market for sunflower-husk based biofuels is yet to be developed. • Main restrictions: low awareness, low demand, poor infrastructure, seasonal availability of feedstock etc.
Non-technical barriers	• When generating energy by burning sunflower biomass (e.g. pellets) one should consider the emissions issue.

Table 17. Summary sugar industry sector

Sugar industry sector	
	Profile
Production	• In Ukraine, sugar is produced primarily from sugar beet. • A tonne of sugar beet yields on average 17 % of its mass in sugar. • Main by-products: sugar beet press (pulp) and molasses.
Volume of the sector	• In 2016, 12 million tonnes of sugar beet produced, sown area 292,000 ha. • Those were processed into 1.7 million tonnes of white sugar • 42 active sugar plants.
State of the sector	• The development of the sector, concerning primary production of sugar beet, as well as production of white sugar, has been sporadic and uneven in the recent years. • The average yield rate of sugar beet was at its highest in 2016 – 48.2 million tonnes. • The domestic consumption of sugar remains stable – averaging at 1.5 million tonnes; • Ukrainian export of sugar started to grow since 2015.
Typical size of the companies	• The sector is dominated by big producers. • 42 sugar plants are producing about 80 % of sugar. • Sugar producing facilities are located mainly in the central and western regions of Ukraine. • Daily sugar production capacity is estimated at 23,100 tonnes. • But sugar plants are active on average for three months per year.
Distinctive facilities of the sector	• Some of the biggest producers are: Astarta, Galsagro, Cygnet, ED&F. • Sector's production facilities remain idle for the most part of the year, though it is unclear, whether these facilities could be used as a part of an IBLC.
Degree of innovation	• The sector does not appear to be particularly innovative. • In 2016, there already were sugar producing plants, which were running at least partially on biofuels – pellets and biogas.
Miscellaneous	• There is experience of handling biomass. Mainly for own consumption as fuel. But as of today, these are only isolated cases, and not a mass phenomenon.
	Opportunities for IBLCs
Sector related residues	• Per 1 tonne of sugar 0.2 tonnes of sugar beet press and 0.25 tonnes of molasses are produced. • Both main residues are suitable feedstock for biofuel production: solid biofuels (pellets) and biogas.

	• Total volume of residues for 2016 can be estimated: 0.4 million tonnes of sugar beet press and 0.52 million tonnes of molasses.
Potential synergies & benefits	• Although big sugar producers tend to have various residues from grain or oil crops, but it is unclear whether idle sugar producing facilities can be used for processing of this biomass. • An opportunity for IBLC may lay in production of bioethanol from molasses, produced by sugar plants, and different private and government distilleries, which current under-utilization is estimated to be as high as 50 %.
Market developments	• The international price for sugar is very volatile, thus the production of sugar has been very uneven in the recent years – there have been no clear long-term trend. It is difficult to predict how the industry will develop in the future. • The sector's experience of handling biomass has been limited as well. But it is likely the number of sugar plants using biomass to satisfy – at least partially - own energy needs will grow in the future.
Non-technical barriers	• Cautious attitude of the industry towards other stakeholders. • Low awareness. • Particularly in this sector, companies are striving to be self-sufficient.

Table 18. Summary feed and fodder sector

Feed and fodder sector	
	Profile
Production	• As feed and fodders for animals in Ukraine are used primarily residues and by-products of major crops, specialized technical agricultural crops, as well as concentrated and mixed fodders.
Volume of the sector	• The biggest part of nutrition value in 2016 was provided by mixed and concentrated fodders. • In year 2016 6,231,562 tonnes of combined and concentrated feed were produced. • The fraction of grain crops in the production of concentrated and mixed feeds (prepared feeds) is about 65-70 %. • In year 2016 1,092,000 tonnes of corn (or 4 % of corn produced), 476,000 tonnes of wheat (2 %) and 64,000 tonnes of barley (1 %) went into production of combined and mixed feeds. • The sown area of agricultural land under the specialized cultures equalled 1,932,000 ha in 2016.
State of the sector	• The sector can be considered to be in stagnation – the production of combined and concentrated feeds has been declining for the few recent years in a row. • That is most likely due to the fact, that the number of big farm animals - cattle, pigs, sheep and goats – has been declining as well.
Typical size of the companies	• 440 producers of combined and mixed feeds for farm animals in Ukraine. 350 of them have maximum production capacity less than 75 tonnes of final product per day, and 90 with a production capacity above – up to 1,150 tonnes per day.
Distinctive facilities of the sector	• 70 % of all mixed and combined feeds are produced by big integrated companies. Some of the biggest producers are: MHP, Ukrlandfarming, Complex Agromars.
Degree of innovation	• Degree of innovation is rather low. Most of feeds and fodders produced are for own needs of agribusiness business and are not being brought to the market.
	Opportunities for IBLCs
Sector related residues	• Sector generates no biomass related residues.
Potential synergies & benefits	• There is a processing capacity surplus (physical processing - grinding, granulating etc.) in the sector. The current underuse of processing facilities is estimated to be at the level of 20-40 %. Due to the fact, that the production of concentrated fodders shares some similar stages with the production of solid biomass (e.g. dehydration and

	granulation), this surplus capacity may be potentially of interest for an IBLC.
Market developments	• The market has been shrinking during the recent year due to decline in livestock numbers.
Non-technical barriers	• Not identified so far.

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9. Annex A – Literature overview

Please note that the main data sources for this desk-study was the State Statistics Service of Ukraine (SSSU) and the UCAB's own statistics. Concerning the official statistics, the SSSU usually makes publications once per year covering the data from the year before the publication, e.g. reports published in 2017 would contain statistics for 2016. The timing of this desk-study is somewhat not optimal, because the current year's reports have not been published yet, and often (not in all cases) the 2016 reports had to be used with numbers from 2015. I would also like to specify that if no explicit source is cited or indicated the official statistics from the SSSU is used.

In the recent years, a lot of scientific literature on the topic of biomass production in Ukraine has been published. A substantial amount of it has been produced either by or in cooperation with various research institutions from the European Union. The S2Biom project[48)] (2016) which was funded by the European Commission and lasted for 3 years is an example of such a project. It covered the EU28, as well as Western Balkans, Moldova, Turkey and Ukraine. It provided a solid overview of lignocellulosic biomass production in Ukraine. Amongst others are for example: the study by the IFC (2016); ordered by the Dutch Biorenewables Business Platform (BBP) and conducted by the ProMarketing Ukraine study (2013)[49]; the paper by Janda and Stankus (2017)[50)], which focuses primarily on biofuel, but covers the feedstock and biomass production in Ukraine as well.

Ukrainian academics and scientists have been occupied with the topic of biofuel production in the recent years too, while primarily focusing on the biofuel's unexploited economic potential, as well as its potential for establishing Ukraine's energy security, e.g. Kaletnik (2013)[51)], Scrypnytchenko (2014)[52)] and Sinchenko et al. (2014)[53)]. Here are some of the recent publications describing the state of the relevant agricultural sectors: Kozak and Gryschenko (2016)[54)] on grain sector; Dankevych

[48] About the S2Biom project - http://www.s2biom.eu/en/about-s2biom.html (Accessed on 10.04.2017)
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(2014)[55] on feed and fodder sector; Tkachyuk (2014)[56)] on vegetable oil; and Bondar (2017)[57)] on the sugar industry. Unfortunately, publications by Ukrainian authors are not usually published in English.

There is an issue that Ukrainian and European publications on this topic tend to have in common. They often rely on the same data source, namely the State Statistics Service of Ukraine (SSSU). Though it might very well be a reliable source of statistical data per se, the problem is the already mentioned delay in publications. It is common to come across a recently published paper which analyses a certain sector, however, based upon outdated data. And since data sources are sparse, there is kind of a cascading effect: many different papers – Ukrainian and European alike – often effectively rely upon and quote the same outdated numbers. On the other hand, the biomass sector develops dynamically. This is especially relevant in the case of the Ukraine, because political and economic factors can change rapidly in the country. Other factors, like technology level and know-how - while boosted by the ever growing FDI influx into the sector - can change rapidly as well. As a result, it is difficult, if not impossible, to get an up-to-date overview of the biomass and biofuel production sector.

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2	IMC	Grain Chain & Feed and Fodder	Information (Interview)
3	ASTARTA	Sugar Industry	Information (Interview)

Main events related to the results of the deliverable			
Title	Date	Press release	Target audience
1 LFM (Large Farm Management), UCAB	September	July-August	Agricultural businesses, primarily big integrated companies
2 BIOMASS FOR ENERGY , UABIO	September	August-September	Agricultural producers, biofuels producers, etc.
3			

Dissemination tools: what short of materials can be created to contribute to disseminate the results?				
x Photographs	x Video	x Power point	x Papers	x Poster
x News for project website	x Networking opportunities	x Training course	x Seminar	x Social network

Potential Paper	
Title	Authors

Abstract / Public summary (500 words)

The grain chain and vegetable oil extraction sectors generate significant amounts of by-products and residues, as during the primary production – respective crops, as well as during the later stages of industrial processing. Those residues can be used as feedstock for production of solid biofuels (e.g. straw pellets). In the vegetable oil extraction sector exists a constant surplus in processing capacities, which constitutes a potential opportunity for IBLC. Logistics seems to be the main obstacle for further development of this market. As well as low awareness in general concerning the possibilities and benefits offered by handling of biomass.

The sugar industry sector also generates residues and by-production, which can be used as biomass feedstock – primarily sugar beet press and molasses. The first, in particular, is used for production of biogas, whereas the second one – for production of bioethanol. There are some sugar producers in Ukraine, which have experience of using biofuels (biogas, solid biofuels) to power sugar plants.

The feed and fodder sector doesn't seem to offer any biomass related residues, but does also have a significant surplus in processing capacities. These can be used for physical processing (dehydration, granulation etc.) of grain and vegetable biomass feedstock generated by other sectors into solid biofuels.

Other dissemination suggestion or comments from the authors of the deliverable

AGROinLOG

INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors

D6.2.5 Country Report Serbia

Project AGROinLOG "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe"
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ABBREVIATIONS

CAP Common Agricultural Policy

CEFTA Central European Free Trade Agreement

EU European Union

EUR euro

FFA free fatty acid

GDP gross domestic product

ha hectare

IBLC Integrated Biomass Logistics Centre

l litre

MJ Mega joule

RS Republic Serbia

t tonne

toe tonnes of oil equivalent

UAA utilised agricultural area

USD United States dollar

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

The report analyses the following five sectors of the agro-economy segment in Republic of Serbia: sugar industry, wine sector, vegetable oil extraction, grain chain, and feed and fodder. Each sector chapter consists of two main parts: a general sector description and a second part concerning sector's interest from the IBLC concept perspective. The grain chain and vegetable oil extraction sectors are dominant due to the fact that they generate large amounts of by-products and residues, during the primary production of respective crops, and later during the stages of industrial processing. Those residues can be used as feedstock for production of solid biofuels (e.g. agro pellets). Log wood is the traditional primary energy source for heating in Republic Serbia as well as coal but recent development of pellet production and specialized combustion equipment for this type of fuel have opened the opportunities for utilisation of various agro residues in this field.

There is a significant surplus in processing capacities in the vegetable oil extraction sector, which is a potential opportunity for IBLC implementation. Nevertheless logistics is the main obstacle for further development of vegetable oil market due to the numerous number of small famers with insufficient capacities for operation according to modern standards, variability of prices, and transportation problems related to biomass delivery.

The sugar industry sector generates significant amount of residues and by-products, which can be used as biomass feedstock – primarily sugar beet press (pulp) and molasses. In particular, the first can be used for the production of biogas, whereas the second one is suitable for the production of bioethanol. However, at this moment there are no capacities in Serbia for the production of either biogas from sugar beet press or bioethanol from molasses.

The feed and fodder sector has no surpluses that can be used for the production of biofuels. Anyway significant production capacities are in surplus, that can be used for processing grain and vegetable biomass feedstock generated by other sectors into solid biofuels.

Serbian agro-industry has the potential for IBLC development in following sectors: vegetable oil extraction, wine sector, sugar industry and grain chain. The main opportunities for these sectors are:

- Significant potential for biomass utilization.
- High infrastructure and well development of selected sectors.
- Existing knowledge and efforts made to implement modernization according to best practices and improvements made in energy efficiency in last decade.
- Potentials for further investment.

Additionally, during the sectors analysis different obstacles were identified:

- Unresolved relationship due to land property issues and the poor leasing of state land.
- Small farms with insufficient capacities for operation according to modern standards.
- Economic aspects: relatively low price of fossil fuel compared to biomass, variability of prices, high input prices and problems with loan repayments for equipment and machinery.
- Uncertainty related to policy measures.

- Transportation problems for biomass delivery - bad road infrastructure, bad conditions in railway sector and insufficient use of river transport.

In Republic of Serbia, renewable energy sources with an estimated technically usable potential of about 5.6 Mtoe per annum can have a considerable contribution to a lesser utilization of fossil fuels and achievement of defined targets regarding the share of renewable sources in the GFEC (27 % in 2020). The biomass potential amounts is approximately 3.4 Mtoe per year (2.3 Mtoe per year is unused, and 1.1 Mtoe is used). The main part of unused biomass comes from the agriculture sector and for this reason IBLC could have a very important role concerning the fulfilment of RES' target.

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1 INTRODUCTION

This country report was written within the scope of the Task 6.2 "Basic analysis of targeted agricultural sectors" of the AGROinLOG project "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe". The primary aim of this report is to provide an actual overview of the agro industry for selected sectors in Serbia, and give specific information with respect to the IBLC related topics. The sectors of the agro-industry in Serbia considered in this report are: the sugar industry, the vegetable oil extraction, the wine sector, the grain chain and the feed and fodder sector. In addition, based on data which will be presented in the following sections, the aim of the report is to define the potential in all or in some of the selected sectors for implementation of the IBLC concept. Therefore, each sector chapter effectively consists of two parts: general overview of the sector current state and an assessment of IBLC opportunities.

In order to easier defining the overview for selected agricultural sector, the methodology of territory division related to the Statistical Office of the Republic of Serbia is used. According to Nomenclature of Territorial Units for Statistics, Serbia is divided into five NUTS 2 regions: Vojvodina, Belgrade, Sumadija and Western Serbia, Southern and Eastern Serbia and Kosovo and Metohija which are shown on Figure 1.

Figure 1. Statistical regions in Serbia. Source: Statistical Office of the Republic Serbia, 2013.

Agro-industry in Serbia is at the heart of the economy and is an engine for development of rural areas. In 2016, agriculture accounted for 11.9 percent of GDP, 2.4 percent higher than 2015, mostly

due to very favourable weather conditions and record yields achieved. This large share in the country's GDP has mostly resulted from Serbia's fertile land and natural conditions for agricultural production, as well as the continued importance of the rural economy to Serbia's population and delays in structural reforms in other sectors of the economy. According to the Serbian Statistical Office, there are 680,000 people employed in agriculture or 21 percent of the total labour force in the country. Agriculture also is the most important export sector in Serbia. In 2016, agriculture and food production accounted for 19.4 percent of all Serbian exports and enjoyed a trade surplus of USD 1.4 billion, USD 130 million more than in 2015 (mostly due to an increase in exports of processed fruit and vegetable). The major part of agricultural land is in the northern part of the country; Vojvodina accounts for 84 percent of total cultivated land in Serbia (Figure 2).

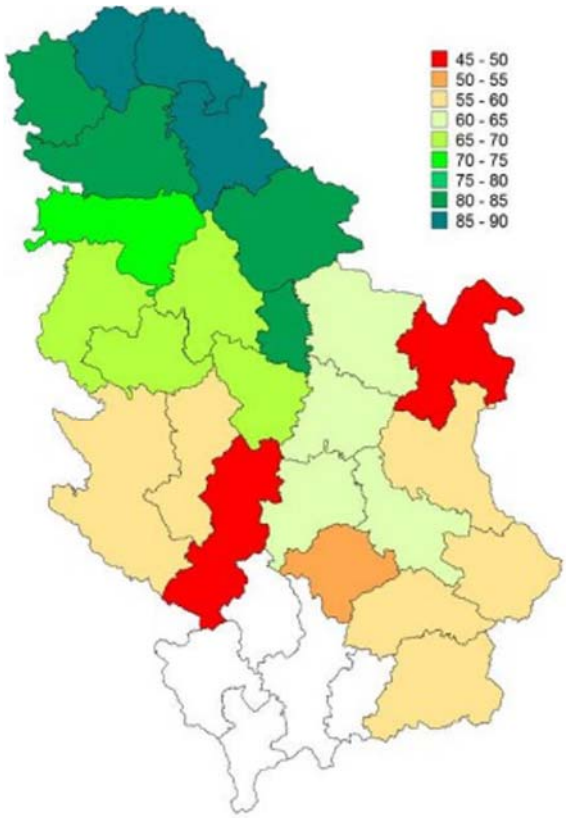

Figure 2. Arable vs total area in %. Source: Statistical Office of the Republic Serbia, 2013.

Approximately 60 percent of Serbia's agricultural land is used for cereal crop production (including corn, wheat, barley), sunflowers, soya, and sugar beets. More than 60 % of the value of the agricultural production is generated by plant production and 40 % by livestock production. The main plant products are maize, wheat, oilseeds, sugar beet, fruits and vegetables.

The country has 5.05 million hectares (ha) of arable land. Approximately 90 percent of this land is privately owned and 10 percent belongs to the state. Serbia's utilised agricultural area (UAA) is 3,437,423 ha, which accounts for 44 % of the total territory. Arable land is the predominant land use

(73 %) followed by permanent grassland (21 %) and permanent crops (6 %). Serbia has defined areas with difficult working conditions for agriculture[1].

This less favoured area" covers 39 % of the total surface and 24 % of the utilised agriculture area used by 29 % of the farms.

According to the Serbian Agriculture Census from 2012, there are approximately 630,000 registered agricultural entities of which approximately 99.6 percent are family households and 0.4 percent are other legal entities. The average size of the family holding is only 4.5 ha large and the average size of commercially registered farms is 10.6 ha.

The largest share in the total number of holdings (48.1 %) consists of small farms (up to 2 ha of land, which are using only 8 % of the area). The holdings with less than 5 ha are 77.4 % of the total number of farms and they occupy about 25 % of utilized agricultural land (UAA). In contrast, the largest farms, over 50 ha, account only up to 1 % of the total number of farms, and cultivate about one third of UAA. One of the reasons for low agricultural productivity in Serbia is the poor level of relevant professional skills, especially regarding farm management.

The agricultural census registered 631,500 agricultural holdings with an average size of 5.4 ha. 99.5 % of the holdings are family farms. Serbia's agriculture is characterised by a mixed farm structure with:

- 6,200 large farms with more than 50 ha using 33 % of the UAA
- 45,300 medium seized farms with 10-50 ha using 24 % of the UAA
- 271,600 small farms with 2-10 ha using 35 % of the UAA
- 308,400 subsistence or semi-subsistence farms with less than 2 ha using 8 % of the UAA

The climate conditions in Serbia are generally favourable for agriculture and Serbia has rich land resources with a good soil quality, a rich biodiversity and a good ratio of agricultural land per capita. Despite these favourable conditions, labour productivity is 20 % below the EU average. Product yields are well below potential, mainly due to lack of finance, modern technology, sufficient input levels, genetic resources and knowledge. Production is also affected by climate change. Farmers are vulnerable to extreme weather conditions which, in recent years, have resulted in increased volatility of production. Nevertheless, Serbia is a net exporter of agricultural products with a favourable ratio between exports and imports of 1.5 to 2 in recent years. Trade consist mainly of primary agricultural products (79 % of exports and 65 % of imports).

Despite its economic and political importance, the Serbian agricultural sector is still hampered by a variety of constraints limiting its full potential. Aside from outdated production technologies and machinery, the lack of adequate infrastructure (e.g. storage/cooling facilities) and inadequate irrigation and drainage systems, the lack of sufficient agricultural finance in comparison to other sectors is considered by many observers to be one of the major impediments to the growth and

[1] The following criteria were used: Altitude- above 500m or less than 100 employed/1,000 citizens or belonging to a nature park. This definition is not aligned yet with the definition of less favoured areas based on EU legislation.

development of the sector. However, although Serbia has remarkable natural resources and a strong production and processing background, in many areas both industry and farms lack modern technology and strongly need technical assistance and increased financial resources for further development. As a result of weakness in technology and access to finance, Serbia does not have productivity on the level of the EU, or, in many cases even on the level of its neighbours.

Considering that Serbia is not yet a member of the EU, the methodology for collecting data from the agricultural sector differs from the methodology applied in the EU. This was the biggest particular constrains during the preparation of this country report, because the data obtained from the national statistical office had to be compared with the data obtained from the field. This is done in order to get relevant information for example about the cultivated areas for specific crop, produced capacities or classification of certain products where the most frequent deviations can be found. In recent years, since Serbia is EU candidate country, its legal framework and the organization of certain state bodies must be harmonized with the EU. This fact makes the difference in some methodology and analysis significantly reduced, but still it could be a fundamental problem in document preparation and country reporting like this. In the following sections, the main characteristics of selected agriculture sectors will be presented, as well as, the opportunities and barriers for IBLC implementation.

2 SUGAR INDUSTRY

2.1 Profile of the sugar industry sector

2.1.1 Production

Traditionally, the sugar industry is one of the key agro-industries in the Republic of Serbia. This position was acquired thanks to the quality of the soils and the favourable climatic conditions that are conducive to the sugar beet cultivation. The sugar beet foreign hybrids production prevails and they are used as the main raw material for sugar production in Serbia. Total production of the sugar beet is mainly dedicated for the needs of the domestic sugar industry. Also the traditional commitment to sugar production as an important agricultural branch has contributed. Unlike other agro-industry sectors in Serbia, production technologies in sugar industry have developed over the years and have largely followed up modern trends in sugar production. In addition to the basic technological process of sugar production (Figure 3), technology includes auxiliary processes and operations in power generation plants, auxiliary materials and the processing of by-products.

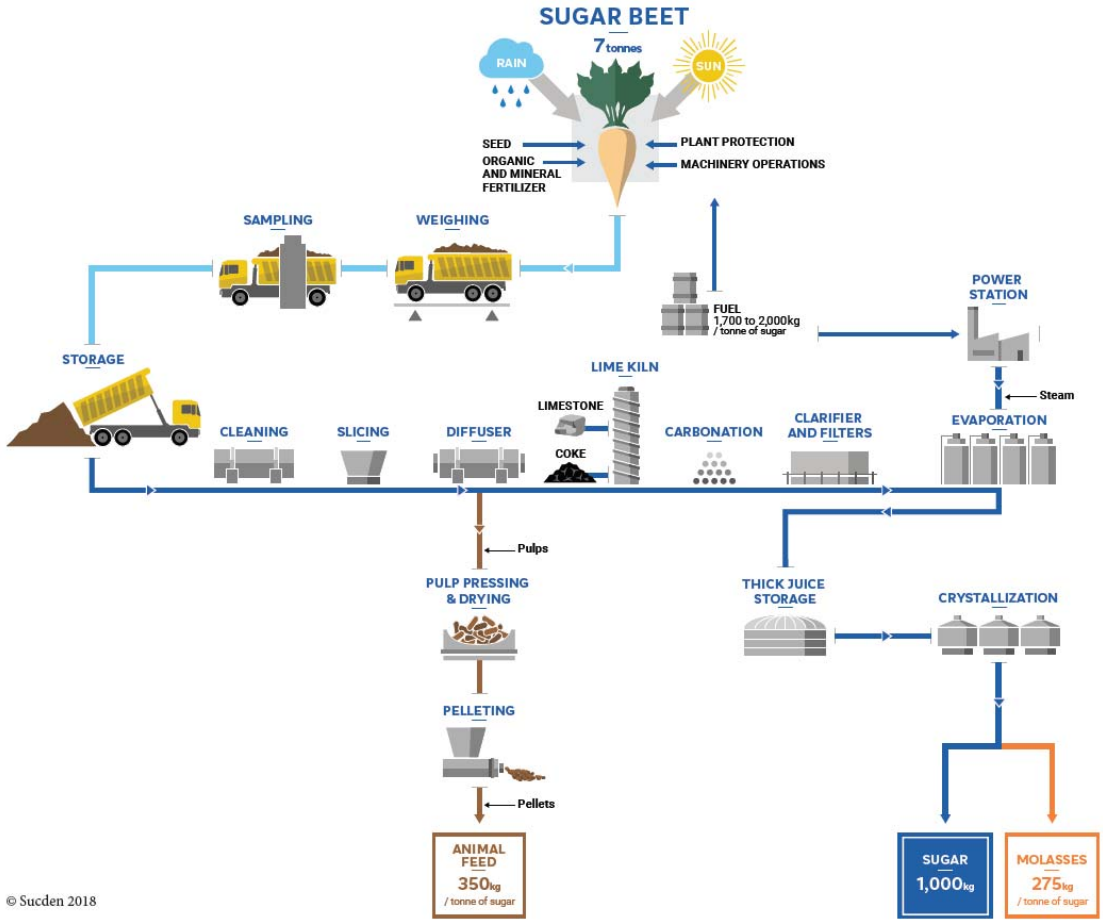

Figure 3. Sugar production process. Source: https://www.sucden.com/, 2018.

The basic technological process of sugar production can be divided into 7 phases:

1. Dose and weighing sugar beets, taking a sample
2. Wet or dry unloading of sugar beets, beet washing, cutting the beets on the noodles
3. Extraction of tail noodles, extraction of juice and dried noodles
4. Cleaning the juice
5. Concentration and evaporation of the juice
6. Crystallization of sugar
7. Finishing crystalline sugar

2.1.2 Volume of the sector

In the domestic agriculture production, sugar beet takes a significant place. The annual production of sugar beet was in the range from 2,200,000 to about 3,300,000 t in the period from 2006 to 2016 (Table 1). For production of sugar beet between 1 and 1.5 % of the total available land is used in Serbia. It is produced by farms with more than 100 ha (≈ 400 farms).

Table 1. Sugar beet production in Serbia 2006-2016. Source: Statistical Office of the Republic Serbia, 2017.

Sugar beet production in Serbia 2006-2016				
Year	Harvested area (ha)	Production (t)	Yield (t/ha)	Export (t)
2006	76,130	3,397,570	44.6	80,000
2007	84,085	3,412,089	40.6	92,000
2008	51,261	2,454,605	47.9	129,000
2009	65,354	2,977,781	45.6	90,000
2010	70,968	3,551,074	50.0	338,000
2011	59,221	3,004,237	50.7	205,000
2012	69,069	2,482,962	35.9	-
2013	66,527	3,180,008	47.8	-
2014	64,112	3,507,441	54.7	34,000
2015	42,123	2,183,194	51.8	21,000
2016	49,237	2,683,860	54.5	100,000

As shown in Table 1 in the period of last ten years, the areas under the sugar beet were extremely unstable according to actual Agriculture Strategy 2014-2020, Belgrade 2014. Regarding to these facts sugar production has also changed: sugar production varies with the changes in the production of sugar beet (400,000 to 500,000t of sugar a year, mainly). So according to the Statistical Yearbook of Serbia in 2015, the production of refined sugar in 2014 amounted 546,000 t, and in 2015 329,440 t [Statistical Office of the RS - Agricultural database, 2017]. Production of sugar in 2015 reduced by 40 % compared to 2014 due to climate conditions. Despite this, the domestic market was supplied with sugar, since domestic production provides significant market surpluses every year. Existing surpluses are mainly exported to EU countries.

The cultivation of sugar beet is done mainly on arable land located on north part of Serbia in the region of Vojvodina. The most important sugar production facilities is also located in that region. The main producers are listed below and presented on Figure 3.

Today, in the Republic of Serbia, seven sugar factories are operating (Figure 4), whose processing capacity, based on average 100 days of processing, is about 4,400 million tonnes which are transported in over 150,000 trucks. The Serbian beet processing sector has gone through a process of rationalization during which a number of factories closed, and the remaining factories invested heavily to expand their capacity. The main sugar production facilities are:

- Production Centre Pećinci (former Donji Srem), located in Pećinci (1)
- Production Centre Bačka, located in Vrbas (2)
- Production Centre Kovačica (former Jedinstvo), located in Kovačica (3)
- Jugozapadna Bačka, located in Bač (4)
- The Sugar Factory "Crvenka", located in Crvenka (5)
- The Sugar Factory "Šajkaška", located in Žabalj (6)
- TE-TO Senta, located in Senta (7)

Figure 4. Main sugar production facilities in Serbia. Source: Hickingbottom & Jackson, 2013.

2.1.3 State of the sector

There are 15 sugar factories in Serbia (in Pećinci, Vrbas, Kovačica, Bač, Crvenka, Žabalj, Senta, Sremska Mitrovica, Kovin, Zrenjanin and Nova Crnja, Šabac, Beograd, Ćuprija and Požarevac). According to the data of the Serbian Business Registers Agency, 8 of the above mentioned factories are undergoing bankruptcy. The facilities still operating today are presented in Table 2.

There are no official industry standards that define the relationship between beet growers and processors in Serbia. Each factory carries out its own contracting directly with the farmers who supply beets.

Approximately 180,000 to 200,000 t/year are exported. The export of sugar to the EU is managed by export licences. The EU has limited the amount of sugar export to its market to181,000 t/yr without additional duty. Serbia stated that it applies an ad valorem (20 %) and specific import duties for raw sugar (EUR 0.14/kg) and white sugar (EUR 0.15/kg). The specific import duties are reduced for imports from the EU, CEFTA, Turkey, Belarus and Kazakhstan. Trade with CEFTA countries and the Russian Federation is completely liberalised.

Table 2. Sugar consumption in Serbia 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Sugar consumption in Serbia 2006-2016					
Year	Food use (t)	Industrial use (t)	Export (t/ha)	Closing stocks[2] (t)	Total consumption (t)
2006	99,000	144,000	222,000	38,000	503,000
2007	99,000	144,000	224,000	56,000	523,000
2008	93,000	130,000	183,000	50,000	456,000
2009	100,000	147,000	235,000	14,000	496,000
2010	95,000	145,000	242,000	44,000	526,000
2011	95,000	145,000	190,000	54,000	484,000
2012	95,000	150,000	181,000	63,000	489,000
2013	100,000	150,000	276,000	78,000	604,000
2014	100,000	150,000	307,000	143,000	700,000
2015	100,000	150,000	193,000	24,000	467,000
2016	100,000	150,000	237,000	139,000	626,000

Table 3. Main sugar production facilities in Serbia. Source: Sunoko; Šajkaška, 2017.

[2] Closing stock is the amount of inventory that a business still has on hand at the end of a reporting period. This includes raw materials, work-in-process, and finished goods inventory. The amount of closing stock can be ascertained with a physical count of the inventory. It can also be determined by using a perpetual inventory system and cycle counting to continually adjust inventory records to arrive at ending balances. The opening stock for the next reporting period is the same as the closing stock from the immediately preceding period [AccountingTools, 2018].

Main sugar production facilities in Serbia			
Factory	Owner	Maximum processing capacity of sugar beet (t/year)	Maximum sugar production (t/year)
Production Center Pećinci	Sunoko	800,000	100,000
Production Center Bačka	Sunoko	600,000	100,000
Production Center Kovačica	Sunoko	700,000	100,000
Jugozapadna Bačka	Sunoko	300,000	40,000
The Sugar Factory "Crvenka"	Hellenic Sugar Industry	650,000	105,000
The Sugar Factory "Šajkaška"	Hellenic Sugar Industry	550,000	50,000
TE-TO, Senta	Sunoko (former owner Sfir, Italy)	800,000	100,000

The structure of companies in the sugar industry is dominated by medium and large companies representing more than 10 % of the total number of companies within the entire agro-industry branch. The equipment in the sugar industry is such that in larger plants the equipment is better. In 2016, the processing capacities of factories that are in operation, operated with 60 % capacity. The trend in the last ten years is that sugar production in Serbia is increasing. The factories are owned by two companies - "Helenik Sugar" and "Sunoko". The fact that two sugar producers operate in this market certainly opens the issue of monopoly, both at the market of raw materials, and selling final product, especially related to the high consumer prices.

The total consumption of sugar in Serbia is around 25-30 kg per capita, which is about 240,000t per year. On the other hand, the annual production of refined sugar in 2010 exceeded 500,000 t, so sugar represents a product that is exported from Serbia (Table 2).

2.1.4 Typical size of the companies

In Serbia, several companies (production centres) are dealing with sugar production and all these companies will be will be described in this section.

Production Centre Pećinci is one of the state-of-the-art sugar plants in the region. During the sugar beet processing campaign, this factory has the highest processing capacity.
Employees: 127 permanent employees, 7 fixed-term employees and around 140 seasonal workers.
Capacities: The plant processes 8,000 t of sugar beet daily and produces 1,150 t of sugar. The annual capacity of sugar beet processing reaches 800,000 t, which is one fifth of the annual sugar beet crop in Serbia.

Production Centre Bačka was founded in 1913 and it is the oldest sugar plant in Serbia.
Employees: 147 permanent employees, 3 fixed-term employees and around 140 seasonal workers.
Capacities: The daily capacity of sugar beet processing is around 6,000 t, which gives around 900 t of sugar daily. The annual capacity of processing is around 600,000 t of processed sugar beet, which represents 15 % of the annual sugar beet production. Planned maximum annual capacities:

- 80,000 t of sugar
  - 22,000 t of molasses
  - 23,000 t of dry pulp pellets.

Production Centre Kovačica was founded in 1976.
Employees: 128 permanent employees, 13 fixed-term employees and around 120 seasonal workers.
Capacities: After the privatisation of the factory in 2002, the daily sugar beet processing capacity jumped from the former 4,000 t to the current 7,000 t. The annual capacity of sugar beet processing is 700,000 t, which represents 17.5 % of the annual sugar beet production, whereas the daily production of sugar is 1,000 t.

The Sugar Factory "Crvenka" was founded in 1912.
Employees: about 218 workers
Capacities: Its optimum slicing capacity is 6,500t of sugar beet per day and 1,000 t of sugar per day, as well as 350 t of dried briquetted sugar beet pulp and 250 t of molasses. Dried briquetted are used as animal food. The molasses is used for production of additional quantities of sugar and as a component for animal food. Today, the factory is in the process of ownership transformation in order to form a stock company again. The development of the Sugar Factory, above all, implied the expansion of its capacity. The annual processing capacity is around 780,000 t of processed sugar beet, which is 19.5 % of the annual sugar beet production.

The Sugar Factory "Šajkaška" was founded in 1976 and it started operation in 1979. Since the company's establishing until the year 2006, the factory has had 28 sugar beet campaigns and processed in total 7,015,000 t of sugar beet.
Employees: 178 permanent workers out of which 17 with a high professional education and 4 with a higher professional education. During the campaign period, 140 seasonal workers are additionally employed.

Capacities: 5,500t of sugar beet/day. The annual processing capacity is around 660,000 t of processed sugar beet, which is 16.5 % of the annual sugar beet production.

2.1.5 Distinctive facilities of the sector

Sugar producing facilities are located mainly in the North part of Serbia, in Vojvodina. The total capacity is higher than needed. Average efficiency of Serbian factories is now close to that of the EU as a whole, and greater than that of the other industries in the region. Additionally, the factories owned by Sunoco transport beets over relatively short distances which reduce the cost of production compared to other factories (the Crvenka factory has the shortest hauling distances and the Senta factory the longest. See for further information http://www.sunoko.rs/en/production-centers/).

There is a huge difference in the cost of fuel between the factories that burn coal (all of which are owned by Sunoko) and those that use gas. Till now, sugar industry didn't express any attempt for biomass processing or to make development in that direction (e.g. biogas production). For development in that direction, detailed analysis of existing equipment will be necessary, as well as, the discussion with private owners about their interest to make additional investment. Based on previous experience with private owners of sugar industry and based on information obtained on different workshops and business contacts with the owners, they have the interest to raise the

quality of process production but they need to know the experience of best practice and all economic aspects.

Technical aspects which could be assessed are: type of biomass which could be used in sugar industry, different characteristics of biomass compared to the sugar beet, availability of biomass and distance from collection point to the IBLC or from IBLC to the final user, possibilities for biomass storage according to certain rules to protect the collected biomass from degradation.

2.1.6 Degree of innovation

There is no exact data and information related to the innovation in the Serbian sugar industry. In the last few years, a lot of efforts and improvements were made in energy efficiency. The energy efficiency measures included:

- innovation in evaporators (new falling film evaporators) as a result of which the energy consumption in the Šajkaška sugar factory was reduced by about 20 %;
- certain changes in the steam distribution (insulation of steam distribution lines, valve changes and installation of new instrumentation and control equipment);
- elimination of mechanical problems during the campaign thanks to the newly installed equipment (Pecinci sugar factory). Thus, it can be expected that in the next campaign the energy demand for sugar production will be lower since there will be not discontinuity in the process when all parts of the equipment work properly.

The major problem in sugar industry is coal which is used as main fuel in the process. Actually gas could also be used, but due to the high prices of gas the owners decided to switch to coal. This has led to high environmental problems especially due to the different, mainly imported, coals. It could be expected that due to the environmental legislation, the factories will have to consider to switch to fuels that have less negative environmental impact.

2.1.7 Miscellaneous

Due to the problem mentioned in the previous chapter there is a significant potential for biomass utilization in the sector. For one sugar production generates various biomass by-products which can be used.

Comparable economic and environmental assessment using Life Cycle Assessment method was carried out for raw sugar juice production. In some studies, the advanced raw sugar juice purification procedure, formed as a combination of several purification techniques were examined. Results indicate that modifications contributed to significant decrease in limestone, coke and natural gas consumption which lead to reduced production costs, carbon footprint and cumulative energy demand of raw sugar juice purification. Benefits due to modifications are more pronounced in the years of better sugar beet quality expressed in terms of quotient of purity.

2.2 Opportunities IBLC

2.2.1 Sector related residues

The overview carried out for sugar sector includes also data collection related to biomass residues – quantities and possibilities for utilization. According to the overview of data available, only for Factory "CRVENKA" accurate and updated data is available. This data could be used to estimate of residues in all other factories due to similar equipment and production process. The data for "CRVENKA" factory is presented below.

Sugar Factory "CRVENKA" has the following products:

- Dried shredded sugar beet, pulp pelleted 12x0,8 mm (about 0.38 per one tonne of sugar);
- High-quality molasses (about 0.28 per one tonne of sugar).

Similar quantities are produced in all other sugar factories in Serbia.

It is important to emphasise that MK Group made the first plant for the production of sugar from molasses in Serbia in 2014 in "Sunoko" in Pećinci. MK Group had decided to invest EUR 20 million in the new plant. "Sunoko" currently producing about 80,000 t of molasses this year in its factories, in Vrbas, Pećinci and Kovačica, and it has started to process the molasses in a new plant in Pećinci. This facility is able to use of 80 % of the sugar from molasses that occurs after sugar beet processing [Crvenka, 2018].

2.2.2 Potential synergies & benefits

In Serbia, there is the opportunity for bioethanol production as by-product. Different studies were developed in the last ten years with the intention to develop the scenarios for bioethanol production [CEI, 2012]. In those study, the molasses as a by-product of sugar production is identified, especially as bioethanol among other possibilities that could be used as component for mixing in gasoline. According to the previous reference, the available bioethanol production is 230-310 l /t of molasses.

The utilization of sugar production residues (dried shredded sugar beet) could be also very interesting, as it will improve environmental situation due to reduction of call utilization as main fuel in sugar industry.

2.2.3 Market developments

Today there are seven sugar factories in the Republic of Serbia, whose processing capacity, based on average 100 days of processing, is more than 4 million tonnes. In 2012 the processing capacities of factories that were in operation operated with 65 % capacity (approximately 2.6 million tonne per year of sugar production), but with the trend for rise of sugar production and possibilities for export in the region.

2.2.4 Non-technical barriers

One of the main barriers lies in the fact that three sugar producers operate in this market certainly opens the issue of monopolies.

The abolition of the sugar production quota in the European Union will also affect sugar beet producers in Serbia (sugar quota for Serbia was 181,000 t). According to experts, the abolition will also affect the cultivation of sugar beet in our country. While it is still early for forecasts, some of them believe that solutions could be further stimulation of beet growers through the payment of incentives based on quality. The situation is very delicate and some farmers who for decades have grown sugar beets will not do it in future (in the next 5 years).

Additionally, Serbia has foreign trade arrangement with Russia in the field of agricultural food products, but the protocol that was signed excludes sugar beets. Sugar beets are burdened with a customs duty of USD 300 per tonne, which makes sugar non-competitive on the Russian market.

According to Serbian Chamber of Commerce, the importance of the problem must be taken seriously as the largest part (76 %) was exported to the EU, while the rest went to CEFTA countries, especially due to fact that sugar industry in Serbia is very modern and competitive. Real problems for domestic producers will begin when EU countries that have imported a lot of our sugar stop doing so.

The unresolved relationship and the poor leasing of state land are also the barriers - the issuing of a land for period of one year is too short for achievement of the desired yields and complying with crop rotation. In such conditions, the diseases can easily occur and the soil can be poisoned with residual herbicides and chemicals which for crops such as sugar beet could have an influence on yield and quality. By comparison, the strongest sugar producer in Europe, France has 16 t of sucrose per hectare, 9.1 t are produced in Serbia, and the average in the EU is 11 t.

3 WINE SECTOR

3.1 Profile of the wine sector

3.1.1 Production

The production of wine in Republic of Serbia has a long history, but in recent years it has been raised to a higher level. Wine production consists of a set of operations that make the grapes transform into wine. Harvesting, destemming and crushing of the grapes are the first stage in the production of wine, while in the second stage it is processed and stabilized, i.e. it is suitable for consumption or for storage. The largest volumes are produced as dry wines, in which all sugar is transformed into ethyl alcohol and other (secondary) products. These include white, rosé and red wines of various types and quality. Smaller volumes are produced as semi-sweet wine, in which a certain amount of sugar remains, in addition to the usual amount of ethyl alcohol. Typical schematic process of production of white and red wine is presented on the following Figure 5.

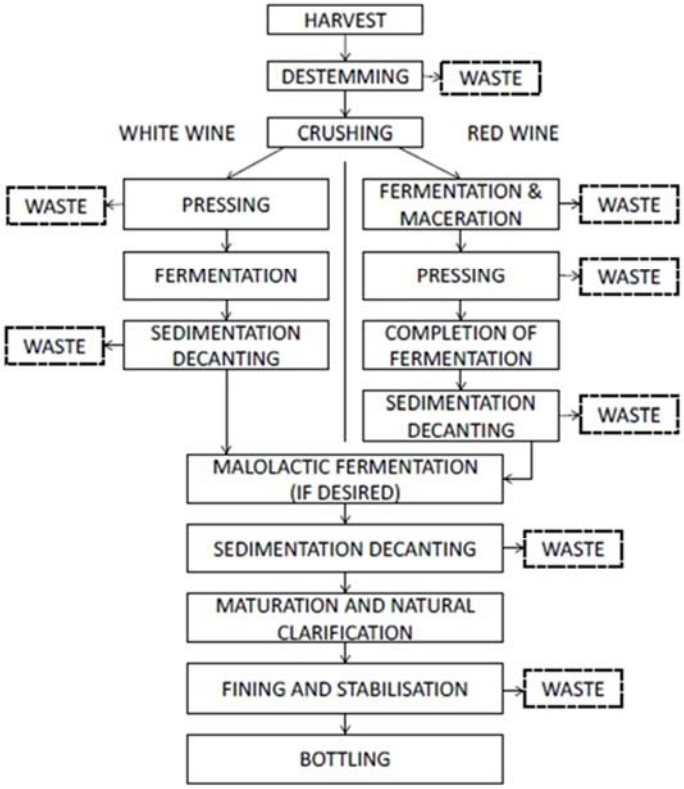

Figure 5. Typical wine production process. Source: Jaksic et al., 2015.

According to presented Figure for usual wine production process, the waste produced are seeds and skin of the grape from the pressing process and waste sludge from sedimentation, fermentation, finning and stabilisation process.

3.1.2 Volume of the sector

According to the collected data from the 2012 Census, wine-growing in Serbia concerned a total area of 22,150 ha (Table 3). It is assumed that today in the entire territory of the Republic of Serbia around 25,000 ha are cultivated with grapevines.

Table 4. Wine-growing area in Serbia. Source: Jaksic et al., 2015.

Wine-growing area in Serbia			
	Area (ha)	Purpose of production	Area (ha)
Central Serbia	17,118	Grape for wine production	17,483
Vojvodina	5,032	Grape for fresh consumption	4,667
Total	22,150	Total	22,150

Regarding vineyard locations there are nine main wine regions in Serbia shown in Figure 6: Timok region (1), Nišava-South Morava region (2), West Morava region (3), Šumadija-Great Morava region (4), Pocerina region (5), Srem region (6), Banat region (7), Subotica-Horgoš region (8) and Kosovo region (9)

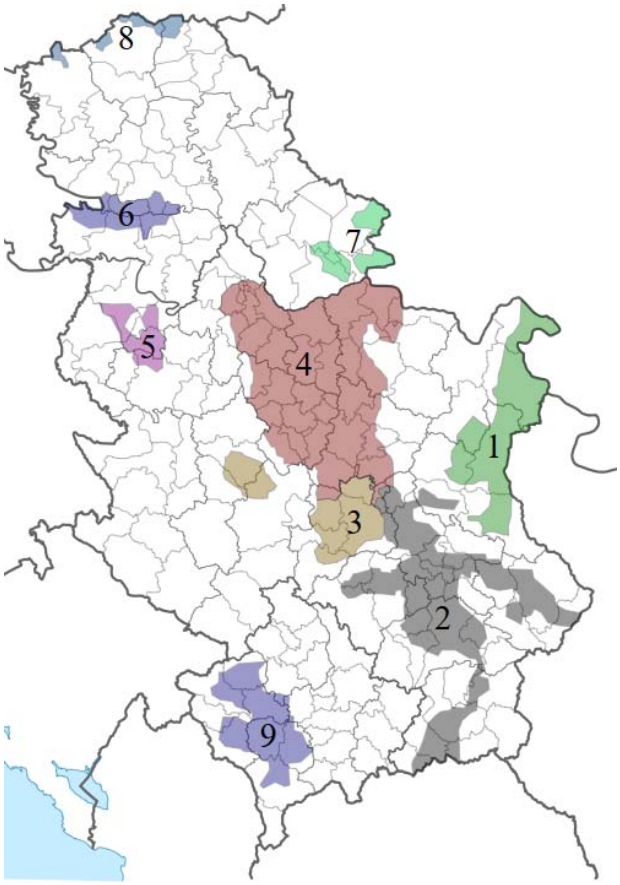

Figure 6. Wine regions of Serbia. Source: Wikimedia Commons, 2017.

Most of the vineyards are within the area of the Three Morava region which is located central and south-eastern part of the Serbia and consists of regions 2, 3 and 4 in Figure 5. At municipality level most of the vineyards are located in Trstenik, town in southern Serbia.

In the Republic of Serbia, 80,341 farms are engaged in the production of grapes, which is 12.7 % of the total number of farms. An agricultural farm that cultivates grapes has an average area of 0.28 ha under grapevine. The average area of vineyard cultivated by a farm in Central Serbia is 0.23 ha, while in Vojvodina the average size of 0.85 ha is significantly higher. Vojvodina is the first region in Serbia which become a member of the association of wine regions of Europe.

Total grape production in Serbia depends of weather conditions during the season and significant deviations can occur from year to year (Table 4).

Table 5. Total grape production in Serbia. Source: Statistical Office of the Republic of Serbia, 2017.

Total grape production in Serbia			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	24,737	193,901	7.8
2007	23,549	191,638	8.1
2008	23,187	216,478	9.3
2009	22,702	240,369	10.6
2010	22,506	171,986	7.6
2011	22,206	193,976	8.7
2012	21,201	149,217	7.0
2013	21,201	199,955	9.4
2014	21,201	122,489	5.8
2015	21,201	170,647	8.0
2016	21,201	145,829	6.9

The last decade was characterized by introduction of new technologies in grape growing and wine production with respect to use of quality and also selected and certified grape variety materials. Selection of varieties, growing of vineyards is the priority and main concern for small winemakers. The way of planting is also changed, suitable for the cultivation of grapevines in smaller, private vineyards. This period of new development is characterized by growing interest among the winegrowers for introduction of organic farming of grapes and production wine.

Grape and wine production technologies are being improved and international trends in wine production are introduced. Quality products are becoming standard but the production volume is still quite limited.

For the period from 2006 to 2016, grape production range was from 122,489 t in 2014 up to 240,369 t in 2009, on almost the same production area. These yield fluctuations are probably caused by cultivation of domestic grape varieties which are not resistant to climate changes.

Production of wine varies from year to year, depending on climatic conditions as mentioned previously. Wine production of producers registered in the Wine Register, is lower compared to official statistics, given that a certain amount of wine is produced for its own needs. Figure 7 presents

the data according the official statistics and wine production of producers registered in Wine register is slightly different as the wine producer is not obliged to be in Wine Register. It is possible to conclude that only 30 % of wine production is originated from wineries with special registration.

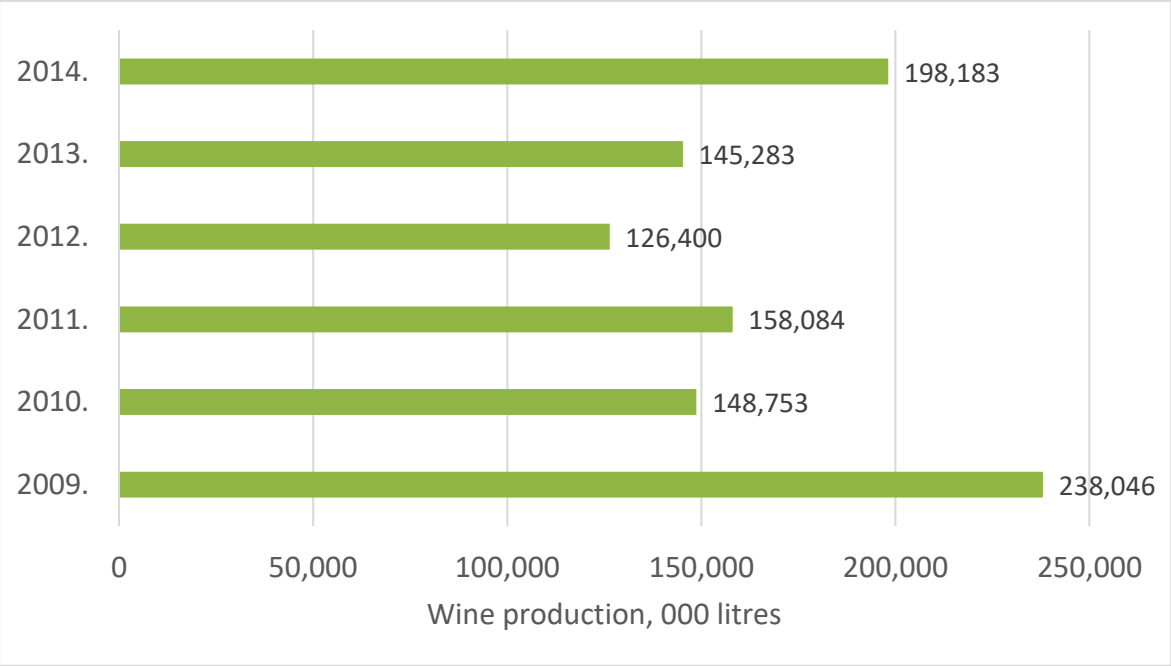

Figure 7. Wine production in Serbia in period 2009 - 2014. Source: Ivanisevic et al., 2015.

It is possible to identify four types of vineyards: 1) small family vineyards of 0.1-0.3 ha; 2) small to medium-sized vineyards that belong to wine grape growers whose focus is on grape production for the commercial wineries—some organized in a cooperative, a few contract growers; 3) modern small-medium vineyards that belong to the wine-makers (integrated firms); and 4) largely older large vineyards of up to 1,400 ha that belong to the industrial wineries. There are an estimated 70,000 farmers with vineyards across these four types. The number of commercial grape vineyards in Serbia is not known, but can very roughly be estimated at being between 6,000 and 24,000.

Based on the data from the Wine Register (January 1, 2014), the number of employees in wineries in Serbia is 3,415 out of which the number of permanent employees is 1,956, and temporary employed persons is 1,459.

3.1.3 State of the sector

In the past few years, the expansion of high-quality wine varieties has started to intensify. The changes in the structure of the assortment were influenced by the adoption in 2005 of the Law on Planting Material, as a result of which the introduction and registration of new varieties and clones was made easier. In addition, subsidies from the Serbian Ministry of Agriculture for raising new vineyard plantations and other positive measures stimulated production. The development of small private wineries and tendency of their founders to produce quality wines also had an impact on positive changes in the grapevine assortment.

In Serbia with production of wines placed on the market, according to the number of producers enrolled in the Wine Register[3] (January 1, 2015), 235 producers are dealing who are exclusively market oriented [Statistical Office of the Republic of Serbia, 2017]. Participation of Serbia in the total world production of wine increased from 0.46 % to 0.80 % from 2006 to 2013. Serbia achieved the largest share in 2010 (0.90 %). In the reporting period, Serbia has recorded a growth of wine production at an average annual rate of 8.63 %.

Table 6. Wine consumption, export and import in Serbia. Source: Statistical Office of the Republic of Serbia, 2017.

Total wine export, import and consumption 2009-2014[4]			
Year	Export (l)	Import (l)	Consumption (l)
2009	10,386,682	21,685,227	27,564,572
2010	10,761,438	29,225,156	24,858,797
2011	15,314,742	32,867,671	23,591,440
2012	22,791,051	33,069,041	22,830,426
2013	11,477,712	23,492,456	18,246,913
2014	11,941,522	31,733,782	NA

Based on the presented data, it can be concluded that the import of wine is two times higher than the export. The largest part of both exports and imports is from the CEFTA countries, while the respective share of EU countries is about 10 % for imports and 5-10 % for exports. Wine consumption is yearly decreasing, so in 2013 it was 30 % lower than in 2009 referring to data presented in Table 6.

3.1.4 Typical size of the companies

According to the data from the Wine Register (January 1, 2015), the number of large winery in Serbia with more than 250 employees is small, i.e. only two wineries, and in a group of wineries with 50 to 250 employees is an only one winery, although measured by their share in the total volume of produced wine they have a large share in production. In Serbia there are 23 medium wineries, with 10 to 49 employees. Small wineries, with less than 10 employees, make up for the largest group of wine producers in Serbia (191).

There are three types of wineries in Serbia:

- Industrial/corporate producers (Vršac vineyards with about 1,700 hectares of plantation, Navip from Belgrade and Rubin from Krusevac have about 700-800 hectares of vineyards) - operate on a large scale with large vineyards, processing facilities, and storage rooms - these

[3] Wine Register is a database held by the Serbian Ministry of Agriculture of wine producers, wineries, and other data in accordance with Serbian Law on Wine [Official Gazette of the Republic of Serbia, 2009].

[4] The data in Table 6 present the volumes of the wine producers that are registered in the Wine Register. Because wine producers in Serbia are not obligated register themselves in the Wine Register and not all producers have been inclined to do this, these data do not represent the entire Serbian, whereas the data in Figure 6 do present the total amount of wine produced in Serbia.

are the privatized former state enterprises, which were focused on quantity and price only. Quality was low. Most of these processors are still struggling with this inheritance, suffering from bureaucratic management, operational inefficiencies, and quality issues. Modern technologies and marketing strategies are largely absent. These wineries also produce about 8 million litres per year of cognac distillate.

- Medium-sized wineries that produce wines in the high-end and premium segments - all of them are family managed, but with some hired employees. There is some heterogeneity in this group. Their intentions are to grow to around 500,000 litres per year and then stay at this level, which they consider as the limit of a winery managed as a family business. Rather than increase scale, they would focus on increasing quality. This group probably has the potential to grow from the current 3 million litres to about 5 million litres over the next five years. Although they currently only represent less than 10 percent of the market in volume terms, they represent an estimated 20 percent of the market in value terms.
- Third are small wineries, each producing a volume of 10,000 to 80,000 litre per year. Their combined output is estimated at around 1 million litres annually. These wineries are 100 percent family run (no hired employees), quality focused, and just getting into commercial production and sales. A significant part of their production is of a slightly lower quality wine sold in bulk from the winery to customers in the region.

It is very difficult to make a strict classification of wineries according to their size. In some cases, the production capacity of wineries isn't the key parameter for classification. The other important parameters are the quality of wine number of full time employs and the type of selling and distribution. For example, the medium wineries should be presented in average production capacity of 30,000, maybe even 20,000 litres per year. Some of the best-quality wineries (for example Janko, Jeremic, Despotika, Jovic, Vindulo, Belo Brdo) are in the production of about 50,000 litres per year. They have full-time employees, do not sell in bulk, they are recognized for the quality and not quantity, although they fit into the description for the medium size and should not be associate in the group of small producers.

3.1.5 Distinctive facilities of the sector

Viticulture zoning divides the territory of Serbia into three wine growing units which comprise 22 regions, 77 wine growing districts and a large number of wine growing oases. Domestic market has developed in last ten years, especially regarding the number of private wineries. A lot of investment was made in winery sector, especially in growing new areas under the grape, as well as, in new capacities for wine production.

Development of wine production will be also followed with development in distilleries development which could represent an opportunity for IBLC implementation. This opportunity will be interesting especially for medium-sized wineries due to the interest they have showed for modernization and application of good and modern practices.

IBLC could be the part of modernization process of industrial/corporate producers, as they started with some activities in planning and realization of modernization. One of them is RUBIN, a company founded in 1955 and privatized in 2005. With the new owner, Rubin has gone even further with the

trend of developing new products and investing in the improvement of the production process, all in order to improve the quality of their wines. According to the information obtained directly from Rubin, in addition to viticulture, numerous investments have been made that have contributed to a significant improvement in the technological process of wine and strong alcoholic drinks production: as for example a new line for cold - aseptic filling of wines, for which a new pneumatic presses was installed and many other investments that have greatly contributed to the improvement of the production process and improving the quality of the wine.

3.1.6 Degree of innovation

Over the last few years, there was a significant progress in improving technologies for viticulture and oenology and in improving wine quality and production of wine with geographical indication. This is proved by the fact that the export of qualitative wine with geographical indications has risen recently.

A large number of measures have to be taken at different levels in order for Serbian viticulture to be renewed and intensified. Although subsidies given for viticulture and oenology are among the largest subsidies in the region, the government should continue providing support for new vineyard establishment, clone selection and certification as well as for the introduction of new modern technology. The producers have to change their habits; they have to cooperate (especially because of the label for geographical indications) and broaden knowledge and improve technologies. National scientific and research work has to be supported and developed.

Official data about degree of innovation are not available, especially related to biomass utilization. Comparing to all other innovation in this sector, the knowledge about the innovation related to biomass is very limited. It could be expected that with the interest for biomass will increase due to interest of make much more efforts in the area of sustainable wine production.

RUBN performed all developing activities in continuity of an idea of developing process and all that resulted in improved technology and quality of RUBIN'S products. Some attempts in biomass utilisation for energy purposes are made at RUBIN. Biomass collection (pruned branches) is organized and it is used in boilers installed within the factory. The opportunity for biomass utilisation is based on large vineyards and large quantity of biomass residue.

3.1.7 Miscellaneous

Serbia has very favourable climatic and soil conditions for grape growing, but wine sector could be much more developed. The main limiting factors for grape production in Serbia are very old plants, which should be renewed and for this a significant investment is needed. It is estimated that more than half of the vineyards are older than 30 years [Milić et al., 2016]. Another reason for the decline is that family farms are bearers of wine production, while big agricultural enterprises are significantly smaller manufacturers. Small plots prevent the use of productive machines and performing the necessary agro technical measures.

3.2 Opportunities IBLC

3.2.1 Sector related residues

According to the investigation related to biomass potential in Serbia, the pruning of vine yields is from 4 up to 8 t/ha of vineyard. This data is important because of the significant area covered with vineyards - about 22,000 ha in Serbia. Based on this data the total biomass residues from grape growing could be estimated at about 170,000 t/year, with average heating value of 12 MJ/kg the energy potential of biomass residues from grape is about 50,000 toe[5]. The energy potential of vine pruning residues alone is about 55,000 toe.

According to information obtained directly from producers, there are no specific data related to the amount of waste after the production of wines (stems, grapes and seeds). After conversation with several respondents (winemakers), average data were provided related to percentages depending on the grape variety and the way of processing. In the production of quality red wines, the amount of waste biomass is 30-40 % of the total weight and in white and rosé wines 40-45 %. Unfortunately, these data are not official but used by wine producers at the stage of production and storage planning of both products and waste biomass, which is unfortunately unused. Collecting the most recent data from the agricultural register and other services related to this topic is in progress. Collected data will include both in the production of wines and in other agricultural production in the municipality of Aleksandrovac and the possibilities of their use.

Regarding economic cost-effectiveness of biomass utilization, IBLC can only be interesting for the largest wineries (where besides large wineries from the first category it will be added from the other Kovačević, Aleksandrović and Radovanović, possibly also the Toplič vineyards). The collected stocks have small bulk density and the costs of transport in a freshly collected state for the purpose of joint processing of the producer group at one location would be astronomical (for example, the collected cropped holders from 4 lines, which is about 300 plants, will add 1m^3, corresponding to a total mass of only 30 kg). The only solution seems to be to collect and utilize onsite. However, due to the cost of the equipment, only big facilities could be eligible. Remnants of fermentation (pulp, flakes) contain a high moisture content and with heterogeneous quality and high quantity of energy is necessary for drying comparing with the energy that could be produced.

In the wineries, there is no need for heating, except for hot water. On the contrary, there is a need for cooling. Therefore, any briquette from the residues could only be a produced for the market.

[5] Tonne(s) of oil equivalent, abbreviated as 'toe', is a normalized unit of energy. By convention it is equivalent to the approximate amount of energy that can be extracted from one tonne of crude oil. It is a standardized unit, assigned a net calorific value of 41 868 kilojoules/kg and may be used to compare the energy from different sources [EUROSTAT, 2018]

3.2.2 Potential synergies & benefits

Biomass residues obtained from grape grown and wine production are heterogeneous and composed of stalks, grape skins and seeds. In previous year, some initial investigations have been done related to the physical-chemical characteristics of each single component of grape residue and influence of grape marc on examined characteristics. The intention of this characteristics was to investigate the possibility of an energy and industrial utilization. In addition, a mechanical extraction test on the seed was performed to evaluate the oil production from grape seed and the characteristics of the cake. Results on grape marc components put in evidence some difference in terms of ash and chemical elements content, which represent, specifically for these materials, the most critical aspects to take into account in combustion heating systems.

The interest for IBLC in wine sector exists. The main reasons for relatively low biomass utilisation lie in lack of adequate equipment for biomass collection and relatively small vineyards area. There are some idea and attempts for biomass collection and joint procurement of the necessary equipment by several small producers. Small wine producers insist in the organization in alliances, which will be responsible for further development, and organization for procurement and utilisation of the new equipment for different activities. In the same time, they are interested for making the connection with biomass from fruit production and its utilisation.

Wine sector should be also related with the brandy and fruit juice industry. Several producers for years have been using apricot plum and peach that they receive free of juice and brandy processors in briquettes. This is for them waste and they were earlier paid to take it away. Drying in air for one year is sufficient to be usable as a fuel without further processing.

3.2.3 Market developments

Wine sector has a lot of opportunities for further development: there are lot of potential for improved quality, lower price on the domestic market and bigger export to other markets. According to a USAID project, five important activities were identified for further market development [USAID Belgrade, 2012]:

- Foreign Direct Investment – Strategic Partnerships at the Industrial Winery Level
- Promotion – Develop Image, Consumer Knowledge of Wines, Wine Regions, and
- Indigenous Varieties
- Good Agricultural Practices at the Grape Grower Level – Expand/Build High-Quality Wine Grape Base
- Small Wineries, especially in Rural Areas – Improve Quality of Equipment, Knowledge and Market Access
- Image Building by Medium-Sized Wineries – International Competitions.

Based on detailed analysis of actual situation and Bilateral Screening of Republic of Serbia for EU accession (Negotiating Group 11 - Agriculture and Rural Development), the following activities have been identified as most important for upcoming period [BOŠ, 2014]:

- Continue the harmonization of legislation (Geographic information service certification bodies, authorisation, rulebooks, and rulebook for aromatized wine)

- Set up professional program (software) for Vineyard Register and techniques
- Set up a professional program (software) for Wine Register
- Set up a professional program (software) for Winery records
- Support wine producers to prepare studies /examination (for product specification)
- Set up Wine Balance Sheet for better statistical data collection
- Improving knowledge in viticulture and wine production, including possibilities for energy efficiency and biomass utilization
- Improvement of producer organizations
- Viticulture mezo zoning (plans for future activities: potential vineyard locations and potential organic vineyard locations) and set up centres for wine variety testing /education
- Set up laboratory system for isotopic analysis and isotopic data bank
- Continuation of support (subsides) for grape (planting new vineyards), wine plant production (certification and clonal selection) and wine production

3.2.4 Non-technical barriers

Wine production costs are high, material and labour costs have a dominant share in total costs up to 85 % [Milić et al., 2016.]. In the analysed period (2012-2014), the largest share was accounted by material costs with an average of 34 %, most of which is the usage of NPK fertilizer, costs of plant protection (herbicides, insecticides and fungicides) and then other material costs. Average cost of wages was 30 %, due to high labour requirements, especially in matters of pruning and harvesting. In addition to these, costs of services accounted for 19 % of total costs.

One of the most essential changes required in the Serbian wine value chain is the expanded use of long term contracts for wine grape supply. Mutually rewarding, legally binding contracts must be negotiated in advance between grape growers and wineries. These contracts need to take into account any regulatory requirements regarding land use and will form the basis for long-term relationship building related to high quality and fair prices for both parties. For growers, contracts help secure a market for their output, and for wineries they secure a supply of a quality wine grape product, customized to the specific needs of the winery. These contracts should indicate practices to follow (pruning, harvesting, transport, and so on), quality standards to achieve, quantity to produce, price to sell at (based in part on lab analysis, with a minimum price), payment terms to comply with, cleanliness of the product, and so on. Quality relates to yield (5-9 t/ha), pest management practices, and agreed-upon ripeness measurements. Price can be set per metric tonne or per hectare. In the latter case, the winemaker shares the risk with the grower (with a minimum cap) and risk is minimized (as is the profit potential). These contracts may be set up for a year or for multiple years. For example, contracts made with larger wineries with larger economic resources could provide or facilitate financing for planting blocks of new vineyards linked to 15-year contracts.

Horizontal linkages among grape-growers and winemaker associations are weak. Serbian wineries are very individualistic in nature and for the greater part do not have the financial resources to contribute to a joint industry promotion fund.

There is a problem with plant disease (vine yellows), and plant protection and inspection are ineffective. Irrigation is largely absent in vineyards and methods for vineyards management, including fertilization, are outdated. The necessary mechanization for efficient, high-quality grape

growing is missing or obsolete in most cases. In addition, the cost of establishing a vineyard in Serbia is high. In combination with a higher labour cost, the above factors negatively influence the competitiveness of Serbian producers in relation to their counterparts in the region.

Equipment for harvesting and collection is outdated and there are no resources to upgrade equipment and to improve winery operation and its efficiency. Adoption of modern techniques, technologies, and equipment is rare. There is no recovery of value from winery wastes, nor is there a waste management system in place in most of the wineries.

4 VEGETABLE OIL EXTRACTION

4.1 Profile of the vegetable oil extraction sector

4.1.1 Production

The most important plants that are cultivated in Serbia for vegetable oil extraction process are rapeseed, sunflower and soybean. The vegetable oil extraction process (Figure 8) comprises three parts:

- Preparation of oil crop grain (cleaning, drying, storing)
- Separation of oil from the grain (peeling, hulling and pressing of the grain, extraction, water degumming of the raw oil)
- Refining of the oil.

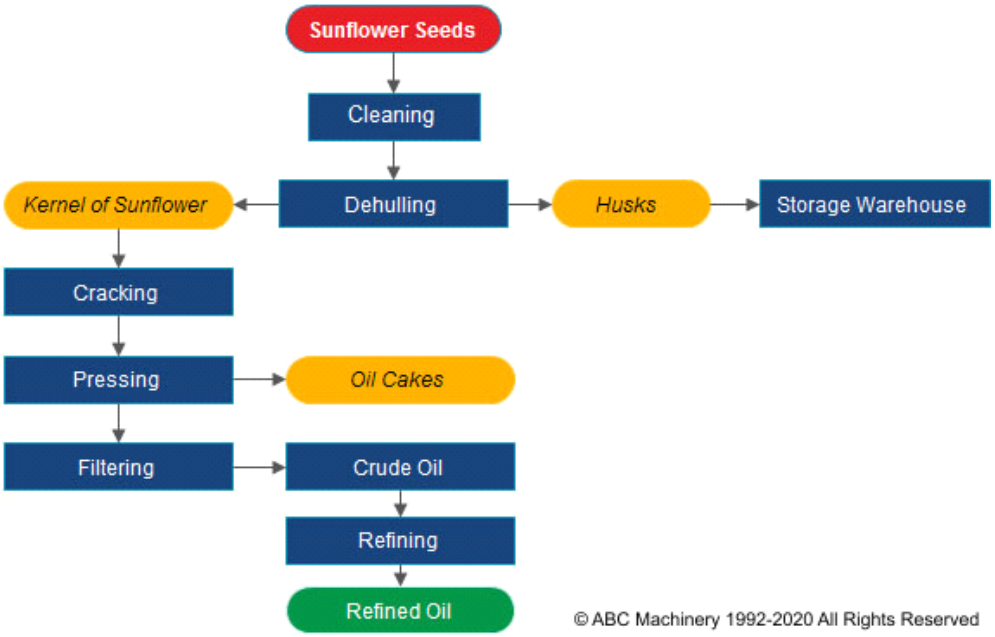

Figure 8. The vegetable extraction oil process. Source: http://www.abcmach.com/, 2018.

Further refining process consider following techno-chemical treatment:

- Degumming – removal of phosphatides, waxes and soaps
- Bleaching – removal of pigments, metal ions and remaining soap and peroxides,
- Winterisation –removing residual waxes if they come through the bleaching phase
- Deodorisation – removal of undesirable smells and tastes, as well as most FFAs (free fatty acids) from the oil, though a vacuum distillation procedure with the addition of direct water steam.

The oil content of the dry rapeseed grain is 40-47 %, and the protein content is 19-29 %. In the rapeseed grain there are also harmful substances: glucosinolates, eruca fatty acid, phytins and tannin which are not used as by-products.

4.1.2 Volume of the sector

The vegetable oi extraction sector is well developed in Serbia and accounts big tradition. Different feedstocks are used for oil extraction: rape, sunflower and soya. This sector is known as a sector with modern equipment and high quality products.

Rapeseed

In Serbia, rapeseed production has been marginally grown, covering not more than 0.7 % of total arable land during previous decades. In 2007, the growth of rapeseed production was caused by opening a biodiesel plant in Šid (Victoria Oil). According to the last Census of Agriculture 2012, the rapeseed is produced only by 319 farms (Statistical Office of the Republic Serbia, 2012).

The yield of rapeseed improved significantly in recent years, thanks to new hybrids with yields of 5-7 t/ha. The agro ecological conditions of some years can affect the yield, especially drought in the sowing period (as happened in 2011). The poor organization during the sowing period of rapeseed, as well as the uncertainty regarding yields and revenues, contributed to the fact that this culture in Serbia has not yet significantly increased.

Table 7. Total rapeseed production in Serbia. Source: Statistical Office of the Republic of Serbia, 2017.

Total rapeseed production 2006-2016				
Year	Production area (ha)	Production (t)	Yield (t/ha)	Export (t)*
2006	3,873	7,595	2.0	NA
2007	12,943	29,825	2.3	NA
2008	17,996	51,907	2.9	NA
2009	18,091	44,300	2.4	NA
2010	12,012	24,399	2.0	NA
2011	15,357	44,531	2.9	NA
2012	8,258	20,076	2.4	NA
2013	9,686	26,992	2.8	NA
2014	9,815	31,419	3.2	NA
2015	12,226	33,402	2.7	NA
2016	13,476	39,404	2.9	NA

*Data are not available

Sunflower

In Serbia, over 150,000 ha are sowed with sunflower, equalling about 5 % of arable land. According to Census of Agriculture 2012 – Agriculture in the Republic of Serbia, the major part of this areal (94 %) is in Vojvodina. Sunflower crop is mainly grown on agricultural farms (74 %). According to Census of Agriculture, sunflower was produced on 28,307 farms, of which 28,046 are family farms and 261 are legal entities. Farms which produce sunflower are predominantly located in Vojvodina (23,893). The majority of sunflower producers are farms with size of 5-10 ha. The largest area (35.54 % covered

with sunflower) is cultivated by 980 agricultural holdings which constitute only 3.46 % of the total number of agricultural holdings producing sunflower. In sunflower production, Serbia is on the tenth place in Europe, and per yield per hectare seventh in the world.

Table 8. Total sunflower production and export in Serbia. Source: Statistical Office of the Republic of Serbia, 2017.

Total sunflower production and export 2006-2016				
Year	Production area (ha)	Production (t)	Yield (t/ha)	Export (t)
2006	186,431	384,945	2.1	6,000
2007	154,793	294,502	1.9	18,000
2008	187,822	454,282	2.4	10,000
2009	157,337	377,549	2.4	2,000
2010	169,384	378,409	2.2	16,000
2011	174,270	432,020	2.5	17,000
2012	185,918	366,020	2.0	52,000
2013	188,189	512,839	2.7	103,000
2014	175,366	509,250	2.9	76,000
2015	166,192	437,084	2.6	133,000
2016	200,299	621,127	3.1	124,000

The production in 2016 was about 621,127 t, i.e. 3.1 t/ha, which is above the annual average (around 2 t/ha). Of this amount of sunflower seeds 283,000 t up to 319,000 t of oil should be produced depending of oil content in the seed, given that the annual demand of Serbia is about 80,000 t. Total capacity of sunflower oil production is 788,000 t/year or soya oil production – 625,000 t/year or rape oil production – 530,000 t/year. The largest sunflower processing and oil production capacities are: "Vital" Vrbas (22 %), "Dijamant" Zrenjanin (27 %), "Victoria oil" Šid (23 %), "Sunce" Sombor (15 %), and "Banat" Nova Crnja (13 %). In 2016, total domestic oil consumption for food was 82,000 t and 117,000 t were exported to the other markets.

Soybean

The average area in Serbia sown for soybean production is 160,000-180,000 ha, with the tendency of constant growth. Soybean cultivation is becoming more and more profitable, and in Serbia part of the sunflower cultivation is already substituted by soybean. The average yields range from about 2.5 to 3.5 t/ha, which is higher than the world average. This soybean is mostly sown in Vojvodina. According to Census of Agriculture, the soybean was produced on 35,246 farms, of which 34,934 were family farms and 312 are legal entities. The largest area covered with soybean (52 %) is cultivated by the farms with size 50 and more hectares.

Table 9. Total soybean production and export in Serbia. Source: Statistical Office of the Republic of Serbia, 2017.

Total soybean production and export 2006-2016				
Year	Production area (ha)	Production (t)	Yield (t/ha)	Export (t)
2006	156,680	429,639	2.7	2,000
2007	146,988	303,950	2.1	1,000
2008	143,684	350,946	2.4	2,000
2009	144,386	349,193	2.4	5,000
2010	170,255	540,859	3.2	83,000
2011	165,253	440,847	2.7	18,000
2012	162,714	280,638	1.7	25,000
2013	159,724	385,214	2.4	23,000
2014	154,249	545,898	3.5	95,000
2015	184,841	454,431	2.5	57,000
2016	182,362	576,446	3.2	95,000

The processing plant “Sojaprotein” in Bečej is the only soybean processing plant in the Balkans. This company is part of the "Victoria Group", one of the largest and most modern vegetable oil processing industries in Europe. “Sojaprotein” is the largest contractor for soybean production in Serbia, followed by “Diamond”, “Invej” and a number of other processors. Serbia is one of the main producers of oil from soybeans in Europe. From the total soybean production of 576,000 t in 2016 50,000t were exported. All produced soya concentrate for feed and fodder production is placed on the world market.

The main vegetable oil extraction facilities in Serbia presented on Figure 9 are:

- Victoria Oil as a part of Victoria Group, located in Šid (1)
- Company Dijamant AD, located in Zrenjanin (2)
- Vital AD, located in Vrbas (3)
- Sunce AD, located in Sombor (4)
- Sojaprotein as a part of Victoria Group, located in Bečej (5)
- Banat AD, located in Nova Crnjaj (6)

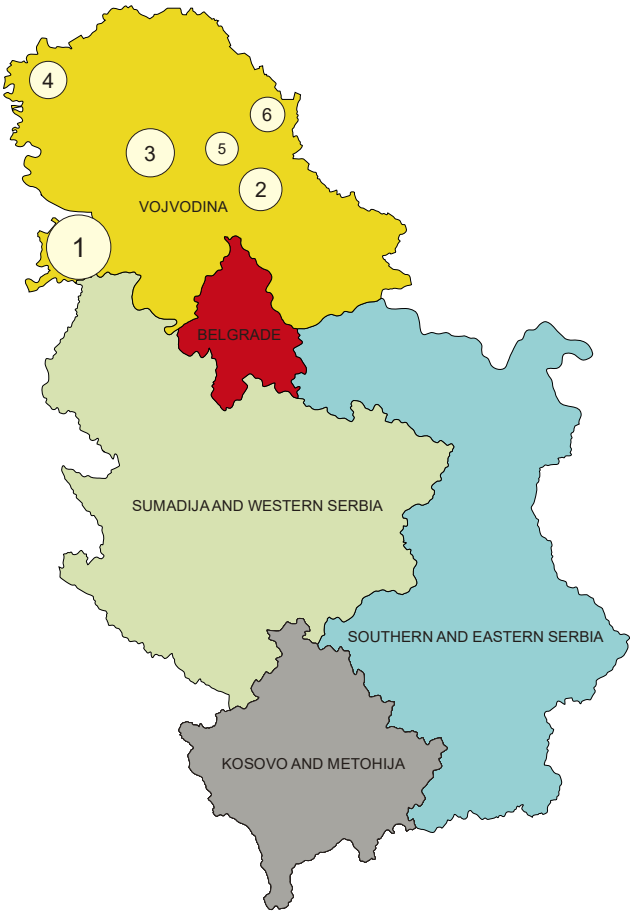

Figure 9. Main vegetable oil extraction production facilities in Serbia. Source: Hickingbottom & Jackson, 2013.

4.1.3 State of the sector

As one of the largest oil producers the Republic of Serbia is also the country with the largest processing capacities in the CEFTA[6] area. The Serbia's vegetable oil extraction industry has a capacity for the annual processing of 885,600 t of sunflower seeds, 482,000 t of soybeans and 247,000 t of rapeseed. However, in the Republic of Serbia the average processing level of sunflower processing in the past ten years was only 40 % of the available capacities, and of soybean at 70 %. The quality of the raw material and the prospective market (primarily in the soybean processing sector) open up the capacity for more efficient use of capacities. Oil consumption is presented in Tables 10 and 11. Consumption of sunflower oil for food use is practically constant and has not changed over the years and participates with about 40-45 % (average 46 %) in total consumption with minor changes resulting from changes in total oil consumption. Export of sunflower oil in the last 10 years has grown and from 25 % of total sunflower oil consumption it reached the value of more than 50 % (average 41 %). A completely different picture is with the soybean oil consumption. Soybean oil is dominantly

[6] CEFTA - Central European Free Trade Agreement, As from 1 July 2013 the parties in the CEFTA agreement are: Albania, Bosnia and Herzegovina, Macedonia, Moldova, Montenegro, Serbia and Kosovo (as UNMIK)

exported (average 52 %) and a smaller part is used at national level for food preparation (average 33 %).

Table 10. Sunflower oil consumption in Serbia 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total sunflower oil consumption in Serbia 2006-2016					
Year	Food use (t)	Other use (t)	Export (t/ha)	Closing stocks (t)	Total consumption (t)
2006	82,000	31,000	45,000	19,000	177,000
2007	82,000	7,000	48,000	5,000	142,000
2008	82,000	7,000	48,000	11,000	148,000
2009	82,000	9,000	83,000	15,000	189,000
2010	76,000	8,000	59,000	15,000	158,000
2011	76,000	8,000	80,000	23,000	187,000
2012	76,000	6,000	93,000	1,000	176,000
2013	76,000	6,000	86,000	3,000	171,000
2014	76,000	6,000	64,000	33,000	179,000
2015	76,000	6,000	64,000	21,000	167,000
2016	76,000	6,000	117,000	8,000	207,000

Table 11. Soybean oil consumption in Serbia 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total soybean oil consumption in Serbia 2006-2016					
Year	Food use (t)	Other use (t)	Export (t/ha)	Closing stocks (t)	Total consumption (t)
2006	48,000	1,000	21,000	10,000	80,000
2007	17,000	1,000	41,000	1,000	60,000
2008	41,000	1,000	28,000	7,000	77,000
2009	22,000	1,000	43,000	15,000	81,000
2010	24,000	1,000	45,000	10,000	80,000
2011	24,000	1,000	49,000	7,000	81,000
2012	24,000	1,000	31,000	10,000	66,000
2013	24,000	1,000	31,000	25,000	81,000
2014	24,000	1,000	59,000	18,000	102,000
2015	24,000	1,000	58,000	12,000	95,000
2016	24,000	1,000	69,000	1,000	95,000

4.1.4 Typical size of the companies

Vegetable oil extraction is manufactured in 6 factories among which Sojaprotein is part of Victoria Group and focus only in soybean processing. As the main producers of vegetable oil and their market share are presented in the previous chapter 4.1.2 and Figure 7, detailed description of the companies will be given bellow.

In this sector, the most important engagement is of the company "Victoria Group", which has contributed much to better sowing organization. By engaging agricultural engineers a number of agricultural producers have been trained, which is one of the most important requirements for accepting cropping system. Four years ago growers sowed up to 20 kg of seeds per hectare and today 2.6 kg/ha. Soil preparation was improved, seed protection from insects, and last year 99 % of surfaces did not need to be treated with pesticides. By applying scientific achievements new hybrid varieties have resulted in increased yields, so the pods do not open under the influence of rain and wind. Harvesting machinery has also been improved.

Victoriaoil's core activity is the production of unrefined and refined oils, biodiesel and protein meals. The primary activity of the company is the production of raw and refined vegetable oils, biodiesel and protein meal. Currently, the factory processes almost 220,000 t of sunflower and over 85,000 t of soybean annually, and the processing technology allows complete flexibility of the oil crop refining production process. Victoria Oil also has a cutting edge plant for bottling and packaging edible oil with a capacity of 12,500 litres per hour. In 2009, a modern filling and packaging plant for sunflower oil was launched when Victoriaoil's most famous brand – the edible oil Iskon – was first created. With a capacity of 14,000 litres per hour, the annual production exceeds 68 million bottles of edible oil. Excellent results were achieved not only in the local market, where Iskon's share is 30 %, but also in Austria, Slovakia, Slovenia, Hungary, Greece, Croatia, Bosnia and Herzegovina, Montenegro, Macedonia and Albania. Total number of employee is 305.

The company Dijamant AD is the largest producer of edible oils in Serbia. With a strong distribution network of distribution centres in Belgrade, Nis, Cacak, Vrbas and Zrenjanin the company covers the entire Serbian market as leading manufacturer of margarine, vegetable fat, mayonnaise and delicacy products based on mayonnaise. In addition, Dijamant produces also ingredients for other food industry, especially for the confectionery and bakery industry. Total number of employee is 732. The company is also an important factor in the agricultural sector, particularly in the production of oilseeds, which includes the development of partnership relations with agricultural producers, as well as the development of logistics coverage for the purpose of purchase and a modern, safe storage of the oil crops. In cooperation with more than 400 suppliers Dijamant, has been actively involved now for decades in the organization of production of sunflower and soy in Serbia. Today Dijamant is one of the largest single purchasers of oil plants in Serbia, with an average of purchased 250,000 t of raw materials annually.

Vital is one of the largest and oldest factories of oil and vegetable fats in the Balkans. After its privatization in October 2005 Vital became part of Invej Corporation and continues its role as an undoubtedly important actor. With the advancement of technology, the application of new business models and the development of a wide range of products intended for the most demanding consumer tastes, Vital has managed to meet the expectations of not only domestic but also foreign. Changing the way of life, new research in the field of human health and its direct connection with nutrition, are the basic guidelines that lead the development team of Vitala when creating new products. Total number of employee is 334.

This company's recognisable consumer brand is Iskon, which is an edible sunflower oil of the highest quality, with more than 70 million bottles produced per year. Exceptional results have not only been

achieved in the local market, in which Iskon has a share of up to 30 %, but also through exports to Austria, Slovakia, Italy, Holland, Slovenia, Hungary, Greece, Croatia, Bosnia and Herzegovina, Montenegro, Macedonia and Albania.

Processing capacity:

- 1,200 t sunflower a day
- 750 t soybean and rapeseed a day

Production capacity of the flexible refinery plant is 300 t refined oil a day.

Capacity of the filling station – edible oil bottling plant is 12,500 bottles an hour

Warehousing capacities:

- Universal silo with three kilns for storage up to 40,000 t sunflower seeds or 70,000 t soybean or 80,000 t wheat grain
- Universal storage for all types of seeds and meal with a capacity 50,000 t
- Protein meal storage with a capacity of 1,000 t
- 17,000 m^3 storage for sunflower husks

The major activity of the factory Sunce Sombor includes processing of all sorts of oleaceous plants, crude edible oil production, production of packaging for own purposes, industrial herbs drying for own purposes etc. Every year, the production program is expanding, capacities are enlarging and production technology is improving. Total number of employee is 170.

Oil factory "Banat" AD is company for the production of vegetable oils and fats, press cake and meal. In the factory are processed sunflower seed (including high olenic type seeds), soybean, rapeseed, and pumpkin seed. The product range includes sunflower edible oil known under the brand The Cvet Banata, and assortment of cold freshly squeezed oil. The Banat AD products are oils from seeds of soybean, rapeseed and sunflower seeds high olenic Olivko type, and meal with various percentages of protein. Total number of employee is 166.

4.1.5 Distinctive facilities of the sector

Vegetable oil industry is located in the North part of Serbia, in Vojvodina. The total capacity is higher than needed. Oil production industry has made significant investments in modernization and equipping, both in large and small capacities for the production of cold-pressed oil in the last ten years. As one of the largest oil producers in the region, the Republic of Serbia is also the area with the largest processing facilities in CEFTA countries.

The good example of modernization and interest for biomass utilization is Victoria Starch, the youngest member company from the Victoria Group business system, which began continuous production of agro-pellets, i.e. pellets from agricultural biomass, in mid-2013. Among others, Victoria Group started to invest in renewable energy sources, especially biomass for energy purposes (Table 12). Victoria Group is currently the only system in Serbia which can adequately respond to the aforementioned challenges, and manages large quantities of biomass thanks to its network of long-time partners, purchase of straw, and organisation of storage in the company system, the use of advantages of its own logistics structure and investing into the pelleting plant. As part of the Victoria

Group system, Victoria Logistics, with its logistics network (12 silos in its ownership, a port on the Danube, transport and handling) has all the preconditions for the efficient collection and management of biomass in the area of Vojvodina.

The company (Victoria Logistics) owns significant storage capacities – silos with a capacity of 200,000 t, while an additional 650,000 t of various types of goods are stored in external storage facilities. The total volume of transport facilitated by Victoria Logistic exceeds 2 million tonnes per year.

Table 12. Biomass utilization plants in vegetable oil extraction sector in Serbia. Source: Victoria Group, 2017.

Biomass utilization plants in vegetable oil extraction sector in Serbia			
Description	Year	Fuel	Capacity
Boiler, Victoria oil	2006	Sunflower husk	15 t/h, p=12 bar
Boiler, Sojaprotein	2009	Straw (bale and pellet) and soya husk	15 t/h, p=12 bar
Boiler, Victoria oil	2013	Sunflower husk	24 t/h, p=13 bar
Pellet production	2013	Straw	4 t/h

In two other vegetable oil factories (Dijamant, Vital and Banat) similar activities were done:

- Construction of new boilers using biomass residues from production process (sunflower husk and oil waste)
- Switching fuel from fossil to biomass (sunflower husk).

The investments in those facilities are much lower the investment made in Victoria Group System.

4.1.6 Degree of innovation

In the oil production sector, significant investments in modernization and equipping were made, both in large and small capacities for the production of cold-pressed oils.

In the past years several modifications were made and investments were done to improve the Banat oil factory's performance:

- Reconstruction of the plant's extraction section with new equipment - improvement of the quality of the meal and increased capacity with more than 20 %.
- Increasing of the pressing capacity for 43 % with the new equipment.
- A new packaging line for 1 litre PET bottles for vegetable oil with a capacity of 6,000-8,000 units per hour.
- A new water treatment plant which provides good quality water for the boiler plant.
- Construction of a wastewater treatment plant.

4.1.7 Miscellaneous

As industry with a big tradition in Serbia, the vegetable oil producers developed very good cooperation with farmers and make a lot of efforts to upgrade it. One of the examples is Victoria Logistic which has the cooperation with around 40,000 farmers through more than 300 co-operatives, insuring necessary intermediate goods and providing advisory services to partners. Through this network, Victoria Logistic organize the purchase of biomass: soy straw, wheat and corn, as well as the production and sale of biomass pellets.

Serbia has very favourable climatic and soil conditions for growing plants that are cultivated for vegetable oil extraction. The main limiting factors are cooperation needed among numerous farmers, necessity of advisory service to support them and significant financial investments.

4.2 Opportunities IBLC

4.2.1 Sector related residues

Residues from the vegetable oil extraction sector, like sunflower husk or residues from oil extraction process (oil waste), are mainly used within facilities for production energy for own use.

Vegetable oil industry in Serbia has a lot of experience with sunflower husk processing. In the previous period (some decades ago), it was used for different purposes:

- fuel (briquettes for household heating or as a fuel for industrial boilers),
- cattle food (grind grain, very low protein value - below 5 %),
- additional material for crushed sunflower seed (grind),
- mulch for cattle.

Today, sunflower husk is dominantly used as a fuel in industrial boilers which are designed and constructed for combined firing of natural gas, medium oil and/or waste liquid residues from production process of edible oil (and margarine).

As mentioned before, Victoria Logistic uses obtained residues for production of biomass pellets. The whole production of pellet is utilized in the company for energy production and not sold to the market.

Victoria Logistic is also engaged in the purchase of biomass – soybean, wheat and barley straw and cornstalks. The transformation of production residues into bio-energy not only ensures the energy independence of most of the Victoria Group factories, but also the reduction of harmful emissions.

Additionally, Victoria Group has been pre-financing primary agricultural production with average annual amounts exceeding EUR 100 million, as a form of support for farmers to try and ensure successful harvests. Thanks to its wide network of partners in the primary agriculture sector, as well as its processing capacities, the company currently purchases raw agricultural products covering 200,000 hectares across Serbia - which directly benefits approximately 100,000 people in various local communities. This successful cooperation with farmers could be good practice for other companies and different agriculture sectors. In future, development of agriculture sector is not possible without consolidating and organizing the farmers, especially in the conditions that exist in Serbia where individual farms are relatively small.

4.2.2 Potential synergies & benefits

The oil production capacity in Serbia is too dimensional and can partly be used to supply plants for the production of biodiesel by raw materials. Several studies and projects were developed with the intention to examine also the possibilities of their partially integration of production of biofuels, especially of next generation biofuels.

Good experience from Victoria Group factories could also be implemented in other companies in vegetable oil industry.

4.2.3 Market developments

The vegetable oil industry as well developed makes constant efforts for further development. They have plans and strategies for further investment in energy efficiency and biomass. With good network with farmers, vegetable oil industry annually invests significant funds through the pre-financing of primary agricultural production and gives support to farmers by providing inputs and free soil analysis.

4.2.4 Non-technical barriers

In Serbia non-technical barriers could be identified as follows:

- Biomass is mostly found in the area of Vojvodina, but its use is modest (around 2 %).
- Small farm with insufficiently high capital reserves and with relatively small capacities for operation according to modern standards. Cooperation with industrial companies and investments in organic agriculture may help it along in its efforts to modernize, in accordance with the general requirements deemed necessary for Serbia alignment with the EU CAP.
- Variability of prices, especially for farmers since they have fewer possibilities to manage risk.
- Uncertainty related to agricultural policy measures which support the production of oil crops in different ways (e.g. premium per kilogram, subsidies for crop production etc.).
- Problems related to “biomass logistics” - the collection, transport, storage, and use of biomass as an energy source in a relatively narrow radius.
- Transportation problems for biomass delivery - bad road infrastructure, bad conditions in railway sector and insufficient use of river transport.

Further sector development is depended to preferential trade agreements with EU countries, CEFTA and other countries. Trade agreement will give the possibilities for strengthen the trade flows and additional utilisation of processing capacities which exist in the country.

5 GRAIN CHAIN

5.1 Profile of the grain chain sector

5.1.1 Production

The cereal grains most frequently grown in Serbia are corn, wheat, rye and barley. The structure of agricultural production in Serbia is such that cereal grain crops are the most important. Of total arable land 63-70 % is annually sown with a combination of these crops. According to the Statistical data for 2017 data, 68 % of the land was under grain crops (Figure 10).

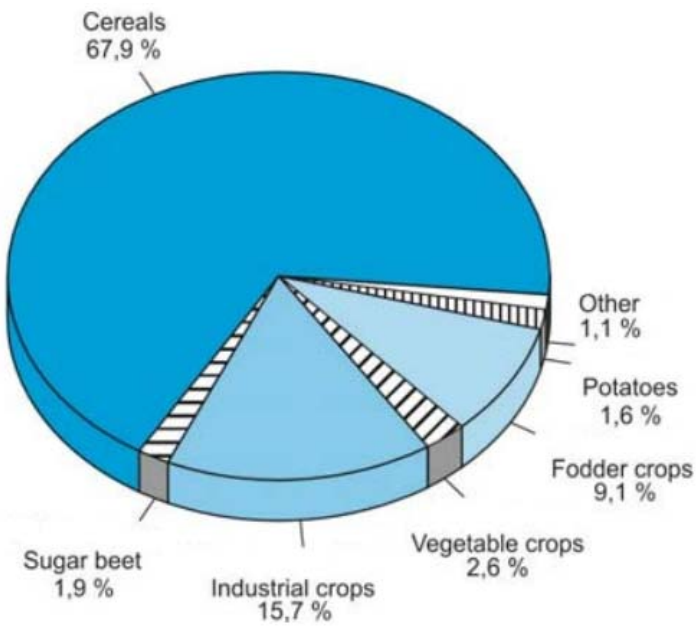

Figure 10. Seeding of agricultural land in Serbia by certain types of crops. Source: Statistical yearbook of the RS, 2017.

Typical use of cereal grain crops in Serbia is for flour production in milling/grinding process. Produced waste from these processes is usually used as a feedstock for the animal feed production. The overall grain chain is presented on the Figure 11. Additional waste which is generated from the field during the harvesting could be used for energy production or for stable flooring.

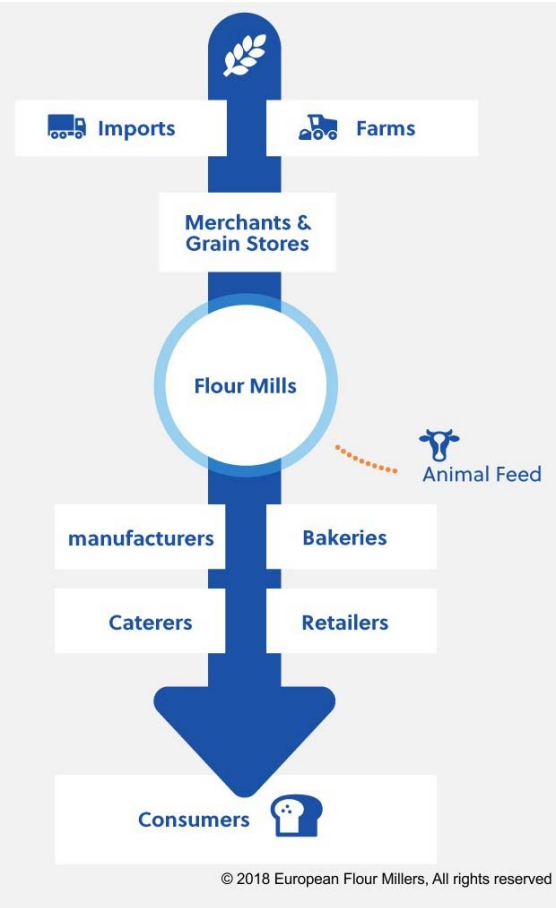

Figure 11. Typical flour production process. Source: http://www.flourmillers.eu//, 2018.

5.1.2 Volume of the sector

Corn (7,376,738 t in 2016) and wheat (595,118 t) dominate the cereal production followed by barley (91,530 t), triticale, oats (27,536 t) and rye (4,891 t). A high share is produced in the north – in Vojvodina. Yields are modest with a high volatility (Tables 13-17).

Corn represents the agricultural crop that is most represented in domestic exports, especially due to the fact that the climatic conditions in the country are especially suitable for corn. During 2011, the export of corn in Serbia was the highest foreign trade income (USD 432 million). Export of corn in Serbia was 551,000 t in 2008, 1,602,073 t in 2009 and 1,626,151 t in 2010 and as it can be seen it has a growing trend – 2,145,679 t in 2016 (USD 383 million).

In Serbia, there are two areas with several districts producing wheat and corn:

- Area of undeveloped districts (South-East Serbia) with the high rank of the land capacities characteristics but with low volume of wheat and corn production,
- Area of relatively developed districts (Vojvodina) with a high level of production volume.

Tables 13 to 19 show the volume of agricultural production in Serbia from 2006-2016 in terms of production of basic types of cereal grains and their utilization.

Table 13. Total production of wheat in Serbia (in thousands of t) in the period 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total production of wheat in Serbia 2006-2016.			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	607,123	2,367,911	3.9
2007	625,912	2,342,244	3.7
2008	612,256	2,632,091	4.3
2009	636,434	2,598,182	4.1
2010	619,403	2,085,529	3.4
2011	619,612	2,609,188	4.2
2012	603,275	2,399,225	4.0
2013	631,640	2,690,266	4.3
2014	604,748	2,387,202	3.9
2015	589,922	2,428,203	4.1
2016	595,118	2,884,537	4.8

Table 14. Total production of corn in Serbia (in thousands of t) in the period 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total production of corn in Serbia 2006-2016.			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	962,636	6,016,765	6.3
2007	992,941	3,904,825	3.9
2008	1,048,815	6,158,122	5.9
2009	994,612	6,396,262	6.4
2010	1,014,570	7,207,191	7.1
2011	1,036,859	6,479,564	6.2
2012	976,020	3,532,602	3.6
2013	980,334	5,864,419	6.0
2014	1,057,877	7,951,583	7.5
2015	1,010,227	5,454,841	5.4
2016	1,010,097	7,376,738	7.3

Table 15. Total production of barley in Serbia (in thousands of t) in the period 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total production of barley in Serbia 2006-2016.			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	98,287	289,652	2.9
2007	98,728	272,489	2.8
2008	97,104	361,617	3.7
2009	100,407	318,491	3.2
2010	89,937	260,998	2.9
2011	81,071	291,613	3.6
2012	80,803	278,367	3.4
2013	90,642	362,205	4
2014	90,803	323,283	3.6
2015	95,984	362,205	3.8
2016	91,530	395,501	4.3

Table 16. Total production of oats in Serbia (in thousands of t) in the period 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total production of oats in Serbia 2006-2016.			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	49,183	97,628	2
2007	45,844	88,709	1.9
2008	45,881	110,620	2.4
2009	41,254	85,809	2.1
2010	39,747	78,619	2
2011	36,587	82,577	2.3
2012	34,554	77,262	2.2
2013	33,506	88,288	2.6
2014	30,732	74,932	2.4
2015	32,420	88,288	2.7
2016	27,536	81,344	3

Table 17. Total production of rye in Serbia (in thousands of t) in the period 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total production of rye in Serbia 2006-2016.			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	7,065	15,888	2.2
2007	5,616	11,034	2
2008	5,657	14,442	2.6
2009	5,279	12,943	2.5
2010	5,140	11,061	2.2
2011	5,036	12,791	2.5
2012	4,375	10,640	2.4
2013	4,735	13,258	2.8
2014	5,699	11,702	2.1
2015	5,689	13,258	2.3
2016	4,891	14,200	2.9

Table 18. Wheat utilisation in Serbia 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Wheat utilisation in Serbia 2006-2016.							
Year	Seed use (t)	Feed use (t)	Food use (t)	Closing stocks (t)	Losses (t)	Export (t)	Total consumption (t)
2006	182,000	519,000	1,313,000	410,000	24,000	306,000	2,754,000
2007	188,000	368,000	1,313,000	327,000	23,000	541,000	2,760,000
2008	184,000	537,000	1,250,000	461,000	26,000	511,000	2,969,000
2009	191,000	552,000	1,250,000	401,000	26,000	647,000	3,067,000
2010	186,000	306,000	1,150,000	124,000	21,000	713,000	2,500,000
2011	186,000	565,000	1,160,000	192,000	26,000	614,000	2,743,000
2012	181,000	420,000	1,100,000	29,000	24,000	853,000	2,607,000
2013	190,000	63,000	1,000,000	30,000	27,000	1,427,000	2,737,000
2014	181,000	100,000	1,050,000	244,000	24,000	838,000	2,437,000
2015	177,000	100,000	1,050,000	218,000	24,000	1,124,000	2,693,000
2016	182,000	519,000	1,313,000	410,000	24,000	306,000	2,754,000

Table 19. Corn utilisation in Serbia 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Corn utilisation in Serbia 2006-2016.							
Year	Seed use (t)	Feed use (t)	Food use (t)	Closing stocks (t)	Losses (t)	Export (t)	Total consumption (t)
2006	25,000	4,400,000	140,000	1,669,000	150,000	917,000	7,301,000
2007	26,000	4,250,000	140,000	772,000	98,000	290,000	5,576,000
2008	24,000	4,100,000	200,000	945,000	154,000	1,511,000	6,934,000
2009	25,000	4,100,000	200,000	1,508,000	160,000	1,351,000	7,344,000
2010	25,000	4,050,000	200,000	2,201,000	180,000	2,062,000	8,718,000
2011	26,000	4,100,000	200,000	1,819,000	162,000	2,380,000	8,687,000
2012	26,000	4,000,000	200,000	416,000	88,000	632,000	5,362,000
2013	25,000	3,850,000	200,000	203,000	147,000	1,865,000	6,290,000
2014	25,000	3,900,000	220,000	757,000	199,000	3,061,000	8,162,000
2015	25,000	3,850,000	200,000	366,000	136,000	1,643,000	6,220,000
2016	25,000	3,900,000	220,000	870,000	186,000	2,550,000	7,751,000

As it can be seen from previous Tables, corn is dominant grain in Serbia total production in some years amounted to more than 7 million tonnes (in addition to the quantities of corn, about 600,000 t of animal feed corn are produced annually). Produced quantities of cereal grains in Serbia completely satisfy and exceed domestic food requirements. It is estimated that market surpluses of cereal grains are significantly. For example, domestic demand for corn is estimated at 4-4.5 million t, which means that from the usual annual production, more than 2.5 million t remain (for 2016).

5.1.3 State of the sector

The yields of most crops are relatively low compared to more developed countries and fluctuate significantly. An analysis of the dynamics of yield changes expressed in 10-year averages over the past three decades suggests that cereal yields still do not reach the 10-year average of the pre-transitional period (1980-1989). These data show that further improvement in the sector could be done in future with the intention to increase the yield. Wheat and corn are the two leading products in terms of cultivated areas, with long tradition, good domestic and available foreign assortment. The reason for the insufficient utilization of the genetic potential of plants is the inadequate application of agro-technical measures, the failure to comply with the requirements of the crop and the lower use of inputs related to optimal values and recommendations. High input prices and problems with loan repayments for equipment and machinery have affected the decline in investment volumes, resulting in a high dependence of production on weather conditions according to the Serbian ministry of agricultural.

Average production costs for the main cereal grains in Serbia for period of 2008-2013 are shown in Figure 12. The production costs are influenced by different factors: demand on the market, prices on the world stock markets, fuel prices, fertilizer prices, labour costs, taxes and duties etc. The main reason for decrease of the production prices since 2012 is due to the influence of the world stock

market on national market due to high excesses of these products on international market. It is obviously related to the higher production cost for wheat (approximately 5%) compared to corn.

Serbia has 465 registered mills, 5,755 registered processors and 3 starch factories. Cereals (mainly corn and wheat) cover 17.3 % of all Serbian agricultural exports. More than 80 % of these products are exported to the EU. Serbia applies ad valorem duties of 30 % on imports of cereals for third countries except for rice (3 %). For the EU a preferential regime with no import duties for an unlimited quantity except some products is in place. Preferential access is given also to CEFTA, the Russian Federation, Belarus and Kazakhstan.

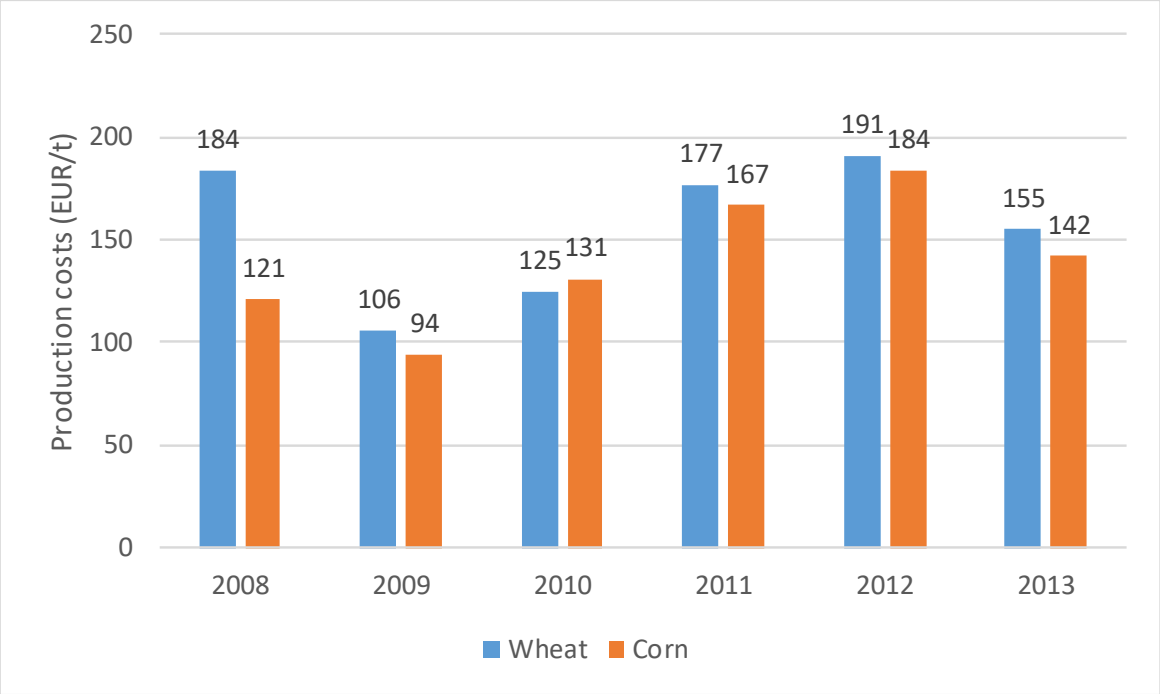

Figure 12. Production costs for wheat and corn from 2008-2013. Source: Official Gazzete RS, 2014.

5.1.4 Typical size of the companies

The company Delta Agrar Ltd. has been present in the agribusiness community since 1993. Its diversified operations are divided into four main organizational segments: primary production, cooperation and repurchase, agro-trade and distribution, and food processing.

Production takes place in five agricultural estates, comprising 15,000 hectares. Crop production includes cultivation of all major field crops: wheat, corn, soybean, sunflower, rapeseed and sugar beet. The export of crop production is up to 40 %. Total number of employees is 1,500.

Danubius Factory from Novi Sad is engaged in the production of milling products and pasta, as well as in storage, drying and transport of grain, all in compliance with strict national and international standards on food safety. Since 2006 Danubius has been operating within Delta Agrar. Total number of employees is 123.

A computer guided mill was installed in Danubius in April 2009 with a daily output of 300 t of wheat processed into various kinds of flours for all purposes. Prior to leaving the mill, all finished products

go through the machines that completely eliminate possible presence of larvae and insects. Danubius has the largest silo in Serbia with a capacity of 65,000 t.

Žitopromet-Ruma was founded in 1950 with headquarters in Ruma. The main activities of the company have always been based on the storage and processing of cereals. The total reconstruction of the mill with new milling technology was done at the beginning of 2014. According to the technological scheme, the capacity of the mill was raised to about 200 t/24hours. A new technology has been introduced for the transport of flour which is pneumatic. All the control process and managing of production is largely automated. In addition to wheat flour in basic types and packages, five types of pasta in three basic categories (short, long and dipped pasta) are produced, so the assortment of final products is increased in comparison with the previous years. Total number of employees is 80.

In addition to trading activities as basic activities, three companies are engaged in cereal processing as well: Granexport, Žitobačka and Maxiprotein. Granexport, based in Pančevo, in addition to the organization of agricultural production and a significant share in the trade activities of the division, as well as the fact that due to its geo-strategic position (the Danube bank, industrial railroad track) represents the main point of the logistics chain with the possibility of loading goods directly to the vessels; with a silo of 50,000 t and a mill (capacity 140 t per day) - also performs final finishing of corn grain. Products intended for the consumer market and industrial consumers are: corn flour, corn semolina and polenta in packages customized to the requirements of the customer. Total number of employees is 101.

Žito-Bačka, with headquarters in Kula, in addition to the organization of agricultural production and trade in cereals - also performs processing of wheat grain, producing more types of flour in packages tailored to the requirements of the end customer (bulk packages, large packages of 25 and 50 kg, small packages intended for sale through a retail chain of distribution).

Žito Bačka's mill was founded in 1916. After a thorough reconstruction in 1975 it began to work as one of the largest and most modern facilities of that time. After privatization in 2004 the company expanded its core business and ensured its leading position in Serbia and the region. The daily flour production is 220 t. It also has a storage capacity for 3,000 t of bulk flour. The mill was reconstructed in 2013, which increased the product range The high-tech laboratory performs daily analyses and takes care of the quality of the flour. With storage capacities of 155,000 t, Žito-Bačka is one of the largest warehouses in Serbia. Silos in Kula have a capacity of 50,000 t. Of the stated capacity 30,000 t is used for the storage of all agrarian crops, including cereals and oilseeds, while 20,000 t are used exclusively for the storage of wheat.

It should be emphasized that the storage and service capacities of Žito-Bačka in Kula are now tripled compared to the previous period (before 2013), since storage is carried out within the silos in Kula with a capacity of 50,000 t, Silos PJ in Bačka Topola with a capacity of 65,000 t and Silos PJ in Belgrade capacity 40,000 t. Total number of employees is 65.

Mirotin Group is a group of companies engaged in the production and marketing of agricultural products, as well as raw materials for primary production and food industry. The company was founded in 1992. The operations of Mirotin Group are largely focused on the foreign markets. Over 70 % of the company's foreign trade operations stem from the export of products, primarily to the

markets of the former Yugoslavian republics (Slovenia, Croatia, Macedonia, Bosnia and Herzegovina, Kosovo, Montenegro), as well as to the markets of the EU Member States: Italy, Germany and others. The main companies within Mirotin Group are Sava Kovačević AD and Mirotin Tisa. Total number of employees is 267.

The main products of company Sava Kovačević AD are following:

Agriculture and vegetables: wheat, barley, corn, sunflower, soybean, sugar beet

Seed production: processing of wheat seeds, corn processing

Corn mill Savino Selo operates within the company Mirotin Tisa. The processing capacity of the mill is 240 t of corn grain in 24 hours. The following products are in the mill's production program:

- edible corn flour
- enriched animal feed corn flour
- beer pie (beer semolina)
- corn semolina for human consumption
- corn semolina for pharmaceutical use

5.1.5 Distinctive facilities of the sector

The overview of grain chain sector has shown that the annual use of wheat for food use in Serbia is 1.2 million t. About 860,000 t of flour is produced which is used for the production of bread and pastry, direct consumption of population, pasta, confectionery and export. Analyses therefore show that Serbia needs an annual amount of 377,000 t of flour and 51,000 t of baked goods. For pasta 42,000 t of flour is consumed, while 54,000 t of flour annually is required for the work of the confectionery industry. In 2016 the export of about 200,000 t of flour was reached. So Serbia needs about 780,000 t of flour annually for normal functioning. Therefore, there is room in the balance of flour to increase its exports.

According to the available data about the companies in this sector, the limited information about the biomass residues are presented. In the last ten years, the companies made a lot of efforts in increasing the grain yield and export. Additional attempts related to biomass residues utilization have been sporadic. Utilization of biomass residues in future will need the investment in the equipment and that could be interesting also for the examination of the possibilities for IBLC. Additionally, the companies underline the need for further development of the infrastructure – collection, transport (road, rail and river) and storage capacities.

5.1.6 Degree of innovation

According to the available data about the companies in this sector, the limited information about the biomass residues are presented. In the last ten years, the companies made a lot of efforts in increasing the grain yield and export. Additional attempts related to biomass residues utilization were/have been sporadic. Biomass utilization residues in future will need the investment in the equipment that could be interesting related to the IBLC implementation. Additionally, the companies underline the need for further development of the infrastructure –collection, transport (road, rail and river) and storage capacities.

The grain sector is considered very suitable for IBLCs and some experience is available from previous period. As big companies are involved in cereals production, they started with different organizational activities (organizing the individual farmers for cooperation), collection of residue from production and utilization of the residue for different purpose.

5.1.7 Miscellaneous

The primary production in the grain chain sector is mainly sustainable with taking care related to crop rotation and soil protection. The main problem is leaving the biomass on field and very often burning of biomass residues in the fields. The problem for insufficient collection and utilization of biomass residue is related to the lack of regulation and inspection, especially in environmental sector which is responsible for prevention of uncontrolled biomass combustion on the field. Additional problem is due to the complete uncompetitive price of different energy sources comparing to biomass energy generation and lack of economic reasons for biomass residues utilization.

5.2 Opportunities IBLC

5.2.1 Sector related residues

The basic production of cereal grains generates the same or higher quantity of plant residues. In some regions, secondary raw materials have taken up their functional position in the continuation of the production process, and somewhere they represent the ballast. Due to this reason, several attempts for estimation of residues from cereal grains production were made. Detailed analysis was done and presented in literature [Ilic et al., 2003]. The total quantity of residues in the field is 8.5 million t, with the share of enterprises and cooperatives of approximately 17 %, and 83 % of the individual producers. The amount of residues that can be expected to be used in energy sector is 2.7 million t, with the share of enterprises and cooperatives of 33 % and 67 % by the individual sector. Additionally, the residue of the most important dominant cereal crops – wheat and corn are estimated for each region (25 of NUTS3). Due to the big differences in harvested area, total yield and yield per unit, the range of residue production per unit is also wide (Table 20).

Table 20. Residues per unit. Source: Statistical Office of the Republic of Serbia, 2017.

Residues per unit		
Type of residue	Residue per unit (kg/ha)	
	Range	Average value
Wheat	2,544-4,847	3,546
Corn stalks	5,033-38,483	17,616

These residues are very interesting for further utilization, as they can be used for different purposes – pellet production, direct combustion of straw bales, utilization for next generation biofuel production, gasification etc. According to National action plan for renewable energy sources in the Republic of Serbia, biomass from grain chain will have an important role contributing to target fulfilment in 2020. According to NREAP targets for different sectors, it could be concluded that

biomass residues will be available for utilization in CHP plants (based on 2009, the additional 19 ktoe in electricity and 10 ktoe in heating sector is planned) and 246 ktoe for transport sector, mainly based on biofuels (preferably 2nd generation). All estimated biomass residues from grain chain sector are suitable for partially utilization in previously mentioned sectors.

5.2.2 Potential synergies & benefits

The grain production sector has the potential to be linked with other sectors and it could so be used for establishment of IBLCs. This is especially interesting as there are unused and larger than needed capacities and the biomass residues, most feasible straw and corn stalk, which are not used. It is necessary to emphasise that two types of companies exist: companies with big capacities (mainly located in Vojvodina) and small companies (in the rest of territory).

Big companies cover great areas and have sophisticated equipment for IBLCs (mainly, for collection, loading and transport). They have the capacities for relatively low cost transport and appropriate storage. Big companies have made a lot of efforts for optimal use of natural resources, strategic planning and application of modern agro-technical measures. They have optimized all costs through control and monitor all operations, trained and efficient labour, automated and modern agricultural mechanization, advanced logistics and strong information support and large and easily accessible storage capacities. One good example is company MK Commerce which is leader in the field of agribusiness. On the domestic market, they are one of the biggest producer in agriculture sector overall, as well as one of the largest producers of agricultural crops, such as sugar beet, wheat and corn.

On the other side, the small producers are faced with several problems: relatively small areas to collect biomass from, lack of equipment, relatively poor road infrastructure and relatively small capacities of warehouses. Due to all these reasons implementation of IBLCs will have higher costs but it could be expected that based on good practice, relatively small companies and private owners will start with implementation of IBLC. Different examples in organization of small producers exist and it could be expected that their good practice will be enlarged. These examples are: associations, clusters and cooperation with big companies based on long term agreement for cooperation. Based on the experience, all these examples have shown the advantages in equipment share, knowledge upgrading, and implementation of new technologies, management and logistics. Additionally, structural shifts whereby large family farms are buying and renting land from elderly households and the government is improving the growing technology. Therefore, yields are increasing as more land is cultivated by professional producers who are better informed about new technologies and modern production equipment.

5.2.3 Market developments

Grain chain industry is the industry with a big tradition in Serbia and with constant development, especially in yield. The companies involved in grain chain sector made in 1978 Association Serbia Grains (previous name Yugoslavian Grains Association). The association includes 46 member companies which organize production on 980.000 ha. Association members share in total grains export from Serbia in period 2007-2017: corn from 68 to 86 % and wheat from 62 to 83 %. According to the Law on agriculture and rural development from 2009, Serbia is exclusively producing NON-

GMO grains. The Danube waterway in Serbia is the main path for grains export, with total storage capacity for grains on Danube in Serbia – 224,000 t.

5.2.4 Non-technical barriers

The main problem is related to economic aspects. The price of fossil fuel is relatively low compared to biomass. Additionally, implementation of IBLCs is linked with additional financial investments and relatively long period for the return on investments.

Another reason for the insufficient utilization of the genetic potential of plants is the inadequate application of agro-technical measures, the failure to comply with the requirements of the crop and the lower use of inputs in relation to optimal values and recommendations. High input prices and problems with loan repayments for equipment and machinery have affected the decline in investment volumes, resulting in a high dependence of production on weather conditions.

6 FEED AND FODDER

6.1 Profile of the feed and fodder sector

6.1.1 Production

Since livestock production occupies an important place in agricultural production in Serbia, the feed and fodder sector is relevant in the country rural economy. Dominant fodder crops which cultivated for use in this sector for feed are maize for forage, clover and alfalfa (lucerne). The traditional production process (Figure 13) used in the processing plant for the animal feed production can be divided into phases, namely:

- Receiving and storing raw materials (which can be received and stored in silos, bags in floor warehouses and "big bags")
- Milling preparation
- Dosing raw materials
- Milling/Grinding
- Mixing
- Packing mixtures of finished products in bulking cells
- Shipping by trucks

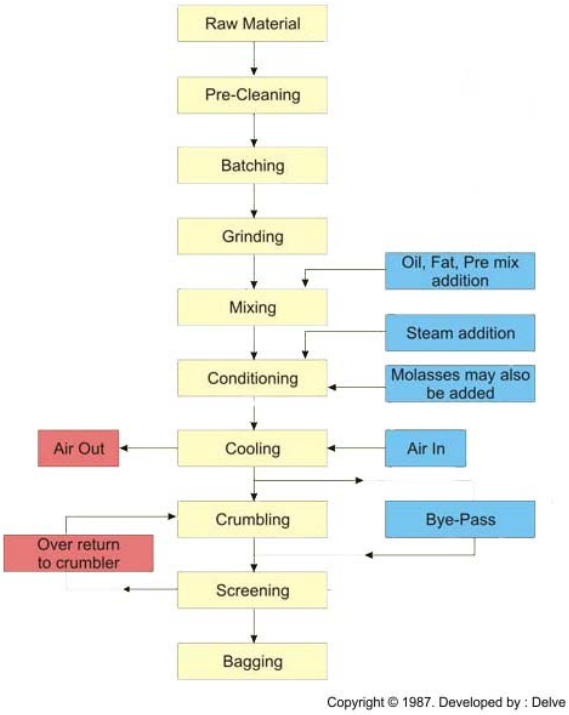

Figure 13. Traditional production process of animal feed. Source: http://spectecindia.com/, 2018.

The commonly used end product of this sector are mixtures for pigs, cattle and poultry that are used in domestic livestock production.

6.1.2 Volume of the sector

There are approximately 100 producers of animal feed in Republic of Serbia and the most important are listed in Table 16. The majority of the producers are with small production potentials and they have been operating only for couple of years. However, regarding the amount of the fodder crops production which is presented in Tables 21, 22 and 23, all installed production capacities for animal feed could be used. Market trends and price fluctuations affect the viability of the animal feed production. For small producers with relatively low storage and production capacities it is most difficult to survive in this market.

Table 21. Total production of maize for animal feed in Serbia in the period 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total production of maize for animal feed in Serbia 2006-2016			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	23,285	502,092	21.6
2007	26,302	460,329	17.5
2008	25,318	459,310	18.1
2009	26,758	586,919	21.9
2010	27,503	657,201	22.9
2011	30,157	655,618	21.1
2012	47,927	736,943	14.9
2013	32,418	693,258	20.7
2014	32,143	617,447	19.2
2015	34,046	589,166	17.3
2016	30,524	650,741	21.3

Table 22. Total production of clover in Serbia in the period 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total production of clover for animal feed in Serbia 2006-2016			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	108,199	635,778	5.9
2007	107,210	520,825	4.9
2008	110,290	609,462	5.5
2009	108,168	634,078	5.9
2010	107,665	628,438	5.8
2011	105,458	561,034	5.3
2012	103,316	416,571	4.0
2013	101,604	504,259	5.0
2014	108,834	565,886	5.2
2015	109,230	481,003	4.4
2016	107,430	611,062	5.7

Table 23. Total production of alfalfa (lucerne) in Serbia in the period 2006-2016. Source: Statistical Office of the Republic of Serbia, 2017.

Total production of alfalfa (lucerne) for animal feed in Serbia 2006-2016			
Year	Production area (ha)	Production (t)	Yield (t/ha)
2006	79,201	358,937	4.5
2007	78,057	285,921	3.7
2008	78,097	331,366	4.2
2009	76,436	344,495	4.5
2010	77,734	352,601	4.5
2011	78,304	314,780	4.0
2012	77,726	245,847	3.2
2013	75,102	282,234	3.8
2014	75,395	244,658	3.2
2015	76,625	222,596	2.9
2016	73,281	291,365	4.0

6.1.3 State of the sector

Production facilities in the feed and fodder sector of Serbia are relatively well distributed in the country regions. Although Vojvodina and Belgrade region are declared with the largest number of manufacturers for animal feed production. This is because of higher population density in that regions and higher raw materials and fodder crops availability. The main companies which deal with production of animal feed in Serbia are shown in Table 24.

Table 24. The main producers of animal feed in Serbia. Source: UBFME, 2018

The main producers of animal feed in Serbia			
Company name	Location	Company name	Location
FSH Sto	Belgrade	AGROPRODUKT d.o.o.	Kragujevac
DOO "Gebi"	Čantavir	TONNEJA	Kraljevo
AGRO MIL	Pojate	PP "POMAK"	Kraljevo
FSH"DE HEUS" d.o.o	Šabac	STR "AGROPLUS"	Kragujevac
HRANA PRODUKT	Sremska Mitrovica	DOO BRANA "MM-KOMERC"	Varvarin
VETERINARSKI ZAVOD "SUBOTICA"	Subotica	NUSCIENCE PREMIX INTERNATIONAL	Velika Plana
PANTELIĆ d.o.o	Kraljevo	FSH INTERFOOD	Valjevo
FSH JABUKA	Pančevo	DOO DREN	Novi Sad
Konzul- PJ FSH "BAFI"	Novi Sad	FARMER d.o.o	Čačak
FSH Nutriko	Vranje	"MELBAT" ŠAJKAŠKA	Novi Sad
DEM KUPLIN	Kulpin	INBERG	Boljevci
AGROSMEŠA	Surčin, Belgarde	DOLINA GRUŽE	Kraljevo

The Republic of Serbia has favourable natural conditions for the development of animal husbandry, since it possesses grasslands of high quality and with significant unused facilities for accommodation of cattle and sheep. Nevertheless, this branch of agriculture has been recording negative trends for the third decade now. Only during the last ten years, the number of livestock and poultry per hectare of agricultural land was reduced from 0.34 to 0.27 (Table 25).

Table 25. Number of livestock and poultry in Serbia. Source: Statistical Office of the Republic of Serbia, 2017.

Number of livestock and poultry in Serbia 2006-2016.				
Year	Cattle	Pigs	Sheep	Poultry
2006	1,098,000	3,759,000	1,527,000	17,596,000
2007	1,106,000	3,999,000	1,556,000	16,595,000
2008	1,087,000	3,832,000	1,606,000	16,422,000
2009	1,057,000	3,594,000	1,605,000	17,188,000
2010	1,002,000	3,631,000	1,504,000	22,821,000
2011	938,000	3,489,000	1,475,000	20,156,000
2012	937,000	3,287,000	1,460,000	19,103,000
2013	921,000	3,139,000	1,635,000	18,234,000
2014	913,000	3,144,000	1,616,000	17,860,000
2015	920,000	3,236,000	1,748,000	17,167,000
2016	916,000	3,284,000	1,789,000	17,450,000

6.1.4 Typical size of the companies

According to Agricultural census 2012, In Serbia there are around 100 companies producing animal feed without classification by size. Also, in the available materials (literature, company presentation etc.) there is limited information about production capacities and other information related to their business results.

6.1.5 Distinctive facilities of the sector

There are no possibilities for other biobased purposes in the existing capacities. All existing capacities are oriented only for feed and fodder production and there are no idle periods in which could be equipment used for biomass processing. This is especially due to the large number of small producers with small capacities and limited financial capabilities.

6.1.6 Degree of innovation

The entire technological process of animal feed production in all factories is automated: by introducing computer technology, precise control and management of the production process has been achieved, and every possibility of error has practically been eliminated. In some of the production process the technologists, with the help of the most modern program for the optimization of mixtures and the latest knowledge in the field of nutrition of domestic animals, creates mixtures that meet the most stringent requirements of customers and prescribed standards. Some companies have established close cooperation with many faculties, mainly department for livestock breeding whose experts regularly monitor and control the quality of the products.

For the purpose of efficiency of production, the factories have modernized their production in order to meet the needs of their customers by investing in machinery and equipment, as well as by building a larger production and warehouse space. For example, company "NUTRIKO" has its own laboratory, equipped with state-of-the-art equipment for quality control of raw materials and finished products.

6.1.7 Miscellaneous

There are no possibilities for future IBLC development due to significant annual fluctuations in price and quality caused by large annual variations in yields and areas in crop production and non-competitive markets (production, import and sale).

6.2 Opportunities IBLC

6.2.1 Sector related residues

Regarding feed and fodder sector related residues which could be used in IBLCs are not available in significant quantities due to old and traditional animal feed production process as well as relatively large number of small producers. Therefore, the amount of residues that could be collected in each small producers facility is quite reduced and will not be worth to implement a system to valorise them. Additionally, the alternative to gather the residues from different facilities close to each other would not be suitable due to the relatively long distance between the facilities and the poor

interconnection infrastructure. Also traditional livestock breeding which is dominant in Serbia, use relatively small quantity of the biomass residues from this sector as additional food for livestock and for flooring of the stables and the cotes. After the changes of biomass used for flooring, this waste material is used as a natural fertilizer for fields and crops in rural areas of Serbia.

6.2.2 Potential synergies & benefits

As mentioned above due to no available residues from feed and fodder sector in Serbia there are no potential synergies and benefits which could be obtained. According to Agricultural strategy it could be expected that in the future period the livestock sector will be in expansion and as a consequence feed and fodder production will increase, which enable some potential synergies and benefits. At the same time, it could be expected that in that case larger companies will appear on the market which will be more interested for implementation of IBLCs.

6.2.3 Market developments

The business plans of companies from this sector have shown the intention for increase the production and export to other markets. For further market development different incentives have been recognized and planed for implementation in the future:

- Incentives for machinery purchasing for the preparation and distribution of animal feed.
- Support through different financial mechanism of construction of fodder storage facilities.

6.2.4 Non-technical barriers

According to the national program of agriculture sector in the Republic of Serbia, different non-technical barriers are recognized:

- Lack of law on fodder food.
- Lack of regulation which define storage, declarations, controls and other issues related to the production and marketing of concentrated animal feed.
- A large number of small manufacturers that do not meet standards and have no homogeneity regarding the quality.
- Lack of procedure to define the custom clearance.

Additionally, as the main non-technical barrier which has the influence on the amount of production is dependence to weather conditions. Dependence on weather conditions is especially pointed out by small producers which are not capable to implement modern technologies and measures in production process due to the lack of knowledge or insufficient investment capacity.

7 SUMMARY ANALYSIS OF THE COUNTRY

Table 26. Summary sector "Sugar Industry".

Sugar Industry	
	Profile
Production	• Sugar is produced from sugar beet. • A tonne of sugar beet yields on average 14-16 % of its mass in sugar. • Main by-products: dried shredded sugar beet, pelleted pulp and high-quality molasses.
Volume of the sector	• In 2016 total production of sugar beet was 2,683,860 t, sown area 49,237 ha. • In 2016 total production of white sugar was 626,000 t. • annual production of sugar beet is in the range from 2,200,000 to about 3,300,000 t in the period from 2006 to 2016. • Between 1 and 1.5 % of the total available land is used for sugar beet cultivation. • 400 farms are involved in the process of beet production.
State of the sector	• Each factory carries out its own contracting directly with the farmers who supply beets. • Approximately 180,000 to 200,000 t of white sugar are exported. • The equipment in the sugar plants is modern, especially in larger plants. • The domestic sugar consumption is stable – 240,000 t, 25-30 kg per capita.
Typical size of the companies	• The sector is dominated by medium and large producers. • 7 sugar plants are operated. • All facilities for sugar production are located mainly in the north part of Serbia (Vojvodina). • Total capacity of facilities for sugar production is 4.4 million tonnes of sugar per year. • Facilities for sugar production are active on average for 100 days per year.
Distinctive facilities of the sector	• Some of the biggest producers are Sunoko (4 facilities) and Helenic Sugar (3 facilities). • Characteristic for all plants is the equal number of permanent employees and seasonal workers. • Huge difference in the fuel cost between the factories that burn coal and those that use gas. • As all sugar plants remain idle for the bigger part of the year it will be reasonable to examine the possibilities for IBLC.
Degree of innovation	• In the last few years many efforts and improvements were made to increase energy efficiency.

Miscellaneous	• It could be expected that due to the environmental legislation the factories will evaluate the switch to fuel with less environmental impact.
	• There is a significant potential for biomass utilization in the sector. • Comparable economic and environmental assessment using Life Cycle Assessment method was carried out for raw sugar juice production.
	Opportunities for IBLCs
Sector related residues	• Dried shredded sugar beet, pelleted pulp and high-quality molasses are the main by-products. • In some plants the use of 80 % of the sugar from molasses that occurs after sugar beet processing
Potential synergies & benefits	• There is the opportunity for bioethanol production. The molasses as a by-product of sugar production is identified as raw material for bioethanol production. • The utilization of sugar production residues (dried shredded sugar beet) could be also very interesting, as it will improve environmental situation due to reduction of call utilization as main fuel in sugar industry.
Market developments	• The trend for increasing sugar production and possibilities for export in the region is realistic.
Non-technical barriers	• As three sugar producers operate in the market certainly the issue of monopolies is opened. • The abolition of the sugar production quota in the European Union will also affect sugar beet producers. • The unresolved relationship and the poor leasing of state land.

Table 27. Summary sector "Wine".

Wine sector	
	Profile
Production	• There are nine main wine regions. • Grape and wine production is increase in last two decades. • The last decades after 2000. was characterized with introduction of new technologies in grape growing and wine production by use of quality, selected and certified grape variety materials. • Residues such as pruning are very rare used as biomass. • Vojvodina is the first region in Serbia which becomes a member of the Association of Wine Regions of Europe.
Volume of the sector	• 80,341 farms are engaged in the production of grapes, which is 12.7 % of the total number of farms.

	• Four types of vineyards: 1) small family vineyards (0.1-0.3 ha); 2) small to medium-sized vineyards that belong to grape growers focused on production for the commercial wineries; 3) modern small-medium vineyards that belong to the wine-makers (integrated firms); 4) largely older large vineyards (up to 1,400 ha) • The number of employees in wineries in Serbia is 3,415, out of which the number of permanent employees is 1,956, and temporary employed persons are 1,459.
State of the sector	• 235 wine producers who are exclusively market oriented • Serbia has recorded a growth of wine production at an average annual rate of 8.63 %.
Typical size of the companies	• Large winery with more than 250 employees - only two wineries, and in a group of wineries with 50 to 250 employees is an only one winery. • 3 types of wineries - Industrial/corporate producers (wine and cognac production), medium-sized wineries that produce wines in the high-end and premium segments (around 500,000 litres per year), small wineries (10,000 to 80,000 litres per year).
Distinctive facilities of the sector	• IBLC could be the part of modernization process of industrial / corporate producers, as they started with some activities in planning and realization of modernization.
Degree of innovation	• Significant progress in improving technologies for viticulture and oenology and in improving wine quality and production. • Subsidies given for viticulture and oenology are among the largest subsidies in the region.
Miscellaneous	• The main limiting factors for grape production in Serbia are very old plants (older than 30 years), which should be renewed and for this a significant investment is needed. • Small plots prevent the use of productive machines and performing the necessary agro technical measures.
	Opportunities for IBLCs
Sector related residues	• According to the investigation related to biomass potential in Serbia, the pruning of vine yields is from 4 up to 8 t/ha of vineyard. • Total biomass residues from grape growing could be estimated at about 170,000 t, which is the energy potential of about 50,000 toe. The energy potential of vine pruning residues alone is about 55,000 toe.
Potential synergies & benefits	• Idle period of wine cellars usually is from January until August. • The interest for IBLC in wine sector exists. • The main reasons for relatively low biomass utilisation lie in lack of adequate equipment for biomass collection and relatively small vineyards area.

	• There are some idea and attempts for biomass collection and joint procurement of the necessary equipment by several small producers.
Market developments	• Wine sector has a lot of opportunities for further development: there are lot of potential for improved quality, lower price on the domestic market and bigger export to other markets. • Improving knowledge in viticulture and wine production, including possibilities for energy efficiency and biomass utilization is one of the activities identified as the most important for upcoming period.
Non-technical barriers	• Equipment is outdated and there are no resources to upgrade equipment and to improve winery operation and its efficiency. • The most essential changes required in the Serbian wine value chain is the expanded use of long term contracts for wine grape supply and biomass which could be used.

Table 28. Summary sector "Vegetable Oil Extraction".

Vegetable Oil Extraction sector	
	Profile
Production	• The most important plants that are cultivated in Serbia for vegetable oil extraction process are rapeseed, sunflower and soybean. • The vegetable production is in Vojvodina. • Main residues form the process are husk and oilcake.
Volume of the sector	• In 2016 total production of vegetable oil was more than 1.2 million t. • Over 150,000 ha are sowed with sunflower, equalling about 5 % of arable land. The major part of this areal (94 %) is in Vojvodina. • The average area in Serbia sown for soybean production is 160,000-180,000 ha, with the tendency of constant growth.
State of the sector	• Average yields of sunflower have been going up and down in the recent years. For soybean and rapeseed – steadily increasing is recorded. Since 2015 there has been a significant (around 20 %) in production volumes of sunflower. Due to high profitability of this crop.
Typical size of the companies	• The companies play as an important factor in the agricultural sector, particularly in the production of oilseeds, which includes the development of partnership relations with agricultural producers, as well as the development of logistics coverage for the purpose of purchase and a modern, safe storage of the oil crops. • By engaging agricultural engineers, a number of agricultural producers have been trained educated, which is one of the most important requirements for accepting this culture.

Distinctive facilities of the sector	• Total capacity of vegetable oil industry is higher than needed. • Oil production industry has made significant investments in modernization. • Developed logistics network. • A lot of possibilities for IBLC. • Vegetable oil industry in Serbia has a lot of experience with sunflower husk utilisation.
Degree of innovation	• Compared to other sectors analysed in this report, the vegetable oil sector may be considered the most innovative. • Investments were done with the intention to improve the factory's performance. • Successful co-operation with farmers.
Miscellaneous	• In Victoria Logistic which has the cooperation with around 40,000 farmers through more than 300 co-operatives, the purchase of different biomass (soy straw, wheat and corn) is organized, as well as the production and sale of biomass pellets.
	Opportunities for IBLCs
Sector related residues	• Residues from the vegetable oil extraction sector, like sunflower husk or residues from oil extraction process (oil waste), are mainly used within facilities for production energy for own use.
Potential synergies & benefits	• Intention for integration production of biofuels, especially of next generation biofuels due to the surplus in processing capabilities. • Big a surplus offers an opportunity for an IBLC.
Market developments	• The market of vegetable oil will grow in future. • Plans and strategies for further investment in energy efficiency and biomass are made.
Non-technical barriers	• Small farm with insufficiently high capital reserves and with relatively small capacities for operation according to modern standards. • Variability of prices, especially for farmers since they have fewer possibilities to manage risk. • Uncertainty related to agricultural policy measures which support the production of oil crops. • Transportation problems for biomass delivery - bad road infrastructure, bad conditions in railway sector and insufficient use of river transport.

Table 29. Summary sector "Grain Chain".

Grain Chain sector	
	Profile
Production	• The cereal grains most frequently grown in Serbia are corn, wheat, rye and barley. • Cereal grain crops are the most important: by 63-70 % of arable land is sowed annually with a combination of these crops.
Volume of the sector	• In 2016 total production of grain crops was around 11.5 million t. • Main grain crops produced in Serbia are wheat and corn. • Two groups of districts with wheat and straw production: undeveloped districts (South-East Serbia) with low volume of wheat and corn production and group of relatively developed districts (Vojvodina) achieving a high level of production volume.
State of the sector	• The yields of most crops are relatively low compared to more developed countries and fluctuate significantly. • Cereals (mainly corn and wheat) cover 17.3 % of all Serbian agricultural exports. • More than 80 % of these products are exported to the EU.
Typical size of the companies	• The main part of production is in medium and big companies. • Some of companies is organized for different operations: primary production, cooperation and repurchase, agro-trade and distribution, and food processing. • Due to geo-strategic position (the Danube bank, industrial railroad track) some of companies represents the main point of the logistics chain with the possibility of loading goods directly to the vessels.
Distinctive facilities of the sector	• Serbia needs about 780,000 t of flour annually for normal functioning. • In 2016, the export of about 200,000 t of flour was reached.
Degree of innovation	• The degree of innovation in the grain chain sector is rather low, which results in substantial amounts of residues generated during primary production, as well as during industrial processing gone unused (or used inefficiently).
Miscellaneous	• The primary production in the grain chain sector is mainly sustainable with taking care related to crop rotation and soil protection. • The main problem is often burning of biomass residues in the fields.
	Opportunities for IBLCs
Sector related residues	• The total quantity of residues in the field is 8.5 million t, with the participation of enterprises and cooperatives about 17 %, and the individual sector 83 %.

Potential synergies & benefits	• The amount of residues that can be expected to be used in energy sector is 2.7 million t, with the participation of enterprises and cooperatives from 33 % and the individual sector from 67 %. • Residues are very interesting for further utilization (pellet production, direct combustion of straw bale, utilization for next generation biofuel production, gasification etc.).
	• The sector of grain production has the potential to be linked with other sectors and it could be used for establishment of IBLC. • Big companies cover great areas and have sophisticated equipment for IBLC.
Market developments	• Grain chain industry is the industry with big tradition in Serbia and with constant development.
Non-technical barriers	• Economic aspects - the price of fossil fuel is relatively low compared to biomass. • High input prices and problems with loan repayments for equipment and machinery. • Inadequate application of agro-technical measures.

Table 30. Summary sector "Feed and Fodder".

Feed and Fodder sector	
	Profile
Production	• Since livestock production occupies an important place in agricultural production in Serbia the feed and fodder sector is important in the country's rural economy. • Dominant fodder crops which cultivated for use in this sector feed are maize for forage, clover and alfalfa (lucerne).
Volume of the sector	• There are approximately 100 producers of animal feed in Republic of Serbia • Regarding to amount of the fodder crops production, all installed production capacities for animal feed could be used. • Market trends and price fluctuations affect the viability of the animal feed production.
State of the sector	• Production facilities in the feed and fodder sector of Serbia are relatively well distributed in the country regions. • Serbia has favourable natural conditions for the development of animal husbandry, since it possesses high quality grasslands and significant unused facilities for accommodation of cattle and sheep. Nevertheless, this branch of agriculture has been recording for the third decade negative trends. Only during the last ten years, the number of livestock and poultry agricultural land it was reduced from 0.34 to 0.27.

Typical size of the companies	• Limited data related to company size.
Distinctive facilities of the sector	• All existing capacities are oriented only for feed and fodder production.
Degree of innovation	• The entire technological process of animal feed production in all factories is automated. • For the purpose of efficiency of production, the factories have modernized its production in order to meet the needs of its customers by investing in machinery and equipment, as well as by building a larger production and warehouse space.
Miscellaneous	• There are no possibilities for future IBLC development.
	Opportunities for IBLCs
Sector related residues	• Sector generates no biomass related residues.
Potential synergies & benefits	• No available residues from feed and fodder sector in Serbia there are no potential synergies and benefits which could be obtained.
Market developments	• The business plans of companies from this sector have shown the intention for increase the production and export to other markets.
Non-technical barriers	• Dependence of production/yield to weather conditions.

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AGROinLOG

INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors

European View

Project AGROinLOG "Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe"

Prepared by: AESA

Date: 17/5/2018

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ABBREVIATIONS

LCIA: Life cycle impact assessment

LCA: Life Cycle Assessment

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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

SCO-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

In task 6.1 the definition of IBLC was given as an Integrated Biomass Logistics Centre (IBLC) being a strategy for business developement for agro-industries. With this, companies will be able to take business advantages, mainly related to unexploited synergies between facilities, equipment and staff capabilities.

This report presents an overview on the below mentioned sectors in respect to the EU activities.

It has to be underlined how the confideality of companies' agreement and information does not allow to have a complete vision of the sectors.

Therefore the following sectors and related opportunities were investigated at European level, in order to give a picture of the situation:

- Vegetable oil extraction;
- Olive mills/ Olive Oil (whole chain);
- Wineries (cellars and distilleries);
- Feed and fodder;
- Grain chain (mills-flour, straw until final product, fuel);
- Sugar industry;
- Food processing industry.

For most of these sectors interesting synergies appear, while for other ones such as feed and fooder or grain chain the synergy possibilities are mainly related to storage capabilities.

As for *vegetable oil seeds*, an interesting increase in cultivated surface, due to the biodiesel market, especially in Bulgaria, Romania, France, Hunagry, Poland and Ukraine was noted. Several by-products are produced by this sector. The main interesting by-product may be hulls (for energy production) and protein cake, which is used for animal feeding. As for protein cake, the EU needs to import more protein cake to cover the existing needs. For biodiesel production, the main source in EU seems to be palm oil.

The *olive oil chain* plays a key role in IBLCs framework. The main producers are Italy, Spain, Greece and Portugal. As regards to by-products, their charateristics depend on the adopted way of oil extraction (traditional, 3-phases and 2-phases); each technology produces by-products with its own characteristics. As the sector produces prunings, these can benefit the income of the farmers and provide power (CHP). Also for mills involved in storage (e.g. cost and less time for storage) this can be of advantage, while for chemical bioproducts husk can represent a valuable source of raw materials to be processed in order to obtain chemicals and pharmaceutical products.

As for *wine by-products*, the EU is the world wide leader in *wine production*. The main by-product of wine production is untreated/treated grape marc, that results, together with prunings, in the main by-products. Prunings are generally used in bakery ovens or, due their chemical characteristics, for production of heat in ovens. Olive husk can also be used in biochemical industry.

In this document *feed and fodder* considers mainly animal feeding, meaning the feeding of animals such as cows, pigs and other edible animals and feeding of pets as well. The production of this material comes from residues of other agricultural processses, and it is sold in the form of pellets. There are synergies in respect to new raw materials (especially proteins) produced in Europe (instead of importing them) through the development of new technologies. Other issues are the reduction of the required energy for the production process and of the use of medicine and antibiotics for animal feeding.

Since the *cereals* have to be considered as commodities, they arrive at the processing facilities already cleaned. On the contrary, rice is characterised to have the glumellae that need to be removed in preparation process. In the *grain chain*, among the straw harvesting which has to be organized at the single farm level, rice hulls seems to be the best source of biomass in order to plan an IBLC platform. This sector is able to concentrate a large amount of residual biomass. Unfortunately facilities are spread over the territory, and direct contacts and requests to stakeholders (such as suppliers, processors, etc.) are needed. The collocation on a new market should improve the business model along the supply chain. New technologies for alternative use apart burning need to be found.

The EU is the world's leading producer of *sugar beet*. Residues from sugar beets are mainly used for animal feeding and bioenergy production, likewise other technologies were and are developing to use sugar beet residues. Due to the confidential characteristic of information, no specific data can be provided. During processing, solid residues (25-30 % of the input) is made of "bagasse" and sugar beet vinasse, that are mostly used for steam generation (generally used in the facility for refining). Another use for the bagasse and other sugar beet processing residues is the integration in the mix of paper production and animal feeding.

As for the *food processing industry*, there are a lot of opportunities. In this document it is underlined how Europe's food and drink industry plays a key role in terms of turnover, value added and employment. The contribution to Europe's economy of this sector is really important: 4.25 million employees throughout the EU, over €1 trillion turnover and a positive trade balance of €25 billion. It is not possible to have a complete list of the companies in the sector, due to small structured nature of the sector as many small scale factories working for a main brand. A creation of an IBLC could be developed in plants that process fresh vegetables, using as biomass the residues and using their yards that are not used in the "off-season".

In addition, the difficulty to obtain specific and disagregated data has to be underlined, due to the market structure and the confidential characteristics of informations.

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1 INTRODUCTION

In task 6.1 of the AGROinLOG project an updated conceptual description of an Integrated Biomass Logistics Centre (IBLC) was provided.

An Integrated Biomass Logistics Centre (IBLC) is a business strategy for agro-industries which can take advantages of unexploited synergies between facilities, equipment and staff capabilities. The scope is to enhance the strenght of agro-industry, both in respect to input (food and biomass feedstock) and output (food, biocommodities & intermediate biobased feedstocks) to further increase the added value delivered by those companies. An IBLC represents four main characteristics:

- integrated value approach towards food and biobased markets;
- regional availability of biomass;
- logistic, storage operations and pre-treatment;
- exploiting the central position.

The possible synergy between two or more value chains using the same facilities basically depends on:

- period used for the main product storage/processing;
- available capacity of facilities;
- capacity of the existing buildings;
- amount of processed material per year;
- quantity of residues/by-products produced per year.

As most of these feedstocks have to be considered as commodities, their price is affected by international markets.

To define IBLC opportunities and agro-industry synergies per sector, a minimum limit of traded volume of the main product and related by-products must be established.

This report addresses the following sectors in EU' countries:

- Vegetable oil extraction;
- Olive mills/ Olive Oil (whole chain)
- Wineries (cellars and distilleries);
- Feed and fodder;
- Grain chain (mills-flour, straw until final product, fuel);
- Sugar industry;
- Food processing industry.

2 VEGETABLE OIL SEEDS AND SEED OIL

2.1 Profile of the vegetable oil seeds and seed oil sector

2.1.1 Production and volume of the sector

Since 1995, oilseed production has increased in cultivated surface due to the biodiesel market, especially in Bulgaria, Romania, France, Hungary, Poland and UK. Actually most of EU's biodiesel production seems to depend on palm oil (imported). This is because the production costs of rapeseed, canola, and other oleaginous crops in the EU is not competitive compared to palm oil production outside the EU (costs and yield; palm oil needs to be well refined, especially if it comes from Africa). In addition, seed oil production is strictly linked to protein cake production used as animal fodder.

At European level, the main representative organizations are Fediol and European Oilseed Alliance.

The main crops are rape and turnip rape (6.9 million of hectares in 2017 all over Europe of which 4.2 million of hectares are in France, Germany, Poland and UK; Figure 1) and sunflower (4.2 million of hectares in 2017 all over Europe of which 3.8 million of hectares in Romania, Spain, France and Hungary: Figure 2). Tables 1-3 presents an idea of the treated volume. Thus, these two crops cover 70 % of oilseed crops surface.

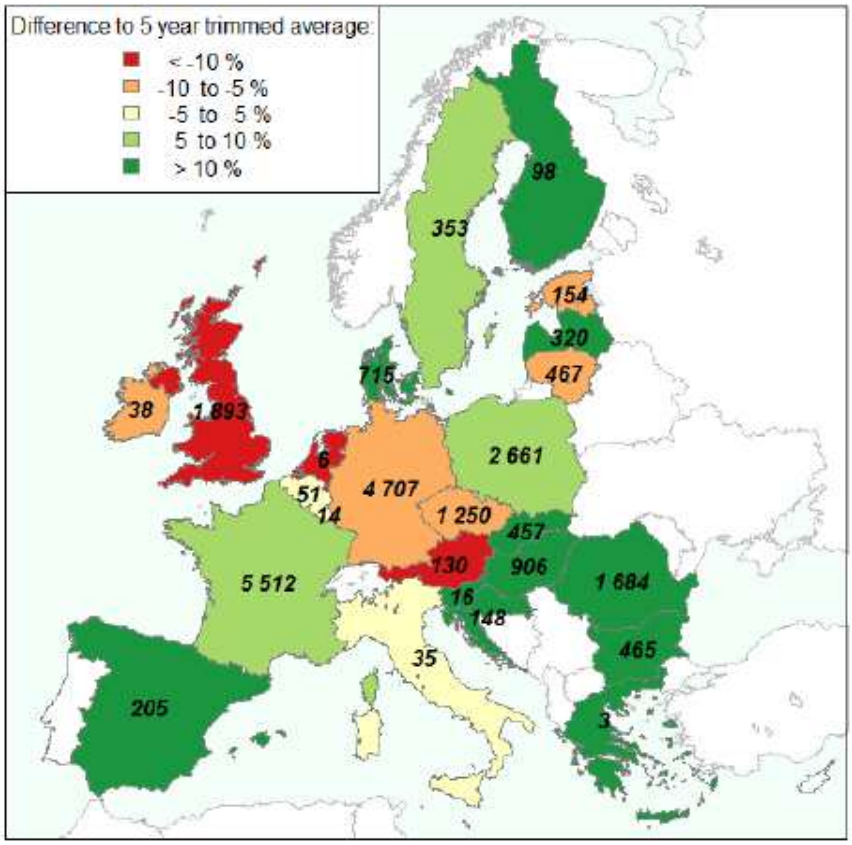


Figure 1. Rapeseed production in Europe 2017 x 1000 ton (source: EC DG Agri)

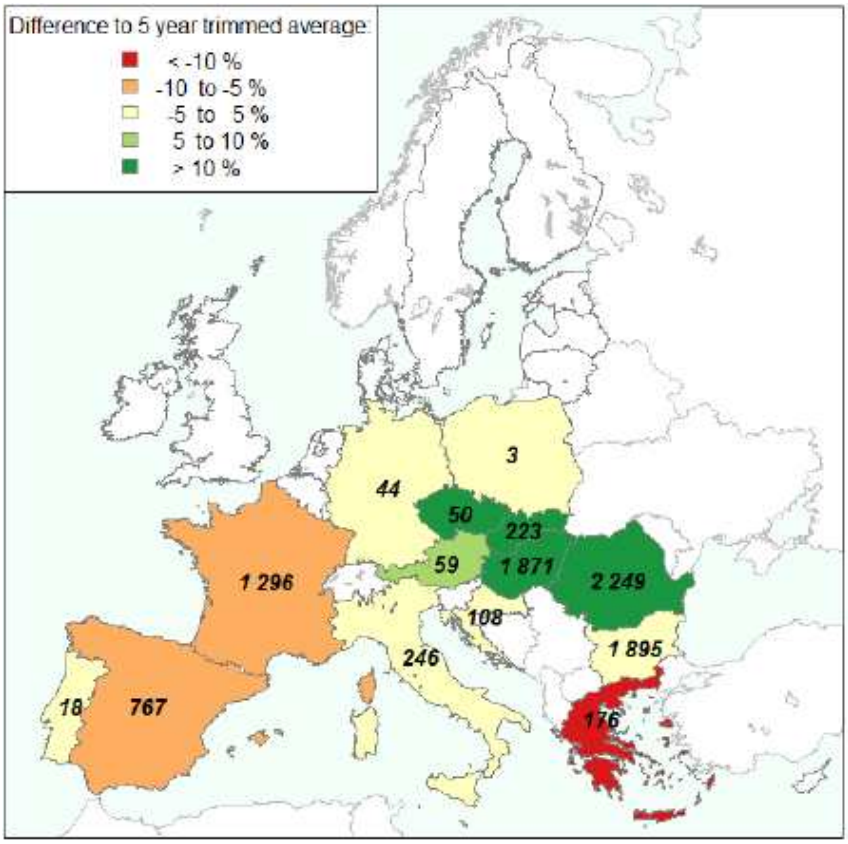


Figure 2. Sunflower production in Europe in 2017 x 1000 ton (source: EC DG Agri)

Table 1. Oilseed crops surface cultivated in Europe: most important countries (Eurostat; x 1,000 ha)

	1995	2010	2011	2012	2013	2014	2015
EU	n.d	11,587.3	11,728.6	10,978.0	n.d	n.d	11,862.4
Czech Republic	291.0	490.4	464.41	470.8	486.9	464.3	446.0
France	1,931.3	2,239.9	2,334.6	2,336.5	2,252.1	n.d.	2,270.5
Lithuania	27.1	253.9	257.3	268.9	265.9	223.3	171.3
Hungary	547	825.6	873.8	820.1	835.9	880.6	934.2
Poland	633.8	791.4	782.4	640.7	904.9	n.d.	994.2
Romania	806.8	1,409.7	1,472.5	1,261.1	1,426.9	1,496.5	1,514.7
Slovakia	123.7	280	250.2	213.6	247.7	n.d.	244.3

Table 2. Cultivation of rape and turnip rape seeds: most important countries (Eurostat; x 1.000 ha)

	2010	2011	2012	2013	2014	2015
	EU-27	EU-27	EU-27	EU-27	EU-28	EU-28
European Union in total*)	7,105.60	6,748.21	6,208.90	6,710.67	6,714.22	6,888.70
Germany	1,461.20	1,328.60	1,306.20	1,465.60	1,394.20	1,285.50
Estonia	98.20	89.00	87.10	86.10	80.00	70.80
France	1,465.23	1,555.94	1,606.94	1,437.74	1,502.99	1,498.64
Italy	20.40	18.93	10.57	18.73	16.64	435.67
Hungary	259.30	233.90	164.92	197.65	213.72	220.56
Poland	946.10	830.10	720.30	920.70	951.10	947.10
Romania	537.33	392.67	105.30	276.60	406.71	367.89

Table 3. Cultivation of sunflower seeds (Eurostat; x 1.000 ha)

	2010	2011	2012	2013	2014	2015
	EU-27	EU-27	EU-27	EU-27	EU-28	EU-28
European Union	3,782.15	4,367.57	4,312.63	4,623.10	4,263.09	4,196.94
Bulgaria	729.88	747.13	780.8	878.64	843.64	810.84
Greece	80.64	98.52	85.27	98.46	84.74	107.21
Spain	682.52	862.87	753.02	865.56	783.43	738.85
France	692.27	740.72	679.97	770.73	657.36	618.16
Italy	100.48	118.07	111.68	127.63	111.35	114.45
Hungary	501.51	579.55	615.1	596.89	593.73	611.64
Romania	790.81	994.98	1,067.05	1,074.58	1,001.02	1,011.52
Serbia	169.38	174.27	185.91	188.18	175.36	166.19

In 2015, more than 11.5 millions of hectares were cultivated with EU oilseeds species (e.g. sunflower, soybeans, linseeds, rape, turnip rape).

Since the other by-products already have their own market, the residues that may successfully improve IBLC's are hulls. Depending on the species, recoverable hulls vary: in soybean and rape seeds they account for 10-15 % of the weight at the final plant, while for sunflower they account for 20-50 % of the seed.

It is difficult to give a detailed frame of the processing facilities and related processed material of oil seeds all over Europe because of the intense trading and industrial information confidentiality. Therefore, crushed oilseed data for the EU is found aggregated in Table 4.

Table 4. Crushing of oilseed in EU (Fediol; x 1.000t)

	2010	2011	2012	2013	2014	2015
	EU-27	EU-27	EU-27	EU-27	EU-28	EU-28
Groundnuts	23	34	32	32	34	34
Soybeans	12,612	12,106	12,558	13,226	13,209	14,197
Rapeseeds	22,250	22,296	22,492	23,149	24,585	24,940
Sunflower seeds	5,434	6,248	6,479	5,939	7,617	7,588
Cottonseeds	339	301	252	377	413	365
Linseeds	451	514	583	556	632	642
Sesame	0	6	21	5	0	0
Maize germs	323	280	462	376	427	498
Grape pips	93	165	155	102	92	86
TOTAL	**41,525**	**41,950**	**43,034**	**43,762**	**47,009**	**48,350**

Note: EU-27 without Luxemburg/Cyprus/Malta; only extra-EU imports and exports are accounted; Updated 18/08/2016

2.1.2 State of the sector

In the medium term a positive picture of the EU oilseed market is predicted, with a strong demand and attractive oilseed oil prices (EC, 2010) tendencies. Supply growth is expected to result mostly from a moderate yield growth and to a lesser extent from a slightly expanding oilseed production area, with some reallocation between crops. The expected increase in domestic use of oilseeds in the EU may also be driven by the growth in the emerging biodiesel and biomass industry following the initiatives taken by Member States in the framework of the RED. The trade balance is not expected to improve over the medium term as additional imports are required to meet the biofuel targets. Anyway, some limits still remain, focused on the aggregation of demand, development of farm structure, trends and processsing.

2.1.3 Typical size of the companies

As mentioned above, it is very difficult to give a frame of the industry size, number and capacity, due to information confidentiality.

The EU's vegetable oil and proteinmeal industry association FEDIOL, counts with a list of members that includes large companies operating at internationallevel. When comparing these figures with other sector industries, vegetable oil industries seem to be high sized and with more available economic assets. Thus, expected investing capacity would also be high, these could potentially support the development of IBLCs.

2.1.4 Degree of innovation

Innovation occurs mainly in the final product processing stages and not for by-products. The only feasible solution of innovation for residues could be hull pelletizing. Soy hulls are a by-product of soybean oil and meal production, they are utilised in the form of pellet in the dairy industry as a partial replacement for forage and concentrate since the fibre in soy hulls is rapidly fermented and highly digestible. Public data on hull pellet for energy purposes, except for some academic research data, are not available or easely accessible. Some researches have been conducted for instance in Slovakia and density and hasheses were pointed out as the main constrains[1].

2.1.5 Miscellaneous

FEDIOL conducted an LCIA (Life cycle impact assessment) of oil seed crushing to understand and quantify the magnitude and significance of potential environmental impacts.

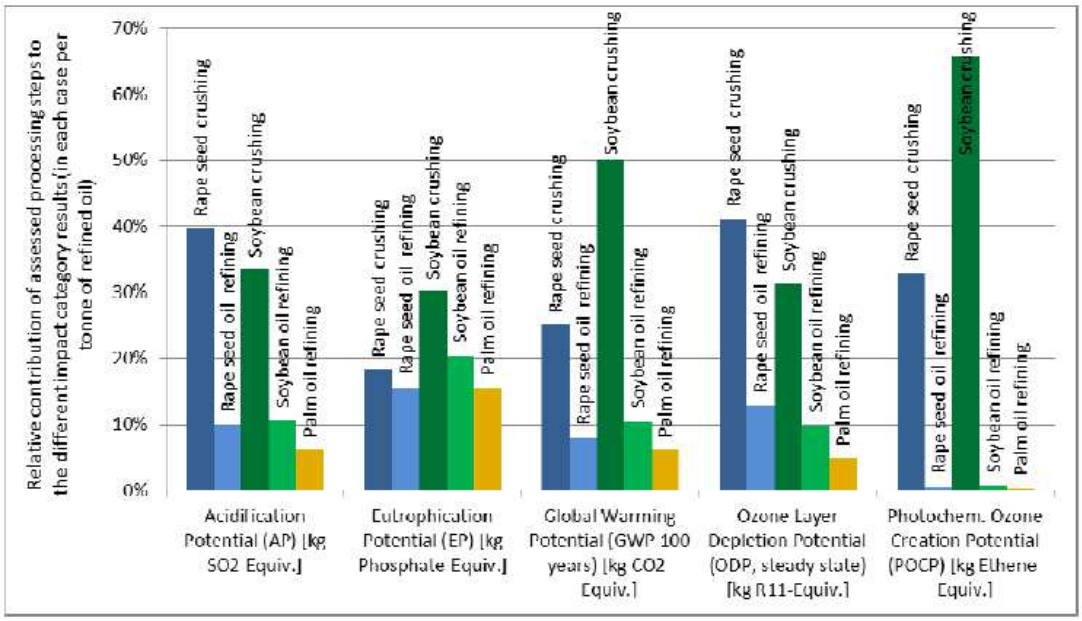


Figure 3. Relative LCIA results for the five environmental impact categories per tonne of refined oil (source: FEDIOL)

Results of the LCIA differ with the methods and on the adopted process and equipment. Emissions such as dust, chemical compounds during production (hexan) and refining and energy consumption

[1] http://iopscience.iop.org/article/10.1088/1757-899X/297/1/012003/pdf

associated with crushing are the main contributors to the results of the LCIA. Several by-products have an effect on the level of impact. Follow-up studies, including a detailed assessment of wastewater and wastewater treatment could assess reasons behind data variations.

2.2 Opportunities IBLC

2.2.1 Sector related residues

Several by-products are produced in oilseed processing. Among the by-products generally used in chemical industry (such as stearins, olefines, glycerine), the most interesting products for the purpose of the AGROinLOG project are, according to the Italian Thermo-technical Committee:

- Hulls: it is the first by-product in weight of oilseed processing. In soybean and rape seeds they account for 10-15 % of the weight, while for sunflower they account for 20-50 %. They are mainly made of cellulose and lignin and could be incorporated in fodder for ruminants and rabbits, medium-density fibreboards and packaging manufacturing, microbic biomass preparation (after acid/enzymatic hydrolisis of cellulose), furfurol production, energy generation.
- Expeller: made of seed residues in the downstream process of the mechanical crushing; the content in fatty matter varies from 8 to 15 %. The disadvantage is the potential formation of peroxides whose main hazards are their fire and explosion ones but they could also be toxic or corrosive.
- Meal: press cake with high protein content, residues of chemical extraction. It has a very low content in fatty matter. It is used as fodder although is not a complete feed but on the other side, its characteristics persist also in case of a long storage time.

These materials are now sent to the animal feed industry. The yield in seeds varies per crop species and per country. Table 5 reports the yield of rapeseed, sunflower and soybean in 2017 in various countries.

Table 5. Cultivation yields in seeds for rapeseed, sunflower and soybean in the highest producing countries in EU (x 1000 ha) (Source: European Commission; 2018)

	Rapeseed	Sunflower	Soybean
	T ha	T ha	T ha
Bulgaria	160.65	897.1	11.53
Czech Republic	394.26	21.6	15.34
Germany	1,308.9	18	19.1

Estonia	73.79	-	-
Greece	5.01	77.1	3.61
Spain	91.21	716.33	1.66
France	1,408.42	586.7	141.03
Italy	15.62	114.45	322.42
Hungary	256.53	641.66	77.27
Poland	900	2.5	5.7
Romania	598.5	993.23	151.15
Serbia	19.4	221.7	203.1

2.2.2 Potential synergies & benefits

As for hulls (the only by-product that seems reliable for IBLCs), the main use may be in biopower/CHP plants. Synergies with bioenergy plants, as well as domestic heating plants, could be a good occasion to improve the positivity of the related LCIA and the economical balance of the crushing facility.

However, due to the low mass volume (density) of the bulk material, transport costs play a key role. For this reason, the shorter the transport distance is, the better is the performance of the value chain.

Pelletizing improves transport issues and should be considered. For instance (according to Debco project' results, www.debco.eu), bio power plants in Belgium use only imported pellets. If developed, this sector could represent a good opportunity for an IBLC set up. The use of European sources of feedstock could be financially beneficial.

Just to give an example, the costs of hull production are considered as part of the oil production costs. Pelletizing costs range between 10 and 12 €/t. A semi-trailer with a capacity of 20 t, can be loaded with no more than 12 t of hull pellets, and the transport cost (including handling) is around 1,5 €/km. This means that for 100 km, the price at the plant gate accounts for 24 €/t. Obviously, economies of scale would also lower the costs.

Residues could also be incorporated in fodder for ruminants and rabbits, medium-density fibreboards and packaging manufacturing, microbic biomass preparation (after acid/enzymatic hydrolisis of cellulose), furfurol production.

Although vegetable oil extractor industries could 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, etc., which could be very useful at the time of implement an IBLC in their facilities.

2.2.3 Market developments

In the European vegetable oils market (in term of seeds and oil) the main operators are farmers, traders, processors of oilseeds and of raw vegetable oils (producing refined oils and meals). Among them, secondary processors (such as industries for food, feed, biodiesel and bio-based material production as well as final distributors) play an important role in the supply chain. As described above, final uses range from biodiesel and oleo-chemicals industry to oil used in food industry.

Transportation and storage are very important in trading and delivering of all products and derivative products between the actors in the chain.

The market situation shows different integrations between the actors along the value chain, including all the actors. These integrations allow to increase the whole value chain. For instance, some companies processing oilseed operate also in storage and trading across the chain, while others are involved in vegetable oil processing (e.g. margarine, biodiesel and bottling). Some firms are involved in compound feed production. Over the past 20 years, the market has been characterised by several waves of company mergers and acquisitions. Due to the confidential information of companies, it is very difficult to have a complete frame of each company business.

Most of the raw material comes from EU countries and from international traders, although initial collectors such as cooperatives have an important role, in the supply chain farmers play a limited role.

For the IBLCs implementation, it may be suggested to take into account the main companies which are well integrated and have a good involvement in the market (i.e. Unilver, Bunge, Sovena, Glencore, AAk, etc.).

As for hulls, due to their phisical cacteristics, they are trated mainly at local level. Maybe an increase of the materials density (tons/m^3), such as pelletizing, briketting, etc. might improve the trade in the European market.

As for technical barriers, the ash content has to be taken into account: a high content in ashes could affect the bioenergy plant performances. Thus, this kind of material should be considered as part of a fuel mix. In addition, pollutant emissions during combustion have to be taken into account.

2.2.4 Non-technical barriers

The main non-technical barriers are related to citizens' acceptability regarding bioenergy plant emissions. As for the acceptability of the storage, transport and use of hulls, no major barriers are considered in terms of their impact on citizens.

The composition of residues (mainly lignin), and the cost of transport and spreading make it unsuitable for its use as a soil improver.

New stricter regulations could enter into force at EU or national level, requiring tighter controls to imported raw materials, limiting the entry of required products for the vegetable oil extractors, and so, negatively affect the vegetable oil industry and, as a consequence, the implementation of IBLCs.

The high investments costs for biomass processing could represent in many cases a significant financial barrier for many companies.

No other non-technical barriers are specifically foreseen for this sector.

OLIVE OIL CHAIN

2.3 Profile of the olive oil sector

2.3.1 Production and volume of the sector

With more than 5 millions of hectares, the EU is the leader of the olive sector, producing around 70 % of the worlds' output. Olive production is concentrated mainly in Mediterranean area, where it plays a significant role in the agricultural economy (Figure 3) .

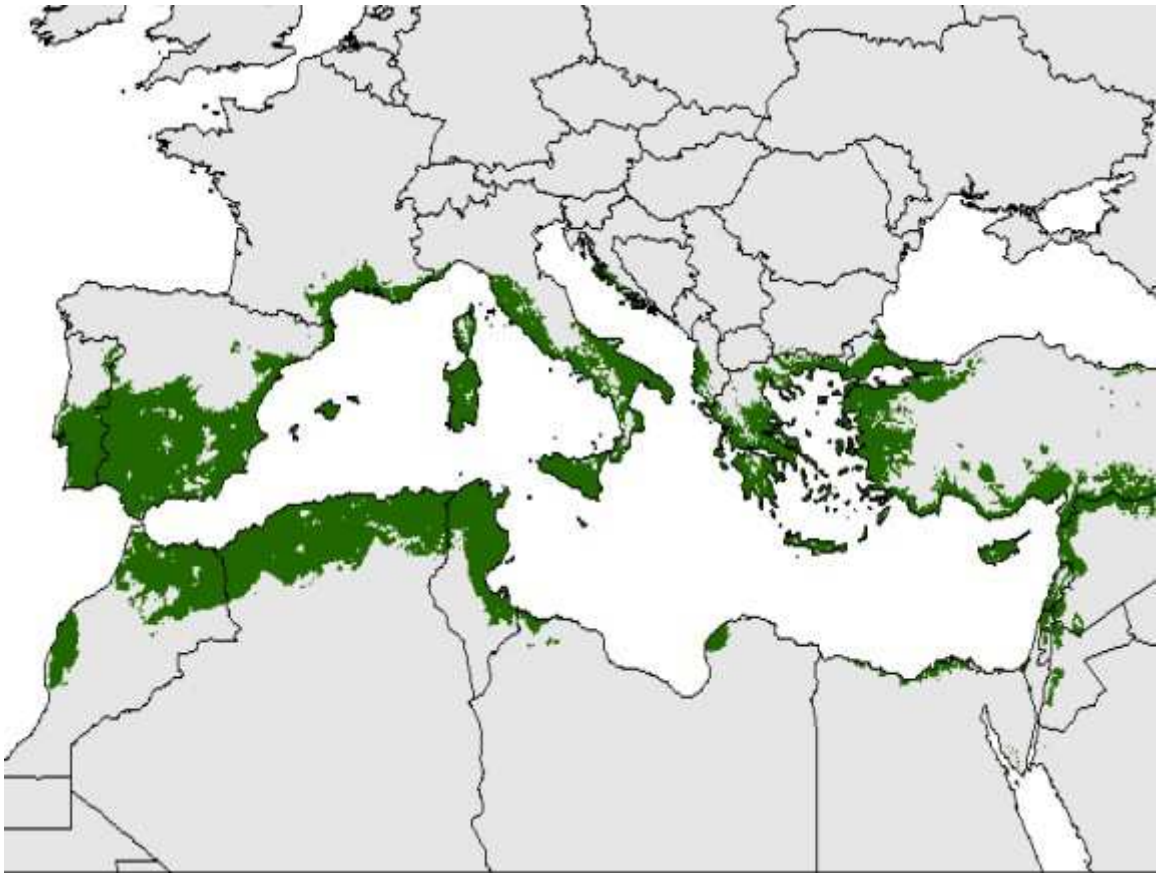


Figure 4. Distribution areas of Olea europaea (Source: J. Oteros, Phd thesis, University of Cordoba - Spain, 2014)

The characteristics of the olive oil are established and framed by the International Oil Council and the European Commission that define oil quality and authenticity for a correct classification. On the basis of specific analytical parameters (e.g. the free acidity, peroxide value and UV specific extinction coefficients and other markers), there are three marketable classes of olive oil: extra-virgin, virgin and lampante.

There are three technologies for olive oil extraction: i) the traditional process, ii) 3-phases decanter process and iii) 2-phases decanter process.

In the traditional process, the ground paste is pressed between mats, in order to extract oil and water. The oil is separated by decantation. The 3-phases decanter system requires the addition of 1 litre of water per 1 kilogram of paste. After the horizontal centrifugation, the oil must is processed in a vertical centrifugal machine to separate oil from water. Finally, the 2-phases process is similar to the 3-phases process, but instead of adding water, the vegetable water is recycled.

The main difference is related to the moisture content of residues: 2-phases pomace has a moisture content of 50-70 %, while that of traditional pomace is 25-30 %. Pomace from 3-phases process has a moisture content of 40-60 %.

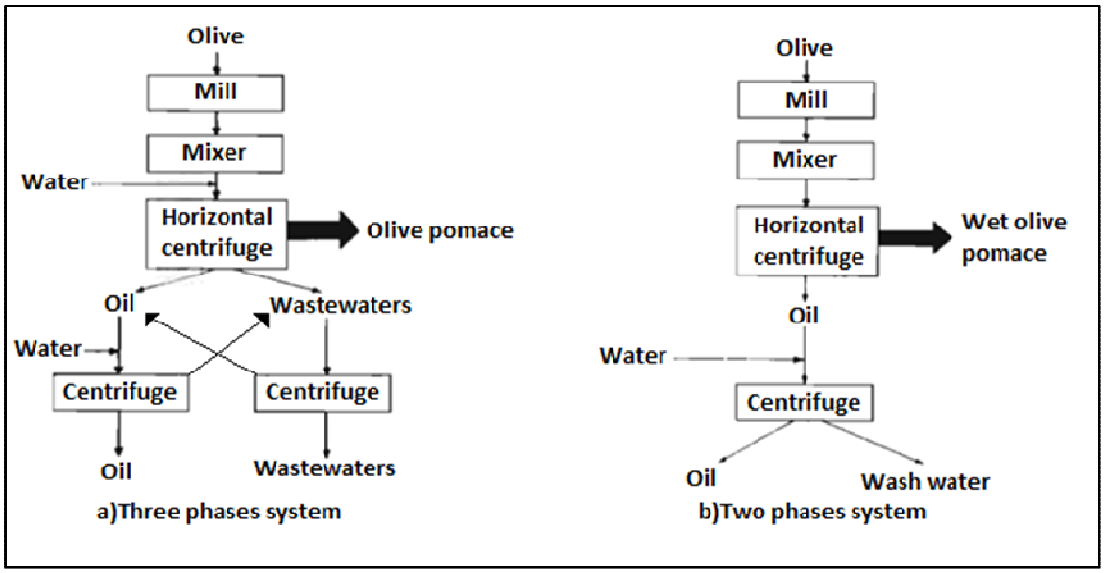


Figure 5. Comparison between three and two phases systems. Source: Expoliva, 1993

For 100 kg of processed olive, the residues/by-product are:

- for traditional extraction, 20 kg of oil, 45 kg of water and 35 kg of pomace (at 25-30 % in moisture content);
- for the 3-phases process, 20 kg of oil, 75-125 kg of water and 55 kg of pomace (at 40-60 % in moisture content);
- for the 2-phases process, 20 kg of oil, 1-2 kg of water and 78-89 kg of pomace (at 50-70 % in moisture content).

Table 6 below presents cultivated olive area in the EU in 2015.

Table 6: cultivated area with olive in EU, 2015 (x 1.000 ha)

	X 1.000 ha
EU	5,029.20
Greece	969.91

Spain	2,526.50
France	17.21
Croatia	19.10
Italy	1,134.05
Cyprus	10.01
Portugal	351.34
Slovenia	1.08

In Spain, Italy and Portugal, the olive tree/farming surface represents 8-9 % of the total agricultural national surface (national UAA), while in Greece it is 20 %.

With reference to the total EU surface dedicated to olive farming, and taking into account only the member states with more than 1.000 ha (which is considered as the threshold in the orchard survey at EU level), the majority of olive tree cultivated is situated in Spain (53 %), Italy (24 %), Greece (15 %) and Portugal (7 %).

Other member states (France, Croatia, Cyprus and Slovenia) represent together only 1 % of the total EU surface cultivated with olive trees.

Olive trees are characterized by their longevity: the 41 % of trees in EU are less than 50 years old, while the rest could be more than 100-200 years old. More than 2.7 millions of hectares are at least 50 years old, 313 000 ha are 5-11 years old and around 130 000 ha are "young" (> 5 years old). Older trees have a higher production in prunings and represent a very interesting source of biomass. Trees older than 40 years produce the greatest amount of dry biomass per hectare (2.3 t ha) showing significant differences with trees younger than 40years (0.8-1.4 t ha)[2]

2.3.2 State of the sector

The most important producer of olive oil in EU is Spain, followed by Italy and Greece. Table 6 presents the olive oil production from 2006/2007 to 2015/2016.

Most of the produced olive oil is consumed in the main producer countries. Table 7 gives a figure of the EU production of olive oil..

[2]https://www.researchgate.net/publication/251628918_Quantification_of_the_residual_biomass_obtained_from_pruning_of_trees_in_Mediterranean_olive_groves

Table 7. Olive oil production from 2006/2007 to 2015/2016 (source: International Olive Oil Council; x 1.000 t)

	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Cyprus	8.3	4.0	2.8	4.2	6.5	6.5	5.6	3.8	6.2	6.0
Croatia								4.6	1.1	5.5
Spain	1,111.4	1,236.1	1,030.0	1,401.5	1,391.9	1,615.0	618.2	1,781.5	842.2	1,401.6
France	3.3	4.7	7.0	5.7	6.1	3.2	5.1	4.8	1.7	5.0
Greece	370.0	327.2	305.0	320.0	301.0	294.6	357.9	132.0	300.0	320.0
Italy	490.0	510.0	540.0	430.0	440.0	399.2	415.5	463.7	222.0	474.6
Malta								0.0	0.1	0.0
Portugal	47.5	36.3	53.4	62.5	62.9	76.2	59.2	91.6	61.0	109.1
Slovenia	0.3	0.4	0.5	0.7	0.7	0.5	0.2	0.6	0.2	0.5
Total	**2,030.8**	**2,118.7**	**1,938.7**	**2,224.6**	**2,209.1**	**2,395.2**	**1,461.7**	**2,482.6**	**1,434.5**	**2,322.3**

Regarding the husk price (resulting from any extraction process), one can say that it depends on the local market and the related moisture content, therefore it is difficult to give a fixed price. In fact this strictly depends on confidential agreements between companies.

Table olives present another sector. The world producer of table olive is the EU, followed by Egypt, Turkey and Algeria. Within the EU, Spain and Greece play a key role (Figures 6-7).

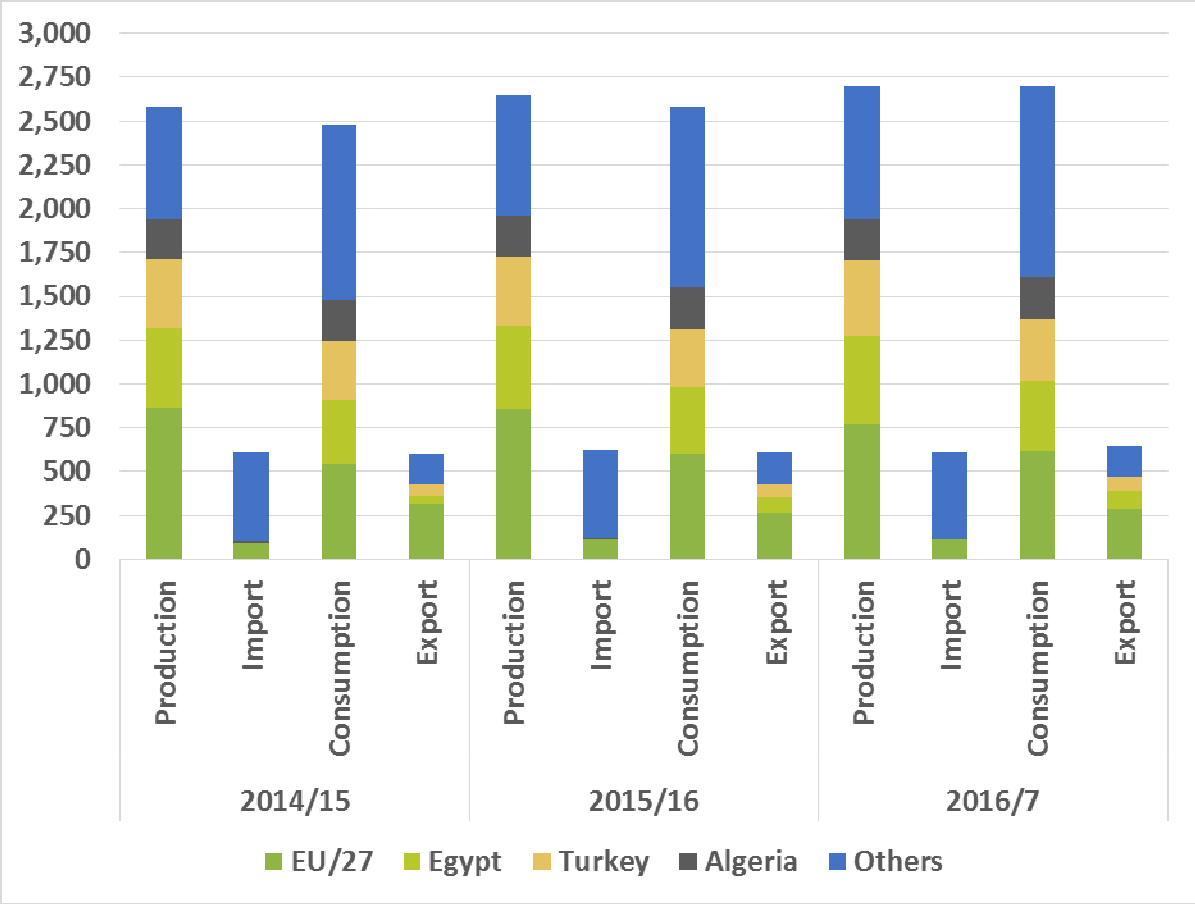


Figure 6. Table olive production, import, consumption and export (at global level; x 1.000 t; source: IOC)

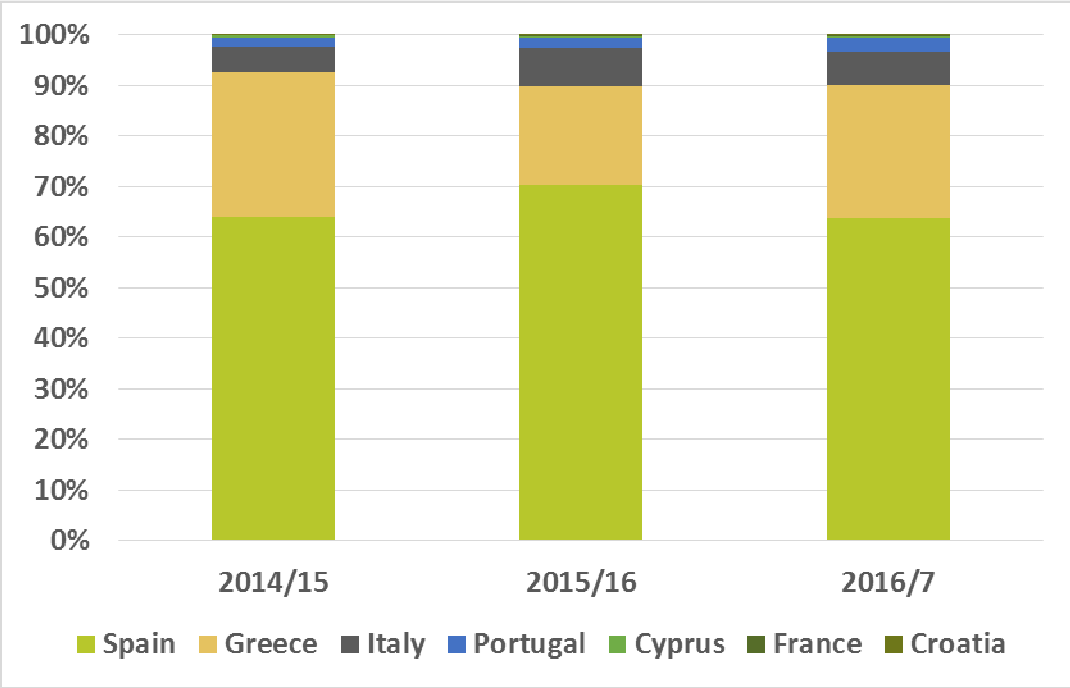


Figure 7. Table olive production within EU (source: IOC)

The main commercial table olives production processes are:

- Treated green table olives in brine: olives are treated in alkaline lye and placed in brine, in which a lactic fermentation takes place. Once the fermentation is complete, the olives need just appropriate physiological-chemical conditions to ensure their preservation: partially fermented olives are preserved by sterilization, pasteurization, addition of preservatives, refrigeration or by inert gas (without leaving them in the brine). This process is generally known as "green olives in brine".
- Untreated natural black olives: olives are placed directly in brine and usually retain a slightly bitter taste. Preservation occurs through natural fermentation in brine. They are usually known as "natural black olives in brine".
- Black (ripe) olives in brine: they are obtained from fruits which, when not fully ripe, have to be darkened by oxidation in alkaline lye. Through this process, the bitterness is removed. They are preserved by heat sterilization (under anaerobic conditions). The common product type is "ripe olives".

Among these, there are other trade preparations such as: untreated black olives in dry salt, untreated naturally shrivelled black olives, dehydrated black olives, etc.

2.3.3 Typical size of the companies

The sector is characterized by a lot of small oil mills. In Spain, for instance, there are more than 1.800 olive oil mills. There are several brands that work with local producers both in olive mills and importing.

Although most of such local companies do not have adequate size and conditions for the implementation of the IBLC concept in their facilities, many of them could have enough workforce and financial assets to ensure the success for the biomass related activities.

In some EU countries such as Spain, association and cooperatives including small companies of the area are present, this allow to collect more residues solving the size problem, as well as to share the investment costs and thus, reduce risk for the IBLC activities.

Unfortunately, it is not possible to get specific data.

2.3.4 Degree of innovation

For the olive oil sector, the most important degree of innovation is the shift of the processing from 3-phases to 2-phases processing. This allows less water to be disposed, although the moisture content in the pomace is higher. Thus, technical solutions for lowering the moisture content of pomace have to be investigated.

Innovation for both olive oil and olive for table include new stations with sensors able to collect data on atmospheric, soil, and biological parameters, such as air and soil temperature, air and soil humidity, soil salinity, leaf wetness, rainfall, solar radiation, and so on. Combined with other information, that data is used to accurately calculate a plant's need for water, identify the best time for irrigation, assess the risk of infection from pests and diseases, monitor plants' vitality, determine fertilization needs, and predict the quality and quantity to be produced.

2.4 Opportunities IBLC

2.4.1 Sector related residues

The residue from olive milling is the pomace, that can be used for domestic heating and industrial power generation. A consolidated market does not exist for this material, however, it represents a good opportunity for IBLCs since it can allow the start of new biomass activities involving different actors in agro-industry and transformation chain for the production, use and market of an high added value commodity.

According to studies done by Agriconsulting, around 5 t/ha pruning can be recovered, 3 t of dry matter per hectar (Agriconsulting ProEN.RI 2005). The recovering of such material needs a good organization and logistic (equipment and transport). Pelletizing studies are currently being conducted on the use of different type of raw materials from olive grove residues considering different physical and chemical properties of pellets, that influence the application of pellets. However, research is still needed regarding the effects of raw material characteristics, seasonal variations, collection and storage of raw material as well as the manufacturing process to facilitate a steering of production in the desired direction to produce pellets from olive prunning that meet the quality standards requirements established by other norms and in consonance with the specific application of pellets (Maravel G. et al. 2010). Therefore, pruning material should become the focus residue.

Additionally to pomace, different compounds can be extracted for several uses i.e. hydroxytyrosol and other biophenols can be exstracted and they have a very high antioxidant activity (E. De Marco

et al. 2007). Such bioproducts can improve the market and the acceptability of conversion plants. In addition, bioproducts have a very good potential market.

2.4.2 Potential synergies & benefits

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.

Oil mills can have assets that could be of great interest for developing an IBLC. Among these can be mentioned 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 bio-commodities manufacture or bio-energy production.

Moreover, prunings represent a potential benefit for farmers through income and power/CHP, as well for mills involved in storage (e.g. cost and less time for storage). For chemical bioproducts the husk can represent a good source of raw material. Among them, polyphenols are a widespread group of secondary metabolites, representing the most desirable phytochemicals because of their potential to be used as additives in food, cosmetics, medicine, and others fields (I. Volf, V. I. Popa 2018).

2.4.3 Market developments

Olive oil sector residues provide the opportunity of manufacture several bio-commodities demanded by markets.

Heat and power of the solid fraction and other chemicals can be extracted from solid and liquid by-products.
The most developed technologies are related to:

- Polyphenols;
- Compounds for cosmetics industry;
- Painting additives;
- Insulating Panels for construction.

2.4.4 Non-technical barriers

Some non-technical barriers are foreseen for pomace and pruning use for energy production. In some regions, the fuels produced from biomass are classified as “waste” and therefore it is not allowed to be used in small-scale boilers (e.g. in households). Wood biomass is used as the reference while agricultural biomass is not recognized. Regulatory barriers at the EU level create difficuties for pruning use, such as the eco-design requirements for small stoves (<50kw) and boilers (<500kw), which put stringent limits on emissions, making it likely that only A1 forestry chips and ENPLUS pellets will be able to be used (Regulation (EU) 2015/1189). This would significantly limit local markets for prunings, which are mainly used for small scale consumption. Whilst the regulations give exemptions for certain uses such as air heating, and resources such as mixed pellets of prunings and straw, this will continue to limit value chain creation (EuroPruning 2017).

Market barriers are related to the low prices of wood biomass that make it difficult for agricultural by-products to compete in a wood biomass saturated market. In addition, it is difficult for biomass

fuels to be competitive in the market dominated by natural gas heating, especially for the agricultural biomass since its use is more complicated than natural gas. Moreover, in some countries different taxing rates are applied to raw material, product and fuel.

Finally, the use of agro-fuels compared to wood fuel requires on the one hand higher investment costs resulting from critical fuel parameters and on the other hand increased maintenance and repair costs due to abrasion and increased ash content.

WINERIES AND DISTILLERIES

2.5 Profile of the wineries and distilleries sector

2.5.1 Production and volume of the sector

The EU is the world wide leader in wine production: the surface accounts almost to 50 % of the global area dedicated to vineyards, while the production in volume is 65 % (Figure 8; data are referred to 2005, but slight modifications have occured; the aim is just to give an idea of the cultivation basin).

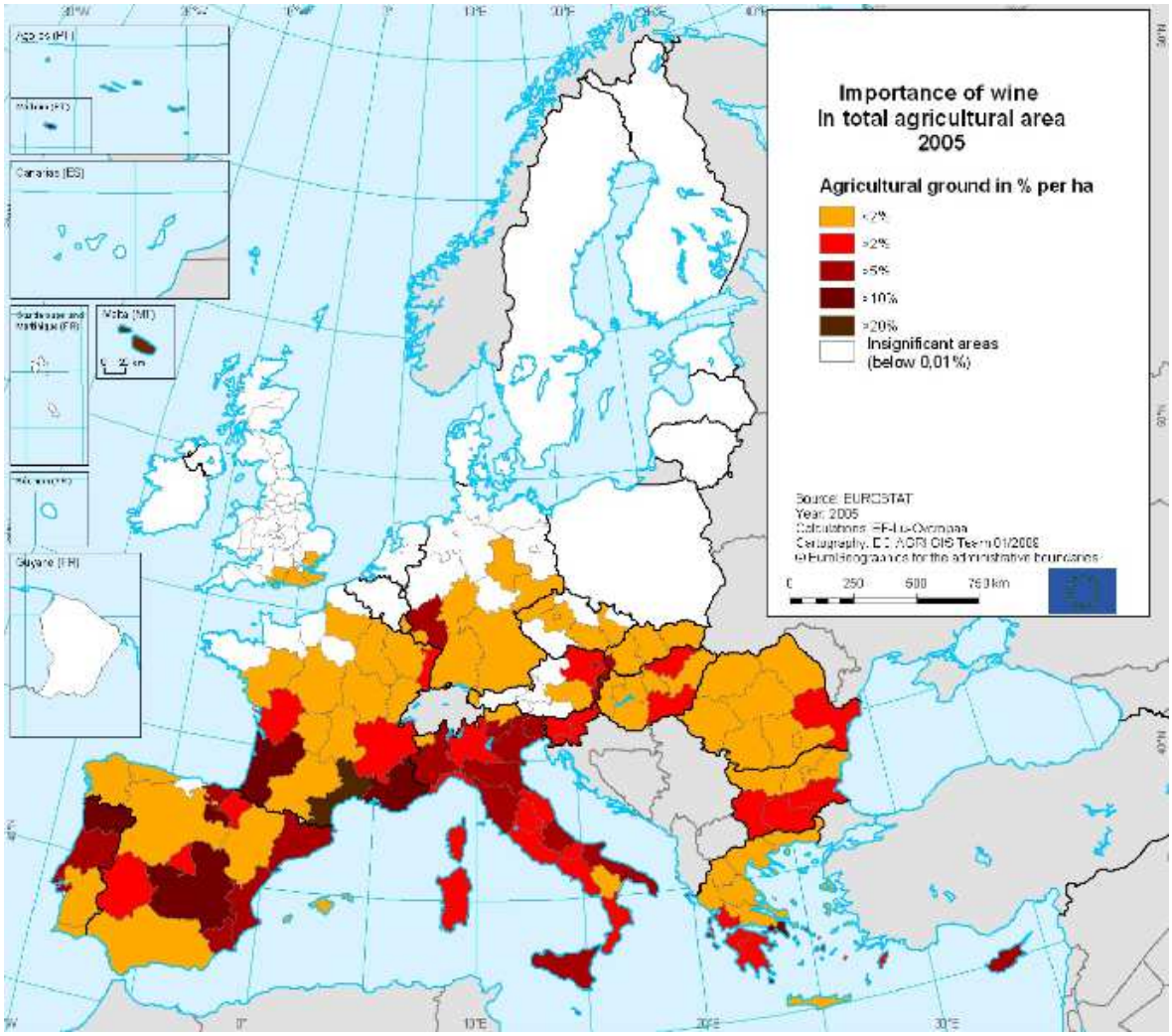


Figure 8. Wine grape surface on total agriculture area (source: Eurostat, 2017; elaborated by European Commission)

In 2014 and 2015 (Table 8), Spain represented 30 % of the total wine grape area in EU, followed by France (25 %) and Italy (21 %).

Table 8. Most important Member States as per cultivated surface with wine grape in the EU (source: Eurostat, 2017; x 1.000 ha)

	2010	2011	2012	2013	2014	2015
EU-28	**3,218.03**	**3,112.87**	**3,088.53**	**3,090.24**	**3,049.71**	**3,044.78**
Germany	99.91	99.75	99.58	99.49	100.08	99.91
Greece	65.56	61.37	61.32	65.92	66.17	65.63
Spain	984.14	945.67	930.2	930.82	931.17	925.32
France	772.41	758.37	755.35	755.15	752.07	747.10
Italy	709.25	661.94	647.04	656.17	637.68	634.64
Hungary	70.16	71.82	68.86	65.96	67.37	68.94
Austria	43.66	43.84	43.62	43.62	44.79	44.79
Portugal	177.66	176.99	176.99	176.98	176.88	176.87
Romania	165.06	166.41	168.03	168.97	167.56	169.55
Serbia	22.50	22.20	21.20	21.20	21.20	21.20

As for grape production (Table 9), due to the different yield, in 2015 the main producer was Italy (30 %), followed by France (26 %) and Spain (23 %).

Table 9. Most important EU Member States for wine grape production (source: Eurostat; x 1.000 t)

	2010	2011	2012	2013	2014	2015
EU-28	**22,497.48**	**22,937.22**	**20,887.68**	**24,611.81**	**22,612.58**	**23,647.76**
Bulgaria	210.40	228.50	251.40	305.9	124.93	244.78
Germany	953.41	1,251.08	1,227.18	1,139.48	1,244.82	1,199.03
Greece	611.62	530.67	566.41	598.51	598.94	574.13
Spain	5,875.65	5,565.37	5,088.00	7,224.01	5,978.49	5,527.10
France	5,868.82	6,595.27	5,326.82	5,501.21	6,156.92	6,212.82
Italy	6,426.80	5,902.90	5,861.43	6,902.04	5,932.17	7,005.60
Hungary	279.08	431.18	340.41	433.97	390.46	457.92
Austria	231.66	375.3	287.3	318.93	266.49	302.45
Portugal	928.17	730.52	823.71	810.27	804.08	915.60
Romania	684.95	817.96	693.04	932.75	743.81	752.85
Serbia	171.99	193.98	149.22	199.95	122.49	170.65

2.5.2 State of the sector

Europe is the largest producer of wine in the world, and most of this production is concentrated in the south. Most opportunities for developing countries can be found in the other countries, such as the United Kingdom, the Netherlands, Austria, Germany and Belgium. Due to insufficient domestic production in these countries, consumers are more open to foreign wines. Although the Eastern European markets are still relatively small, wine markets there are growing and also provide opportunities.

Besides wine grape production, the amount of wine produced in EU is reported in Table 10.

Table 10. Wine production in EU) (source: FAS Europe Offices; x million litres)*

	2012/2013	2013/2014	2014/2015
France	4,136	4,149	4,650
Italy	4,412	5,243	4,442
Spain	3,560	5,355	4,161
Germany	900	838	930
Portugal	630	624	589
Romania	410	520	370
Greece	311	334	290
Other EU-28 countries	701	990	853
EU-28	***15,060***	***18,053***	***16,285***

**) Volume of product removed from fermenters after the first natural fermentation of the must of fresh grapes (juices and other musts excluded)*

The most important countries in terms of wine production are France, Italy and Spain, producing 23-30 % each of the EU-28 total production.

Total European wine exports amounted to €18.7 billion in 2015, recording an average annual increase of 3.8% between 2011 and 2015. About 55% of European exports is destined to end up in other European countries. Countries in Eastern Europe are also becoming attractive destinations for European wine. Although exports to Eastern European countries are still small, exports to Poland and Czech Republic recorded annual increases of 9.0% and 1.1% respectively in 2015. Other attractive export markets for European wines are traditionally the Unites States, Japan, Canada and Singapore. Those countries are seeing an increase in wine consumption. Spanish wines are increasingly exported to Japan because of the favourable price/quality ratio. Due to an economic crisis in Russia, European wine exports to Russia declined by 27.7% in 2014. China is an emerging destination for European wine (4.1% average annual increase in wines from Europe since 2011) (CBI NL 2016)[3].

2.5.3 Typical size of the companies

Small cellars with "in-house" grape processing can be found commonly throughout the EU. The sector is characterised also by cellars collecting wine grape (private and co-operatives) that process it. To understand this better, further analysis for each countries is needed.

[3] https://www.cbi.eu/market-information/wine/what-demand/

Since the main biomass is grape, IBLCs opportunities should concentrate in distilleries. Considering their wide experience in residues management, the ownership of compatible equipment with the biomass processing and the considerable amounts of raw material that distilleries usually receive, these industries are very likely to become succesful IBLC's.

2.5.4 Degree of innovation

The wine sector is characterized by the fatc that from one side is anchored to a sector that sometimes could be reluctant to innovation like the agrarian one and, by the other side, to another more active on innovation like food and beverages sector.

As for the innovation degree, data from the European AGROinLOG partner show that the most important innovations are related to increasing the efficiency of the fermentation and extracting processes, as well the cost reduction.

Over the last few years, Europe saw a significant progress in improving technologies for viticulture and enology and in improving wine quality and production of wine with geographical indication. Legislative Decree 61/2010, replaced by Law No. 238 of 12 December 2016 "Regulation on the organic cultivation of grapes and the production and trade of wine", with which the previous Law 164/1992 on designations of origin for wines was revised at national level, established that DOCG and DOC wines merge together in the PDO wine category, while IGT wines are identified with the acronym already in place for similar food products (PGI). The new regulation renders the link between the wine's characteristics and its geographical origins even stronger, as the link with the territory is specified in the product specification. It is obligatory for the vinification and bottling areas to correspond; there is loss of right to claim a particular designation for musts and wines that are suitable to become a PDO or PGI if they are not produced within the specific production area (Qualivita foundation, 2017).

A new generation of sensor-driven viticulture tools is giving growers the ability to monitor and measure their vines. Unfortunately, most of new technologies aiming to this are strictly confidential, and no detailed information can be given at European level. Some projects have been funded by the European Framework Programmes i.e. ORWINE whose aim was the development of environment and consumer friendly technologies for organic wine quality improvement and scientifically based legislative framework (CORDIS).

2.6 Opportunities IBLC

2.6.1 Sector related residues

The main by-products of wine production are untreated grape marc and the prunings. Athough prunings collection on fields could play a key-role, grape marc is the residues offering the best opportunities for IBLCs because exhausted grape pomace can be used for the extraction of bio-compounds (such as polyphenols, tartaric acid or grape seed oil), feed manufacturing, compost production or as a solid biofuel for energy production.

Untreated grape marc is made of:

- Skins;
- Grape seeds, (2-3 per grape berries). They have a hard epidermis protecting them from fermentation and distillation, they can be separated from the marc for oil extraction;
- Stalks, that can be present or not. They affect the storage of the marc.

Table 11 reports the product and by-products of grape.

Table 11. Average yield in products and by-products of processing 100 kg of grape (source: Agriconsulting).

Typology	Quantity (kg)
Must (skin excluded)	80-85
Skins	9-10
Grape seeds	3-4
Stolks	3-4

Must (with or without skins, depending on the vinification process) is sent for fermentation to produce wine. When the vinification is completed, the skins are removed. Seeds can be used for oil extraction or left in the marc. Marc is then sent to distilleries, in order to obtain ethanol (spirit, grappa, etc.). Distilleries also blend untreated grape marc with wine lees (the residue decanted in the fermenter, made of inactive yeast residues, potassium salt and tartaric acid). The final product of distilleries is the exhaust marc. It can be used for feeding (in mix with other products), or be mixed with grape stalk, for energy production. Wine residues can have other uses in the following markets:

- Direct on-field agronomical use (the quantity per hectares depends on national and local legislation and soil characteristics);
- Indirect on-field agronomical use, through conversion into fertilizers;
- Energy use;
- Pharmaceutical, cosmetic use and other bioproducts production;
- Extraction of poliphenols, enocyanin and other compounds for feed industry.

Table 12 estimates the gross availability of by-products per country. After distillation, 90-95 % of the residues are obtained.

Table 12. Estimation of by-product production from grape for the most important wine producers in the EU (x 1.000 t; 2015)

	Grape processed	Skins	Grape seeds	Stalks
EU-28	**23,647.80**	**2,246.50**	**827.7**	**827.7**
Germany	1,199.00	113.9	42	42
Greece	574.1	54.5	20.1	20.1
Spain	5,527.10	525.1	193.4	193.4
France	6,212.80	590.2	217.4	217.4
Italy	7,005.60	665.5	245.2	245.2
Hungary	457.9	43.5	16	16
Austria	302.5	28.7	10.6	10.6
Portugal	915.6	87	32	32
Romania	752.9	71.5	26.3	26.3

In addition, prunings represent a good source of biomass. According to Agriconsulting experience, their recovering (at least 2 t/ha of dry matter) requires setting up a logistic plan (e.g. in the south of Italy there are companies specifically working in this field). The destinations cover power production, gunpowder production as well as the extraction of chemical compounds.

Pellet from vineyard residues fulfil the specifications of the type B non-woody pellets (European Pellet Council 2011[4]); however, during combustion test of vineyard-based pellet the high emission of CO indicates incomplete combustion; and vineyard-based pellet NOx emissions are more than double compared to those obtained during the control tests, confirming that the analysed vineyard-based pellets are unsuitable, as they are, for use in traditional pellet stoves (Zanetti et al., 2017). Moreover, since vineyards are exposed to treatments based on Cu and Zn, those metals last in wood residues during the pruning while the European Standard about general requirements of solid biofuels establishes Cu values for different biomasses for energy use. As a consequence, the use pruning residues is preferably in large-scale power plants with appropriate emission filters instead of small-scale boilers or plants (D. Duca et al. 2016).

Another by-product is the seed which, for its oil quality, has its own market all over Europe for pharmaceutical uses. Grape seed oil is an excellent cosmetic ingredient for controlling moisture of

[4] http://www.infobio.ru/sites/default/files/ENplus-handbook-3.5.11.pdf

the skin. According to a report of an independent study published in Free Radical Biology and Medicine, grape seed oil can also accelerate the healing process of wounds on human skin and can also be valuable for the cure of any acne problems. It is rich in vitamin E, linoleic acid, omega fatty acid and antioxidants and it provides moisture and protection against free radicals. As stated by the University of Maryland Medical Center, grape seed oil is able to increase the amount of antioxidant in the blood and to maintain the existence of collagen and elastin (E. Sotiropoulou et al. 2015)[5].

2.6.2 Potential synergies & benefits

The main synergies regard the storage yards and use of marc for energy and bioproducts production. Marc is generally stored in piles (preferably under a roof), while prunings can be stored in piles (if they are already chipped on field) or in bales. Among storage yards, good synergies can be reached with the bioproducts production. Also here, the confidentiality of information plays a key role.

Residues for energy production have already been tested and used. But results on grape marc components put in evidence some difference in terms of ash and chemical elements content, which represent, specifically for these materials, the most critical aspects to take into account in combustion heating systems.

Other by-products show minor potential synergies.

2.6.3 Market developments

Wine sector residues offer the opportunity to extract several bio-compounds with a wide range of benefits applied to different fields and, thus, arising as a chance for targeting different markets from food, feed to bio-based ones.

By-products are used mainly for energy generation (burning in form of chips). Most of the harvesters produce bales while others produce short sticks limiting soil contamination and preserving biomass quality.

Actually new technologies are emerging for chemical compounds (e.g. Anthocyanins, Flavonoids, etc.). Due to the increasing cost of chemicals and the increasing demand for sustainable sources, the by-products from grape residues represent a really interesting pathway. A dedicated and deeper investigation would be needed in order to know operators, volumes and expected income. As for costs, no public data are available for by-products being send for chemical processing, while for cipped prunings used for energy generation the price is in the range of 85-115 €/t (for domestic use). In case of long term contracts with power plants the price can be approx. 70 €/t (it depends on private agreements).

[5]https://www.researchgate.net/publication/312578959_GRAPE_SEED_OIL_FROM_A_WINERY_WASTE_TO_A_VALUE_ADDED_COSMETIC_PRODUCT-A_REVIEW

2.6.4 Non-technical barriers

Non-technical barriers may be expected, especially for material converted in bioproducts. In addition, some countries face problems related to plant diseases (i.e. vine yellows), and plant protection and inspection are often ineffective.

Referring energy production, non-technical barriers are similar to the ones describe in the above section 3.2.4 about olive waste.

3 FEED AND FODDER

3.1 Profile of the feed and fodder sector

3.1.1 Production of the sector

Animal feed industries final products are homogeneous mixes of several raw materials such as: grains, cereals, vegetable and animal by-products and components like oil and fats, molasses, vitamins and minerals from which a balanced and nutritious food is achieved.

Fodder industries process herbaceous matter for better preservation of the nutritious elements contained on it through three different industrial processes; silage, haymaking and dehydration.

This chapter basically deals with animal feeding. Two different sectors may be defined for this study:

- Feeding of animals used for breeding such as cows, pigs and other edible animals;
- Feeding of pets.

Generally the production of animal feed comes from residues of other agricultural processes, and it is sold in form of pellets. The present food–feed–food system is shown in Figure 9.

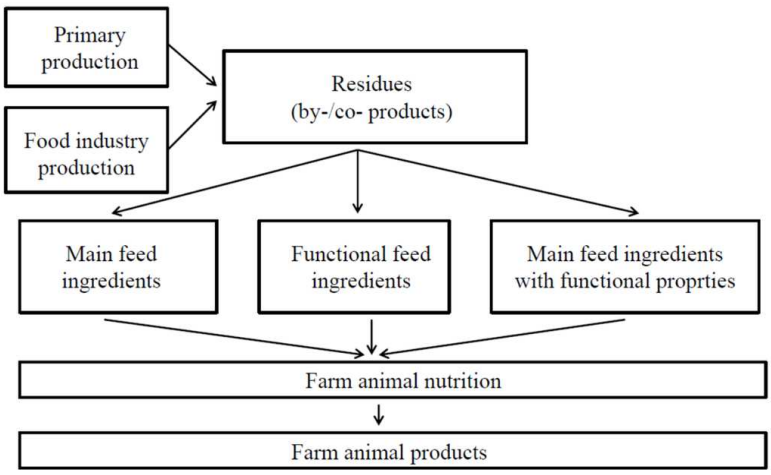


Figure 9. Simplified schematic presentation of the food–feed–food system (source: Agriculture 2015, 5(4), 1020-1034)

Fruit and vegetable industry co-products are collected either from primary production fields, such as in the case of olive leaves, or from the processing factories, such as with pomaces; they are then used either as unprocessed residue or are subjected to processing. Processing procedures may involve drying, since most of these materials have a high moisture content that leads to product spoilage, or they may be subjected to advanced processing/biorefinery techniques for the collection of specific compounds such as phenols, vitamins, fatty acids, or carotenoids. The

moisture content of olive cake moisture stands around 30%–50% [36], and the average moisture content of grape pomace is approximately 64% (E. Kasapidou 2015).

Thus, residues can not be considered as an important source for an IBLC facility.

3.1.2 Volume of the sector

Pig feed, based on maize, cow milk, fish flower and essential amino acids, represents the main output of the sector. Regarding cattle feed, the situation is very contrasted across Europe, depending on the weather conditions for forages production.

The effect of the quota regime, with a +1 % of milk delivery in 2015/16 vs 2014/15, was hardly foreseeable for the compound feed industry EU-wide, with an overall 1 % decrease in industrial cattle feed.

Finally, poultry feed production continued to increase by almost 2 % in 2015, boosted by an increasing per capita consumption of meat, which benefited primarily from poultry meat (+2.5 %).

As a consequence, poultry feed consolidated its position of the leading segment in the EU compound feed production, well ahead of pig feed (Table 13).

Table 13. Poultry feed production in EU (x 1.000 ton)

t x 1000	2014	2015
Cattle feed	42.5	42.1
Pig feed	49.2	49.2
Poultry feed	51.8	52.7
Total	155.8	156.1

As for the number of companies it is not possible to present detailed data, since the products are moved to production plants all over Europe and abroad.

3.1.3 State of the sector

The sector is sourced with residues coming from other processing sectors, such as straw, sugar beet pulp, protein cake and food residues hence, no significant amount of residues are produced.

Utilization of agroindustrial by-/co-products in farm animal nutrition reduces the environmental impact of the food industry and improves profitability and valorization of the agricultural by-products since feeding food residue to livestock is an efficient way to upgrade low quality materials into high quality foods (Elferink, E.V. et al. 2008).

Figure 10 shows the trend of compound feed in the EU.

Figure 10. Development of compound feed production in the EU (Source FEFAC)

Despite variations in feed material prices over the last years, the proportion of feed materials per categories remain relatively stable (48 % for cereals, 28 % for oilseed meals). However, this does not reflect significant changes for some feed materials e.g. for corn gluten feed or dried distillers grains, usually imported from the USA, which have almost disappeared since 2007 due to repeated trade disruptions. This was mainly due to asynchronised authorisations of GM crops.

3.1.4 Typical size of the companies

The sector is led by large companies that commercialize various products with their brands but who subcontract third parties that produce locally. Contacting specific firms could further analysis these issues.

Table 14 gives an idea of the main food production for animal feeding in Europe (producer associations).

Table 14 (part A). Main companies operating in Europe and their annual production (Source FeFAC 2015)

			National compound feed production (t)				
National association	Member state	Number of members	Cattle	Pigs	Poultry	Others	Total
Deutscher Verband Tiernahrung e. V. (DVT)	Germany	277	6,700,000	9,646, 000	6,515, 000	909,000	23,770 ,000
Eurofac - La représentation de la nutrition animale Francaise	France	170	5,115,000	4,899,000	8,536,000	1,848,000	20,398,000
Assalzoo - Associazione nazionale fra i produttori di alimenti zootecnici	Italy	100	3,134,000	3,598,000	5,887,000	1,006,000	13,625,000
Nevedi - Nederlandse vereniging diervorederindustrie	Netherlands	100	4,202,000	5,222,000	3,851,000	1,190,000	14,465,000
Bemefa- Apfaca - Association professionelle des fabricants d'aliments composés pour animax A.S.B.L.	Belgium	124	1,350,000	3,500,000	1,312,000	429,000	6,591,000
AIC - Agriculture industry confederation	United Kindom	106	5,071,000	2,028,000	6,880,000	1,674,000	15,653,000
IGFA - The Irish grain and feed association	Ireland	59	2,573,000	669,000	655,000	108,000	4,005,000

Table 14 (part B). Main companies operating in Europe and their annual production (Source FeFAC 2015)

			National compound feed production (t)				
National association	Member state	Number of members	Cattle	Pigs	Poultry	Others	Total
Dacofo - The Danish grain and feed association	Denmark	40	880,000	2,330,000	600,000	200,000	4,010,000
Cesfac - Confederacion Española de fabricantes de alimentos compuestos para animales	Spain	223	7,500,000	10,000,000	4,440,000	150,000	22,090,000
IACA - Associacao Portuguesa dos industrias de alimentos compostos para animais	Portugal	57	750,000	800,000	1,430,000	190,000	3,170,000
VFÖ - Verband der Futtelmitterindustrie Österreichs	Austria	12	543,000	543,000	601,000	176,000	1,577,000
Lantmännen	Sweden		859,000	338,000	665,000	78,000	1,940,000
FS - Foder & Spannmal	Sweden	60	Confidential	Confidential	Confidential	Confidential	Confidential
FFDIF - Finnish Food and Drink Industries' Federation	Finland	4	677,000	262,000	351,000	115,000	1,405,000
CAFM - Cyprus association of feed manufactorers	Cyprus	24	129,000	33,000	45,000	111,000	318,000
SKK – Commodities and feed association	Czech Republic	42	533,000	765,000	983,000	77,000	2,358,000

Table 14 (part C). Main companies operating in Europe and their annual production (Source FeFAC 2015)

			National compound feed production (t)				
National association	Member state	Number of members	Cattle	Pigs	Poultry	Others	Total
HGFA - Hungarian grain and feed association	Hungary	94	500,000	1,330,000	1,540,000	130,000	3,500,000
LGPA - Lithuanian grain processors association	Lithuania	35	148,000	36,000	243,000	172,000	599,000
IZP - Izba zbozowuo-passzowa	Poland	56	915,000	1,960 000	6,270 000	605,000	9,750,000
AFPWTC - The association of feed producers, warehouse - keepers andtrade companies	Slovenia	36	200,000	224,000	222,000	16,000	662,000
CCIS - Chamber of agricultural and food enterprises	Slovenia	8	83,000	44,000	224,000	16,000	367,000
VFS - Federation of the Swiss compund feed manufactores (not part of EU)	Switzerland	81	504,000	633,000	370,000	48,000	1,555,000

Table 14 (part D). Main companies operating in Europe and their annual production (Source FeFAC 2015)

CFIA - Grupacija industrije stočne hrane hgh	Croatia	100	136,000	238,000	280,000	10,000	664,000
NFS - Norvergian seefood federation *)	Norway	517	1,005,000	493,000	447,000	19,000	3,692,000
ANFMC – National association of combinated feed producers	Romania	50	49,000	1,176,000	1,529,000	2,000	2,756,000

*Notefor all the Table 14: *) plus 1 728 000 is for fish breading*

3.1.5 Degree of innovation

The intensification of livestock farming is a solution for land scarcity. This is tied to the improvement of feed efficiency and animal health (related to animal breeding sustainability). The entire technological process of animal feed production can be automatized by introducing computer technology for the precise control and management of the production. In some of the production processes, modern programming can enable the optimization of feed mixtures. Advancements in the field of nutrition of domestic animals, may also create mixtures that meet the most stringent standard requirements.

To foster innovation, an industry-run innovation centre known as the Feed Design Lab was formed by Vitelia, Dinnissen, Imtech, HAS den Bosch and DSM seven years ago. Its R&D programmes focus on feed innovation and ecological sustainability. In the last seven years, the Feed Design Lab has evolved into a vertical partnership of 40 industry stakeholders engaged in feed milling, feed technology, premix making and feed additives.

The discovery of new raw materials (especially proteins) at European level must be highlighted as a contributing factor towards reducing the dependence on raw material imports. Other aspects include the development of new technologies to utilise raw materials more efficiently (e.g. process soya beans not only into feed themselves, but process the whole plant) and better logistics, such as transport. Other issues that are pushing innovation in the sector are environmental concerns that promote the reduction of energy consumption as well as of the use of medicine and antibiotics. The feed industry has a great potential to improve the sustainability of the EU livestock sector and resilience of the food chain by reducing the environmental footprint of livestock by improving feed use and feed conversion rates and trough a responsible sourcing, production and use of feed ingredients. The feed industry is engaged with other chain partners to optimise risk management along the feed chain and to develop effective early warning and feed safety management systems, while reducing the need for antibiotics at farm level through advanced knowledge of the impact of feed processing and composition on gut health and use of specific micro-ingredients (FEFAC, FEFANA, 2016).

3.1.6 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.

As observed by FEFAC (the main EU organization in the field), the feed industry was able to partially compensate the short-term negative effects of the Russian import embargos. While the compound feed sector has the ability to buffer price volatility for raw materials, livestock farmers and processors still do not make use of hedging tools to lock in prices for livestock products in order to limit the financial risks of price shocks.

European Commission has developed a horizontal methodology, called Product Environmental Footprint (PEF) to measure and communicate in a harmonized way the life cycle environmental performance of products.

3.2 Opportunities IBLC

3.2.1 Sector related residues

As described section 5.1.3 no major residues are produced in the feed sector. Feed and fodder facilities are featured by their small or null generation of residues. While the feed industries produce amounts that range between 2 and 10% of their production, fodder dehydration industries do not produce any important biomass residue, either in the agrarian or processing phase (Sucellog, 2017).

The sector is highly suitable for IBLCs due to a good potential in biomass storage and trading.

Production Process	Waste and by-Products (%)
White wine production	20–30
Red wine production	20–30
Fruit and vegetable juice production	30–50
Fruit and vegetable processing and preservation	5–30
Vegetable oil production	40–70
Sugar production from sugar beet	85

Figure 11. Percentage of food wastes and by-products in fruit and vegetable production (source: Agriculture 2015, 5(4), 1020-1034)

Fruit and vegetable processing co-products still remain an underexploited source for the dietary supplementation of farm animals with functional compounds and the production of valueadded products. Commercial application of fruit and vegetable industry co-products as functional feed ingredients provides challenges and opportunities for new researches and busnises.

However, waste from feed and fodder can also be used for biogas production. But detailed analyses on local conditions are always needed because for the plant efficiency a combination with solid biomass from agroindustry residues is requested.

3.2.2 Potential synergies & benefits

As discussed in section 5.1.5, new technological developments in Europe are providing new sources of raw materials (especially proteins). The most important synergies within this sector seems to be the capacity of storage of non-fooder material.

The feed sector benefits from a strong synergy with the other sectors. It acts as a storage facility allowing intermediate ground for biomass exchange and works as a IBLC.

3.2.3 Market developments

From an IBLC point of view, only storage yards are considered as a potential market development as reported in the previous paragraph. Unfortunately, due to confidentiality of industrial information, there is no reliable data available for the EU to date.

3.2.4 Non-technical barriers

The use of additives in the manufacture of compound animal foods can hamper acceptance, because it could cause unexpected problems i.e. allergies, intollerances, other negative effects. The use of food supplements in this field is strictly controlled by the local national authorities. Thus, generally the acceptance of the material does not require deeper analysis (although sample controls are done by the responsible authorities). In addition, as described above, the increase of food production efficiency can foster societal acceptance. This often results in new product lines (e.g. the increasing popularity of “slow-growing chickens”).

In some countries, i.e. Spain, the legislative barrier that concerns these industries is the mandatory disposal of their residues by an authorized manager, reducing chances of using those for any biomass purposes.

Thus, at European level, there are only few non-technical barriers foreseen for the food sector and no evidence of any non-technical barrier regarding the fodder industries that could impede the development of an IBLC.

GRAIN CHAIN

3.3 Profile of the grain chain sector

3.3.1 Production and volume of the sector

The EU is not self-sufficient in terms of cereals. Thus, cereals have to be considered as commodities. The species to be taken into account are:

- Wheat (both T. durum and T. aestivum);
- Barley;
- Maize;
- Other minor cereals as rye, oats and triticale.

In addition, rice plays a key role for residues production.

The production of cereals (including rice) in the EU-28 was around 301 million tonnes in 2016. This represented about 12.5 % of global cereal production.

Common wheat and spelt, barley, grain maize and corn-cob-mix (CCM) accounted for a high share (86 % in 2015) of the cereals produced in the EU-28. Compared to the five-year average level, EU-28 cereal production increased by 5.7 %. An increase was recorded for common wheat and spelt (13.8 %), and barley (10,3 %), while grain maize and CCM production decreased by about 11.2 % (minus 23.1 % compared with 2014) (Eurostat 2017). This was mainly due to one of the warmest summers ever recorded in south-Eastern Europe. Rye and winter cereal mixtures production accounted 7.1 % below the 5-year average. The production of oats decreased by 3.8 %.

France accounted for more than one fifth (22.9 %) of the EU-28 cereal production in 2015. Germany (15.4 %) and Poland (8.8 %) together contributed to a quarter of the EU total. The United Kingdom was the next largest cereal producer, accounting for 7.8 % of the EU-28 total. Among the EU Member States, France was the largest producer of common wheat, barley and grain maize, and CCM, in 2015.

Table 15 reports the cereal surface in EU.

Table 15. EU area for cereals production (source: DG Agri; millions of ha)

	2014	2015	2016
Soft wheat	24.4	24.3	24.2
Durum wheat	2.3	2.5	2.7
Barley	12.4	12.2	12.3
Maize	9.6	9.2	8.5
Rye	2.1	2.0	2.1
Oats	2.5	2.5	2.6
Total	**58.1**	**57.3**	**56.9**

Figure 12 reports the distibution of the surface cultivated with cereals in each EU Member State in 2016.

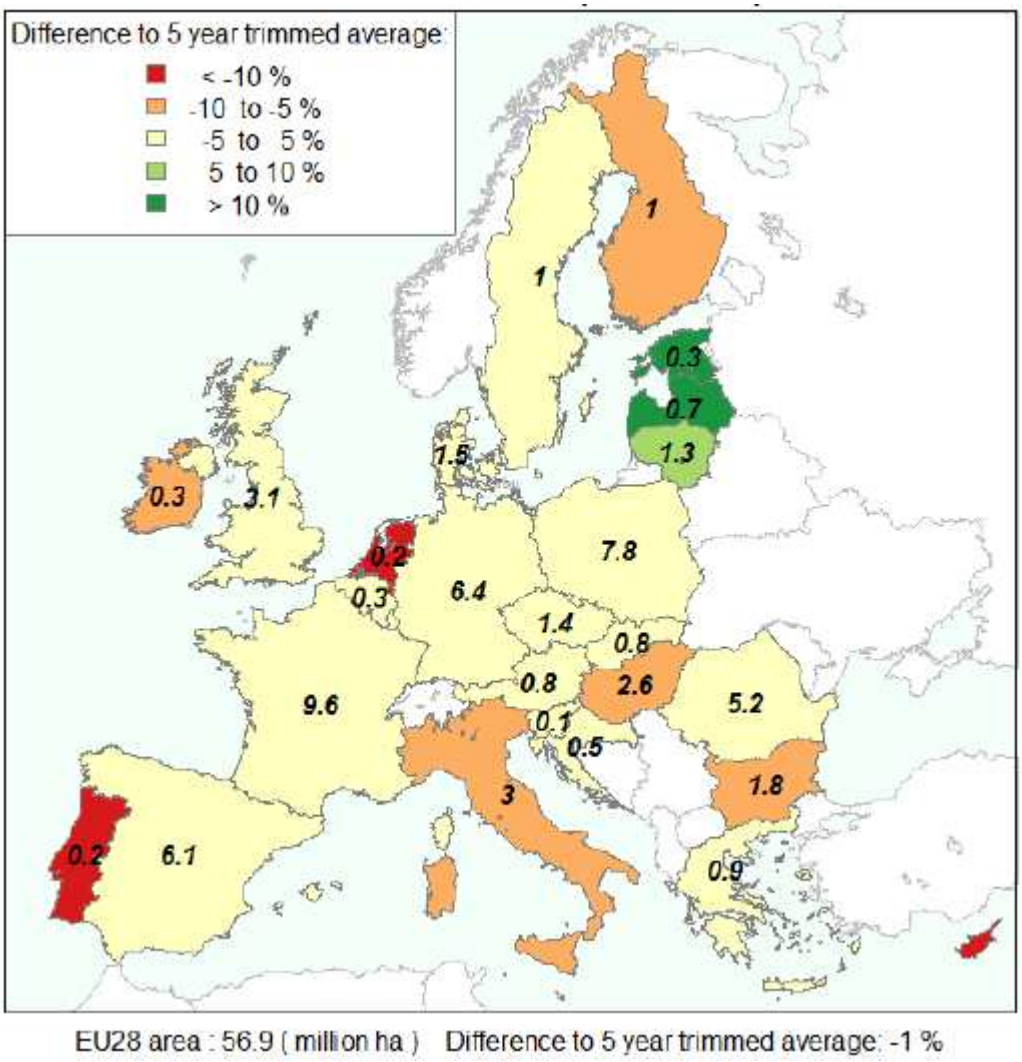


Figure 12. Cereal surface per Member State (2016; source DG Agri)

As for the usable production, Table 16 shows the proper data.

Table 16. Usable production of cereals in EU (Millions of t; source: DG Agri)

	2014/2015	2015/2016	2016/2017	Change 2015/2016
Soft wheat	148.7	151.3	134.1	-11.4
Durum wheat	7.6	8.3	8.9	7.2
Barley	60.2	61.4	59.3	-3.4
Maize	77.9	59.1	60.2	1.9
Rye	8.7	7.6	7.9	3.9
Oats	7.7	7.5	8.1	8.0
Total	**329.2**	**311.6**	**294.6**	**-5.5**

The main rice producers are Italy and Spain. Tables 17 and 18 show surface and production of rice.

Table 17. Surface cultivated with rice, most important countries (x 1.000 ha; source: Eurostat)

	2010	2011	2012	2013	2014	2015	2016
European Union	**473.70**	**483.10**	**454.15**	**432.94**	**432.27**	**443.33**	**441.80**
Bulgaria	11.97	11.79	9.90	10.21	11.04	12.41	11.99
Greece	34.02	32.39	30.21	29.10	30.72	35.08	35.18
Spain	122.18	122.37	112.82	112.15	110.42	109.29	109.33
France	23.55	23.18	20.73	20.71	16.68	16.17	16.78
Italy	238.46	246.55	235.05	216.02	219.53	227.33	227.33
Portugal	29.12	31.44	31.17	30.18	28.75	29.14	29.14
Romania	12.40	12.67	11.30	11.93	12.72	11.11	9.11

Table 18. Rice production in EU, most important countries (x 1.000 t; source: Eurostat)

	2010	2011	2012	2013	2014	2015	2016
European Union	**3,230.76**	**3,122.90**	**3,127.79**	**2,921.34**	**2,852.73**	**2,995.44**	**Not available**
Bulgaria	57.43	59.62	54.90	56.12	54.16	67.68	64.72
Greece	229.49	254.99	215.52	239.49	229.90	251.15	266.15
Spain	927.82	927.55	899.60	876.63	861.10	847.03	821.46
France	115.05	130.40	123.22	80.86	83.41	80.86	80.64
Italy	1,671.82	1,497.04	1,594.48	1,433.11	1,415.73	1,518.25	1,518.29
Portugal	170.22	185.02	187.03	180.16	167.32	184.92	166.43
Romania	61.59	65.26	50.86	54.65	45.16	49.77	42.55

3.3.2 State of the sector

As described above, cereals are considered as "commodities". Thus, the economic figures depend on the market conjuncture. As for the cereal price, the main reference is the Rotterdam port. Further, the Commission gives aggregated data and forecasts (Figure 13). Price fluctuation depends on factors such as geopolitical situation, embargoes, climate, etc.

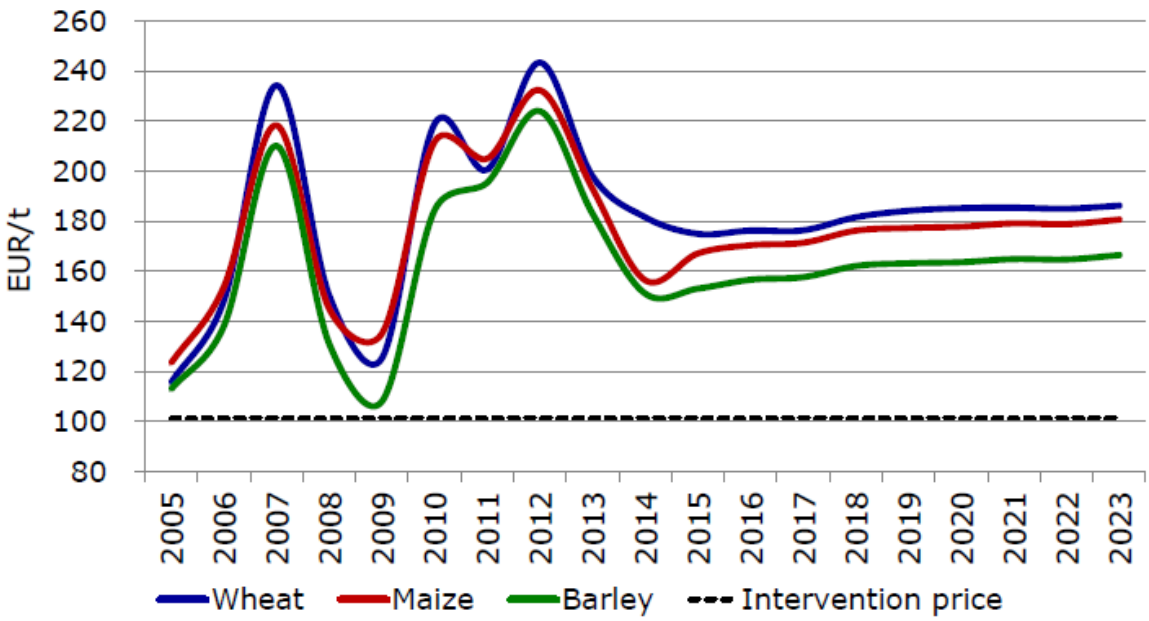


Figure 13. EU cereal prices above historical averages over the medium term (source: EU commission; €/t)

Another 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 such as straw.

For instance, dry season cowpea grain and fodder become available in late April/early May when prices peak and farmers are able to make a high profit. Similarly, cowpea fodder prices in the dry season were three times higher than the price of fodder in the early rainy season (CGIAR).

The recovery costs for straw plus the nutrient value inherent in the straw can be regarded as the minimum price of straw. The idea behind this approach is that, generally, leaving cereal straw on the fields constitutes the best alternative use of straw. The actual long-term value of this practice is difficult to measure, but the value of the nutrients contained within the straw can be directly calculated using market prices for these nutrients. Therefore, the minimum price for straw is the price that will at least compensate the farmer for the foregone nutrients (BIOCORE FP7 project, 2012).

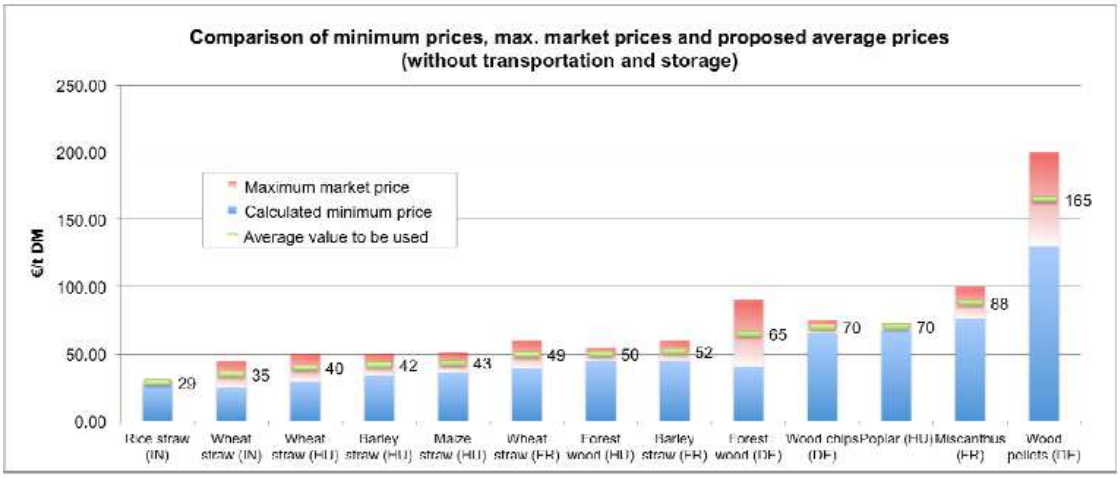


Figure 14. Comparison of minimum prices, maximum market prices and proposed average prices (Source: NOVA, 2012)

3.3.3 Typical size of the companies

In Europe the sector is represented by numerous small mills that operate also for large brands (i.e. Bunge or Cargill). As an example, in Ukraine the majors producers for wheat and corn producing between 50.1 – 200 tonnes per year while the barley production is dominated by small agricultural producers. The most numerous categories are the ones with gross yearly production between 10.1-20 tonnes, 20.1-50 tonnes and 50.1-200 tonnes (The State Statistics Service of Ukraine, 2015).

A new consumer trend of “local and small scale” production is on the rise and should be noted. Thus, a local analysis may be useful to understand which facilities could act as IBLC.

3.3.4 Degree of innovation

Technology is well consolidated and improvements may target grain drying efficiency. new technologies are needed to enhance quality, reduce energy consumption, improve safety and reduce environmental impact. As examples of emerging drying technologies include: heat-pump-assisted drying, microwave-assisted drying, low pressure superheated steam drying, pulse combustion spray drying, pulsed and ultrasound-assisted osmotic dehydration as well as novel gasparticle contactors such as impinging streams and pulsed fluidized beds (A. S. Mujumdar, S.V. Jangam, 2015).

However, innovation is clearly influenced by the size of companies, with large variations between the innovation effort of big players and the small ones mainly related the costs of investments.

3.4 Opportunities IBLC

3.4.1 Sector related residues

The grain sector generates a variety of residues and by-products, which can be used directly as feedstock for biomass production or pre-processed into secondary products. Residues are produced in all stages of the grain chain. Among the primary residues are for example wheat straw,

corn stems, sunflower husks etc. These represent a cheap and rich in lignocellulose feedstock for bioenergy generation.

The milling process of wheat produces large amount of wheat bran and germ as a byproduct. During milling, the endosperm is broken down into fine particles (white flour) while bran and germ are removed. Wheat is a significant agricultural and dietary commodity worldwide with known antioxidant properties concentrated mostly in the bran. Wheat germ, being a byproduct of the flour milling industry, is considered a natural source of highly concentrated nutrients at a relative low cost (Y.Y. Tsadik 2015).

Most cereal grains are delivered to mills clean from residues. Rice hulls seem to be the only useful by-products. In fact, rice is generally delivered in form of paddy rice, with husks. The refining process aims to separate husks from the grain, in order to obtain an edible grain. Unfortunately, rice husks residues (glumellae) presents some problems in burning (due to its silicious content that improves ash production). In addition, the melting point of such material compromises the burning performances. Other uses (such as fermentation) should be investigated. Taking into account that the rice husk represents 17-23 % of grain weight (depending on the cultivar), the estimation reported in Table 19 could be considered as representative.

Table 19. Estimation of rice residues for the most important countries (x 1.000 t)

	Processing residues (t)
European Union	59,908.80
Bulgaria	1,353.60
Greece	5,023.00
Spain	16,940.60
France	1,617.20
Italy	30,365.00
Portugal	3,698.40
Romania	995.40

Straw can be considered as a residue and it is already used in the animal feeding and animal bedding sector. Due to the structure of its market, in which the larger industries are not involved, it does not presents an opportunity for IBLC at present.

Maize processing industries have also several unexploited residues such as the corn cob, leaves or stalks that could be potentially valorised both for bio-energy and the manufacture of bio-commodities purposes.

Corn is processed using a wet milling procedure to produce several important products. The most abundant of these is starch, which is further processed to generate sweeteners used mostly in soft drinks. In addition, oil is also separated from the corn in this process. One hundred pounds of dry corn produces 67 pounds of starch and sweeteners, 3.6 pounds of oil, and 29.4 pounds of byproducts or coproducts. The byproducts consist of the bran (seed coat), germ (center of the grain), gluten (high protein component of corn flour), and other solids (extractives). Major byproducts are corn gluten feed and corn gluten meal (M. Wahlberg, 1999).

3.4.2 Potential synergies & benefits

A lot of biomass fuels are available as by-product from agricultural crop production including grain chains. There is an interesting amount of rice residues that can be used in an IBLC framework. Rice husk is the most prolific agricultural residue in rice producing countries around the world. It is one of the major by-products from the rice milling process and constitutes about 20% of paddy by weight. Rice husk, which consists mainly of lingo-cellulose and silica, is not utilized to any significant extent and has great potential as an energy source (S. Zafar, 2015).

Spain and Italy may especially contribute in terms of rice husks, although further updated technologies have to be set up. On the other hand, this sector is able to concentrate a large amount of biomass. Unfortunately, facilities are spread over the territory, and valuable contacts are needed among the producers to achieve details about products and quantities. Especially for rice residues, the collocation on a new European market should improve the business model of the companies involved also to be competitive at national level. New technologies may play a key-role.

The benefits of using rice husk technology are numerous. Primarily, it provides electricity and serves as a way to dispose of agricultural waste. In addition, steam, a byproduct of power generation, can be used for paddy drying applications, thereby increasing local incomes and reducing the need to import fossil fuels. The by-products are fly ash and bottom ash, which have an economic value and could be used in cement and/or brick manufacturing, construction of roads and embankments, etc. (S. Zafar, 2015).

3.4.3 Market developments

Agriculture is an important part of the economy in all of the EU member countries. Together with the specific crops, large quantities of residues are generated every year. Rice, wheat, sugar cane, maize (corn), soybeans and groundnuts are just a few examples of crops that generate considerable amounts of residues. These residues can constitute a relevant part of the total annual production of biomass and they could be an important source of energy both for domestic and industrial purposes.

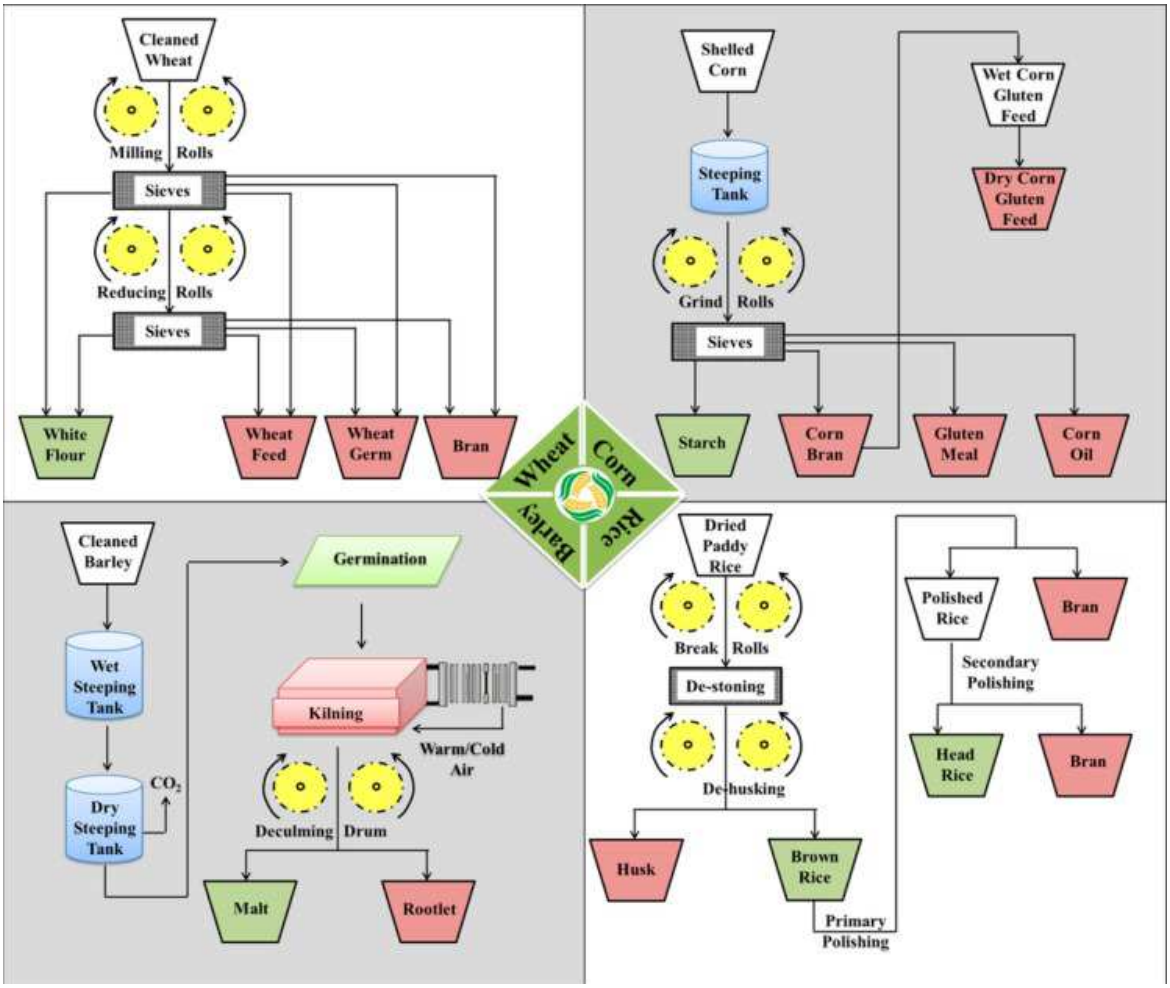


Figure 15. Schematic diagram of the main industrial processing of cereals illustrating products (green shade) and some byproducts (red shade) (Source: US National Library of Medicing, 2013[6])

As already explained in the previous section 6.2.1, technical barriers occur in the use of some by-products for instance corn cob o rice husk – glumellae. Specifically, a lot of ash is produced which affects burner performance and life. Evidence suggests that there is potential for bioproduct production, however, there is no specific information publicly available.

3.4.4 Non-technical barriers

Relevant non-technical barriers are not foreseen due to the particular environment friendly characteristics and potential of the sector residues as reported in the previous sections. Only smell coming from drying processes could become a disturbance to the local community. However, with the right equipment (such as post-burners or other uses by fermentation) this issue can be overcome. Supportive national environmental policies permit this material to be considered as

[6] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3774676/

secondary raw material instead of waste. This is also encouraged by the EU circular economy strategy.

Another non-technical barrier is represented by the high investments costs for biomass processing that could represent in many cases a significant financial barrier for many companies.

4 SUGAR INDUSTRY

4.1 Profile of the sugar industry sector

4.1.1 Production and volume of the sector

The EU is the world's leading producer of beet sugar, with around 50 % of the total, but beet sugar represents only 20 % of the world's sugar production while the other 80 % come from sugar cane. Most of the EU's sugar beet is grown in Northern Europe, where the climate is more suited to growing beet. The most competitive producing areas are in northern France, Germany, the United Kingdom and Poland. The EU also has an important refining industry that processes imported raw cane sugar.

EU sugar production in 2015/16 was lower than the years before (see Table 20). This reduction in supply came in the context of an unprecedented period of low prices and an abundant supply of quota sugar resulting from large quantities carried forward from 2014/15. Fresh EU production for 2015/16 amounted to 14.7 million tonnes, down 22.9 % compared to 2014/15.

The exceptional harvest in 2014 (13 % above the 5-year average) led to almost 3 million tonnes of out-of-quota sugar being carried forward to 2015, to be counted as quota sugar in the following season. This meant that about 22 % of the quota sugar for 2015 de facto had been produced before the season started. This led to a strong incentive for sugar producers to reduce sugar output significantly in 2015 (DG AGRI 2015).A combination of a reduction in sown area and unfavourable summer conditions led to a 22 % reduction in sugar beet production compared to 2014, which was 12 % below the 5-year average.

In 2015, the EU-28 produced 101.9 million tonnes of sugar beet - 29.2 million tonnes less than in 2015 (see Figure 5). More than half of the EU-28 sugar beet production in 2015 came from France (32.9 %) and Germany (22.2 %) Poland (9.2 %) and the United Kingdom (6.1 %) being the next largest producers. Table 20 shows the European surface cutived with sugar beet, while Table 21 shows productions.

Table 20. EU surface cultivated with sugar beet; most important countries (source: Eurostat; x 1.000 ha)

	2010	2011	2012	2013	2014	2015	2016	2017
European Union	:	1,624.54	1,637.70	1,557.95	1,632.40	1,420.32	1,505.22	:
Belgium	:	62.20	61.20	59.80	58.60	52.35	55.50	63.70
Czech Republic	56.39	58.33	61.16	62.40	62.96	57.61	60.74	66.10
Denmark	39.20	40.00	40.80	38.00	38.00	36.00	33.10	36.00
Germany	364.12	398.10	402.10	357.40	372.50	312.80	334.50	403.80
Greece	13.20	5.51	8.05	5.81	7.87	5.18	4.99	5.24
Spain	43.38	44.93	38.95	32.05	38.41	37.61	32.91	36.62
France	383.76	393.13	389.79	393.63	406.74	385.05	405.23	471.87
Croatia	23.83	21.72	23.50	20.25	21.90	13.88	15.30	20.00

Italy	62.67	62.24	45.55	40.71	51.99	38.12	38.12	38.12
Lithuania	15.30	17.60	19.20	17.70	17.00	12.24	15.24	16.00
Hungary	13.86	15.15	18.72	18.82	15.42	15.51	15.94	16.02
Netherlands	70.56	73.33	73.00	73.00	75.00	58.43	70.60	85.40
Austria	44.84	46.58	49.26	50.85	50.60	45.44	43.50	42.89
Poland	206.40	203.50	212.00	193.70	197.60	180.10	205.57	:
Romania	22.03	18.82	27.30	28.14	31.28	26.59	24.21	26.33
Slovakia	17.93	18.10	19.74	20.33	22.21	21.52	21.48	22.22
Finland	14.60	14.10	11.50	12.00	13.70	12.40	11.60	11.90
Sweden	37.95	39.60	39.00	36.23	34.26	19.38	30.60	31.08
United Kingdom	118.00	113.00	120.00	117.00	116.00	90.00	86.00	91.00
Serbia	70.97	59.22	69.07	66.53	64.11	42.12	49.24	
Ukraine	27.9	36.3	41.1	39.9	47.7	43.6	48.2	

Table 21. EU production of sugar beet; most important countries (source: Eurostat; x 1.000 t)

	2010	2011	2012	2013	2014	2015	2016	2017
European Union	:	1,624.54	1,637.70	1,557.95	1,632.40	1,420.32	1,505.22	:
Belgium	:	62.20	61.20	59.80	58.60	52.35	55.50	63.70
Czech Republic	56.39	58.33	61.16	62.40	62.96	57.61	60.74	66.10
Denmark	39.20	40.00	40.80	38.00	38.00	36.00	33.10	36.00
Germany	364.12	398.10	402.10	357.40	372.50	312.80	334.50	403.80
Greece	13.20	5.51	8.05	5.81	7.87	5.18	4.99	5.24
Spain	43.38	44.93	38.95	32.05	38.41	37.61	32.91	36.62
France	383.76	393.13	389.79	393.63	406.74	385.05	405.23	471.87
Croatia	23.83	21.72	23.50	20.25	21.90	13.88	15.30	20.00
Italy	62.67	62.24	45.55	40.71	51.99	38.12	38.12	38.12
Lithuania	15.30	17.60	19.20	17.70	17.00	12.24	15.24	16.00
Hungary	13.86	15.15	18.72	18.82	15.42	15.51	15.94	16.02
Netherlands	70.56	73.33	73.00	73.00	75.00	58.43	70.60	85.40
Austria	44.84	46.58	49.26	50.85	50.60	45.44	43.50	42.89
Poland	206.40	203.50	212.00	193.70	197.60	180.10	205.57	:
Romania	22.03	18.82	27.30	28.14	31.28	26.59	24.21	26.33
Slovakia	17.93	18.10	19.74	20.33	22.21	21.52	21.48	22.22
Finland	14.60	14.10	11.50	12.00	13.70	12.40	11.60	11.90
Sweden	37.95	39.60	39.00	36.23	34.26	19.38	30.60	31.08
United Kingdom	118.00	113.00	120.00	117.00	116.00	90.00	86.00	91.00
Ukraine	13.79	18.74	18.43	10.78	15.73	10.33	14.01	

4.1.2 State of the sector

The EU was the world's leading producer of sugar beet (around 50 % of the total). The EU 28 produces on average close to 20 million tonnes of white sugar per year, from around 2 million

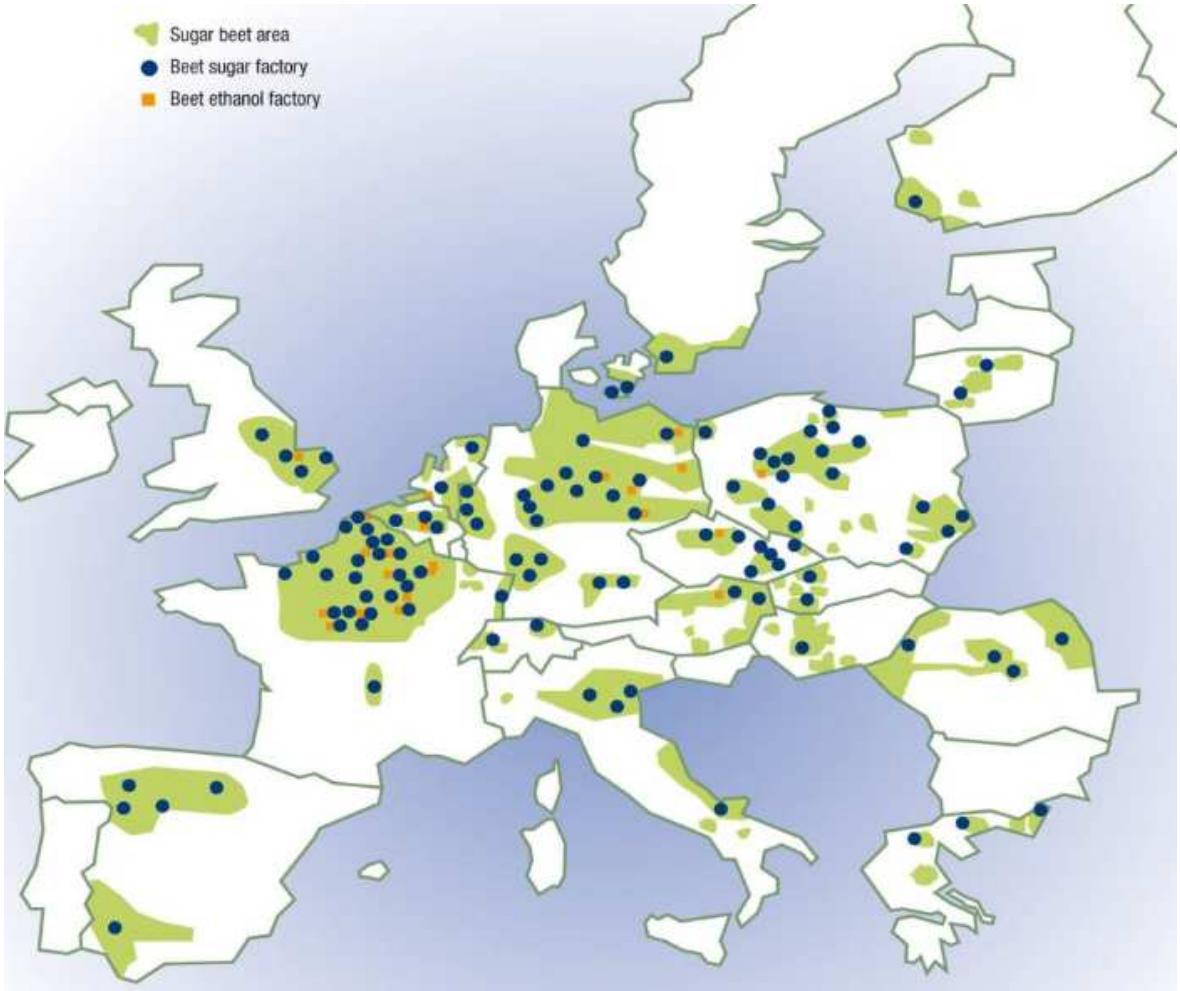
hectares. Sugar beet seed is produced on approximately 9.000 hectares, mostly in France. Further info on the sugar market can be found under the DG Agri of the Commission.

The EU Seed Marketing Directive for beet seed (2002/54) and the Reforming the European Union's sugar policy are the legal and regulatory basis to be taken into account.

In 2006 a major reform achieved simplification and greater market orientation of the EU's sugar policy, which is now part of the Single Common Market Organisation (CMO). Income support for sugar beet farmers has been integrated into the direct payment system. EU sugar policy today concerns three main areas: quota management, a reference price and a minimum guaranteed price to growers, and trade measures. The quota management ended on 30 September 2017.With regards to volumes of sugar in the UE and worldwide, there has been a shift from global oversupply in the sugar market to a period where consumption is greater than production, which has led to strong price increases on the world market. Within this new global market situation the expiring of the sugar and isoglucose quotas in 2017 will have a profound impact on the EU sweetener market. Despite lower domestic prices, EU production is expected to increase significantly in the first post-quota years.

It is not easy to identify facilities with potential as IBLC due to the sub-contracting of production to small local companies that can be seen in almost all the European sugar producing countries. To go on-field would be necessary to verify real interest and potential.

Figure 16 gives an European figures of the sector.



Note: Please consider that some facilities have beed cut down with the new reform of sugar market

Figure 16. Sugar beet sector in Europe (source: http://www.cibe-europe.eu)

4.1.3 Typical size of the companies

The structure of companies in the sugar industry is dominated by medium and large companies because the equipment needed in the sugar industry is better suited for larger facilities. The Hellenic Sugar Industry SA is the only sugar producer in Greece while in Ukraine, over the last years agricultural holding companies big producers have pushed small and medium size producers aside, controlling about 80% of the sugar market.

It is quite difficult to have official data about this sector, due to the sub-contractor agreements with brand companies that makes not easy to collect information from each local producer.

4.1.4 Degree of innovation

Sector innovation is focused on reducing the energy input by improving efficiencies and adopting renewable energies.

Sugarcane can be used to develop multiple forms of energy, including ethanol, bioelectricity and biohydrocarbons. Probably the most recognized is sugarcane ethanol which reduces greenhouse gas emissions by 90 percent on average compared to gasoline. Sugarcane mills can be energy self-sufficient burning leftover stalks and leaves in boilers to produce enough bioelectricity to power their operations with also the possibility to sell energy back to the grid. Producers can also obtain carbon credits from bioelectricity project. (sugarcane.org).

To produce biomethane from sugarcane residues and use it in diesel engines in farm machinery is another possibility for the sector.

Greece and other countries are conducting research aiming at creating the appropriate genetic material, include the endurance to biotic and abiotic factors, the upgraded quality and the optimum productive potential.

Other innovative technologies involve material elements such as equipment to control pollution and measurement instruments, as well as operating methods, such as waste management practices and guidelines to create responsible approaches on the project of products, manufacture, environmental management, etc.

Enhancing technology innovation and adoption in the sugar industry will allow for new products and applications within the industrial biotechnology and biofuels sector generating market opportunities structured around global value chains.

4.2 Opportunities IBLC

4.2.1 Sector related residues

Sugar residues from sugar beets are mainly used for animal feeding and bioenergy production. Harvesting residues, namely beet top, are generally ploughed in the soil. Hence, the most interesting residues come from the sugar extraction process. During processing, solid residues (25-30 % of the input) are turned into "bagasse" and sugar beet vinasse. These are mostly used for steam generation, commonly in the same refining facility.

Other residues include sugar beet pulp, suitable for biogas production by means of anaerobic digestion and molasses that can be used as feedstock for bioethanol. However, this type of production is not widespread because sugar beet pulp deteriorates very fast requiring rapid transportation to biogas production facilities.

Other uses of sugar beet residues include animal feed and cellulose for paper mix production. Potential opportunities can also be found in bioplastics, and polymers production. An example comes from the PHBottle project that has created a prototype bottle from sugars recovered from

wastewater used in the juice industry, making what it calls "active bio-based packaging". The project partners claim that 30% of the sugars from juice industry wastewater can be recovered and re-used. The bottle is made from polyhydroxybutyrate (PHB), a polymer produced by bioproduction (microbial fermentation) in which certain bacteria use the sugars in the wastewater and synthesise this type of bioplastic. The project, coordinated by Ainia, has been working to exemplify the "circular economy" concept promoted by the EU in its commitment for innovation and sustainable technological development, under the 7th Framework Programme (J. Snodgrass, 2016).

4.2.2 Potential synergies & benefits

Potential synergies are mainly related to animal food market using sugar residues as feed. However, new bioproduct production technologies may offer new synergies and related markets, as described in the previous 4.2.1.

4.2.3 Market developments

Residues of processing already have their own market for all the main producers, mainly in animal feeding and food industry. Although new market or alternative uses can be seen in the renewable energy production. Nevertheless, new technologies for bioproduct production may open new market opportunities.

4.2.4 Non-technical barriers

The abolition of the sugar production quota in the European Union will affect sugar beet producers in many countries. From 2006-2010, the EU sugar sector underwent a significant reform, which saw a system of voluntary compensation (worth EUR 5.4 billion) finance a significant restructuring of the sector, reducing production by roughly 6 million tonnes with the closure of roughly 80 sugar beet processing factories, including the end of production in a number of Member States. The 2013 CAP Reform saw Member States and the European Parliament reach agreement on the abolition of sugar quotas at the end of the 2016/17 marketing year, i.e. from 30 September 2017 (EC DG Agri, 2016).

In countries like Serbia, problems appear due to the unresolved relationship and poor leasing conditions of state land. In this case, short timeframes for the leasing of land (for periods of just a year) limit yields and make crop rotation difficult. In such conditions, disease build-up and soil contamination with residual herbicides and chemicals affects yield and quality of sugar beet crops.

FOOD PROCESSING INDUSTRY

4.3 Profile of the food processing industry sector

4.3.1 Production and volume of the sector

Europe's food and drink industry plays a key role in terms of turnover, value added and employment. The food and drink industry also accounts for more than 285,000 SMEs that generate almost 50 % of the food and drink industry turnover and value added and provide 2/3 of the employment of the sector (FoodDrink Europe, 2016). The sector is mainly characterized by the production of:

- Deep-freezed food;
- Fresh food;
- Pre-cooked food;
- Drinking product such as soft drink, beer and wine.

The EU food and drink industry is competitive on a global scale and produces high quality, healthy and safe food. Still, in recent years, the sector is facing a decrease in its relative competitiveness compared to other world food producers, mostly in terms of slower growth in labour productivity and added value. Certain problems have been observed in the functioning of the EU food supply chain linked to transparency, sub-optimal business-to-business relationships, a lack of attractiveness for skilled workers and low market integration across EU countries. Table 22 gives a figure of the EU situation.

Table 22 (part A). Food and drink industry data (source FoodDrinkEurope National Federations; 2014)

	Emploiment ranking in manifuactoring	Turnover (Billion of €)	Value added (Billion of €)	Number of emploiers (x 1.000)	Number of companies
Austria	-	22	5.1	82.6	3,872
Belgium	1	48	7.6	88.5	4,532
Bulgaria	2	4.9	0.9	94.7	5,963
Croatia	1	5.1	4.7	31.7	2,970
Czech Republic	4	11.6	1.9	92.4	7,538
Denmark	2	25.8	4.3	44.8	1,589
Estonia	2	1.9	0.4	15.1	525
Finland	3	11.2	2.7	38	1,700
France	1	184.5	36.2	619.5	62,225
Germany	2	172.2	35.2	559.8	5,828
Greece	1	14.5	2	86.4	1,330
Hungary	2	11.2	1.9	99.8	6,700
Ireland	1	26.4	7.1	39.2	607
Italy	3	132	27	385	54,931
Latvia	1	1.8	0.4	25.8	1,003
Lithuania	1	4.2	0.7	42.5	1,601
Netherlands	1	66.8	10.9	126.3	5,639
Poland	1	49.5	10.6	423.6	14,625
Portugal	1	14.9	2.7	104.3	10.807

Table 22 (part B). Food and drink industry data (source FoodDrinkEurope National Federations; 2014)

	Emploiment ranking in manifuactoring	Turnover (Billion of €)	Value added (Billion of €)	Number of emploieers (x 1.000)	Number of companies
Romania	1	11.1	-	178.9	8.798
Slovakia	3	3.8	0.7	28.1	268
Slovenia	3	2.2	0.5	16	2,160
Spain	1	93.4	29	479.8	22,343
Sweden	4	18.4	4.3	54	3.965
UK	1	120.9	33.4	415	6.300

4.3.2 State of the sector

The contribution of this sector to Europe's economy is important with 4.25 million employees throughout the EU, over €1 trillion turnover and a positive trade balance of €25 billion.

The Fooddrink Body has estimate the following frameworks trend:

- As for the decrease in production and stable sales growth:
  - In 2017, EU food and drink industry production decreased by 0.3 %.
  - EU food and drink industry turnover increased by 1.0 % compared to the previous quarter.
  - The year-on-year comparison shows that food and drink industry turnover growth was lower than total manufacturing turnover (4.3 % vs. 6.7 % compared to 2016). Total manufacturing production growth also exceeded food and drink industry production (1.9 % vs. 0.9 % compared to 2016).
  - Food manufacturing prices increased by 1.0 % in 2017, and were 2.5 % higher compared to Q1 2016.

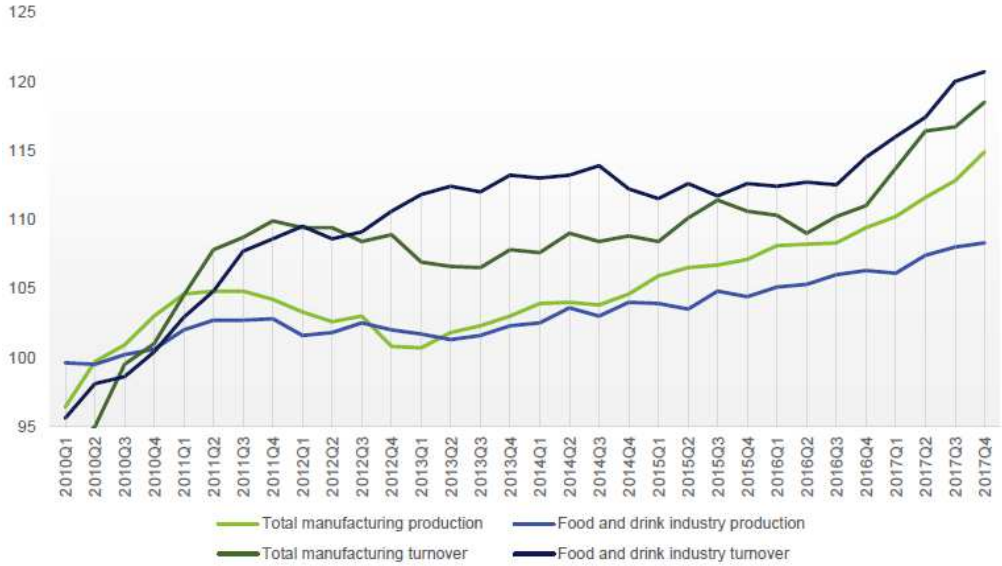


Figure 17. EU quarterly manufacturing production and turnover, 2010 - 2017 (2010=100) (Source: FoodDrink Europe, 2017)

- As for external trade: EU exports reached €26 billion:
  - EU exports of food and drink products totalled €26 billion in 2017 (2017 and 2016: +11.8 %). The trade surplus reached €7.5 billion in Q1 2017.
  - The top 5 products with the largest share in export value generated €12.6 billion in 2017 (meat products, dairy products, wine, spirits, processed fruits and vegetables).

More info can be found at www.fooddrinkeurope.eu

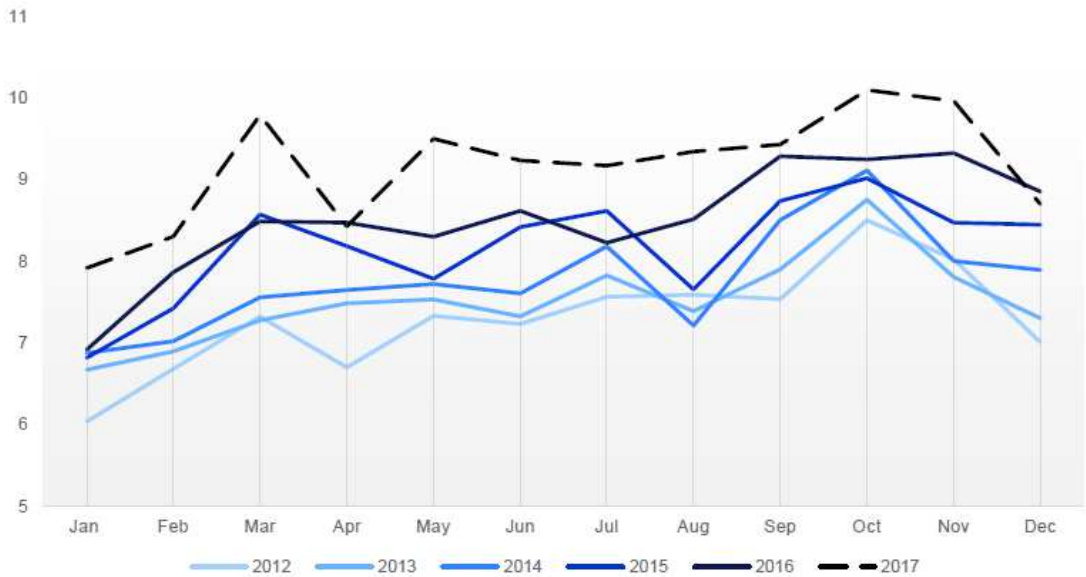


Figure 18. EU food and drink export, 2012-2017 (€ billion) (Source: FoodDrink Europe, 2017)

4.3.3 Typical size of the companies

The market is led by big companies (i.e. Danone, Lactalis, Nestlè) however, SMEs role is becoming more and more relevant in the EU scenario (see Figure 19). Of course, large brands give commissions to other small local plants for food production, thus, specific investigations at country level are needed.

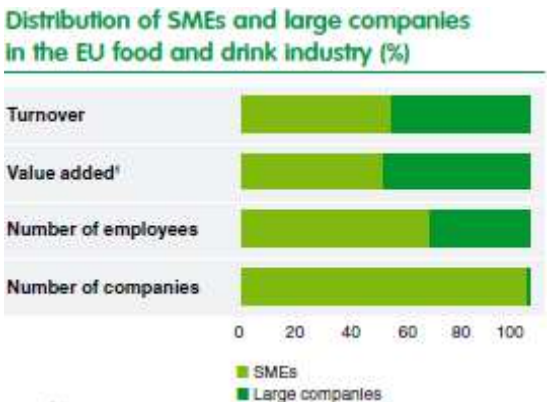


Figure 19. EU Food industries distribution (% values; source: FooddrinkEurope 2014)

4.3.4 Degree of innovation

The food and beverage industry is investing a substantial amount of money to place new products on the market and to refine them.

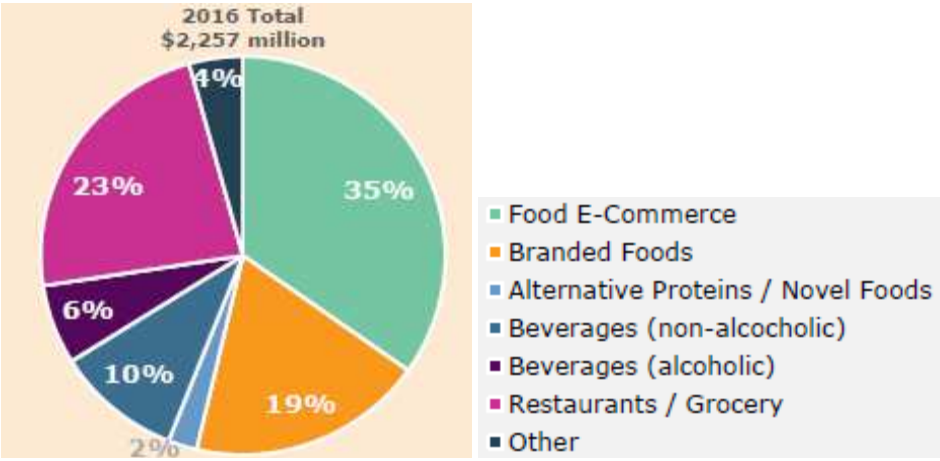


Figure 20. Total Food & Beverage Investment–By Category; source: Rabo Securities 2017)

Venture capital firms poured over $1.1 billion last year into food and beverage startups. (Ken Fenyo, 2018).

Figure 21 shows the innovation trend in EU (2014 orange colour; 2015 blue colour).

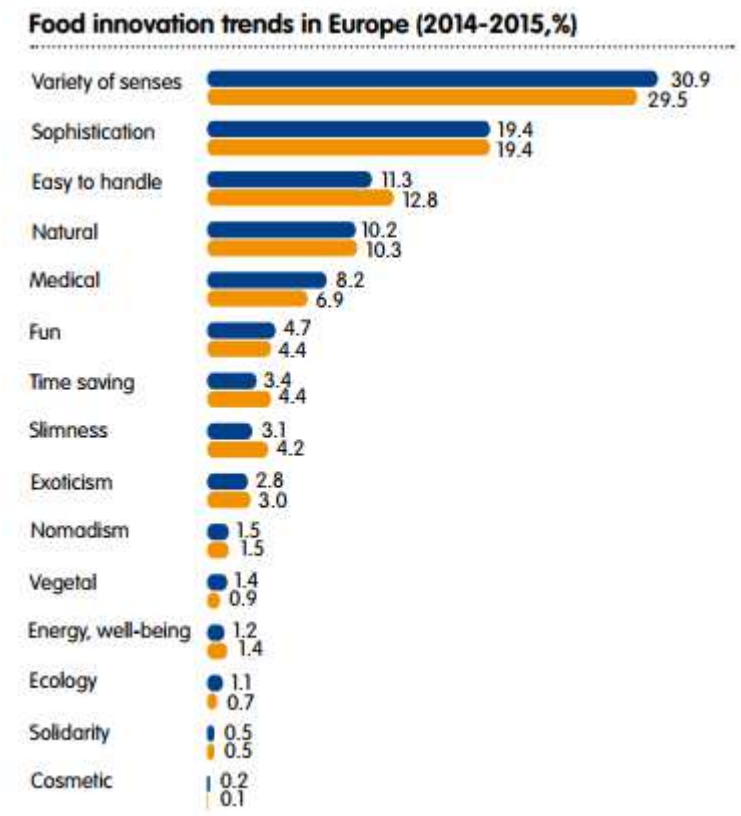


Figure 21. Food innovation in EU 2014-2015 (% values; source: FooddrinkEurope)

4.4 Opportunities IBLC

4.4.1 Sector related residues

The main available residues are:

- Vegetable residues from fruit processing;
- Vegetable residues from vegetable processing before their freezing;
- Wine husks, that were described above;
- Beer production residues.

Unfortunately it is not possible to enter deeper into the sector, due to the strong spreading of small structures that work for their main brand. In our opinion, a creation of an IBLC could be developed in plants that process fresh vegetables, using as biomass the residues and utilizing their yards during “off-season”.

4.4.2 Potential synergies & benefits

All residues can be destined to biopower energy production with consideration to emissions limits set by the national regulation. The provision of a secure, continuous energy supply is becoming an issue for all sectors of society. The food processing industry as a major energy user must address

these issues. Anaerobic digestion of food waste is an opportunity to produce energy in a sustainable manner. The most important reason that food waste should be anaerobically digested is for capturing the energy content. Unlike biosolids and animal manures, post consumer food scraps have had no means of prior energy capture. In fact, in a study done by East Bay Municipal Utility District[7] it was revealed that food waste has up to three times as much energy potential as biosolids. Moreover, food waste in landfills generates methane, a potent greenhouse gas. Diverting food waste from landfills to wastewater treatment facilities allows for the capture of the methane, which can be used as an energy source. In addition to decreased methane emissions at landfills, there are greenhouse gas emissions reductions due to the energy offsets provided by using an on-site, renewable source of energy (US EPA, 2016).

4.4.3 Market developments

Cleaner production, supply chain and life cycle assessment approaches all have a part to play as tools supporting a new vision for integrated energy and waste management. The sector reliance on high-energy processing, such as canning and freezing/chill storage, might also need re-assessment together with processing based on hurdle technology defined as the use of a combination of barriers to microbial growth and possible spoilage or pathogenicity.

Processing residues such as fruit pulps are interesting in the framework of an IBLCs set up. Technological development for such by-products into bioproducts may become significant and has to be taken into account. Again, data about processing volumes of companies is confidential.

4.4.4 Non-technical barriers

The main non-technical barrier is related to economic aspects. The price of fossil fuel is actually relatively low and this can influence the decision to invest for bioenergy plants. Additionally, implementation of IBLC is linked with additional financial investments and relatively long period for return of investments.

No other relevant non-technical barriers are foreseen for this sector.

[7] https://www.epa.gov/sites/production/files/documents/Why-Anaerobic-Digestion.pdf

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6 Annex – Summary of sectors

Table A. Summary sector of seed oil

Sector seeds oil	
	Profile
Production	• 34,000 tons crushed in EU.
Volume of the sector	• 11.5 millions of hectares cultivated in EU.
State of the sector	• Stimulated by biodiesel and renewable energy demand.
Typical size of the companies	• When comparing these figures with other sector industries, vegetable oil industries seem to be high sized and with more available economic assets.
Distinctive facilities of the sector	• Although vegetable oil extractor industries do not have any specific equipment compatible with the processing of biomass, they have other valuable resources such as the access to workforce, means of transport, silos to storage the seeds, etc., which could be very useful at the time of implement an IBLC in their facilities.
Degree of innovation	• Only for by-products.
Miscellaneous	• .LCIA done by Fediol on seed crushing.
	Opportunities for IBLCs
Sector related residues	• Hulls, expeller, meal, mainly sent to animal feed industry.
Potential synergies & benefits	• Hulls used for bioenergy production (in bulk or pelletized).
Market developments	• Very good market performances. Companies are investing in different pheses of the value chain.
Non-technical barriers	• Citiziens acceptability of emission from hulls burning.

Table B. Summary sector olive oil

Sector olive oil	
	Profile
Production	• More than 4.5 millions of hectares (70 % of the world production).
Volume of the sector	• In Spain, Italy and Portugal, the olive tree/farming surface represents 8-9 % of the total agricultural national surface (national UAA), while in Greece it is 20 %. 2.322.300 t of oilve oil produced in EU (2015).
State of the sector	• It is static.
Typical size of the companies	• Size differs between countries. The typical size of the Greek companies in this sector differs from the Spanish or the Italian ones. In Greece, olive mills are mostly owned by cooperatives controlled by farm owners.
Distinctive facilities of the sector	• Facilities such as storage areas, dryers, centrifugators or purification systems can be also used for different purposes. For example the storage areas can be used in order to store prunings or mulched material from olive or vine prunings that are produced from the olive trees or vines from the nearby areas. Moreover, the centrifugators and the purification systems can be used from the wine industry as well as from the vegetable oil extraction sector in order to extract their main products. Furthermore, dryers used in pomace mills, can find various applications during their idle times like drying other materials such as olive prunings, cereals etc.
Degree of innovation	• Shifting of the processing from 3-phases to 2-phases processing.
	Opportunities for IBLCs
Sector related residues	• Pomace, that can be used for domestic heating and industrial power generation and biochemical products. Prunings for energy generation.
Potential synergies & benefits	• Storage of material.
Market developments	• In progress expecially for bio-compunds.
Non-technical barriers	• Nothing to be underlined.

Table C. Summary sector wineries and distilleries.

Sector wineries and distillaries	
	Profile
Production	• The EU surface accounts almost to 50 % of the global area dedicated to vineyards.
Volume of the sector	• The production in volume is 65 % (expressed in tons).
State of the sector	• The market is much alternating depending on the season. An interesting part of the European wine is exported to Russia.Unfortunalely, the embargo to Russia had a strong afffectly the market. 16.285.000 l of wine produceed in EU (2015).
Typical size of the companies	• Many "in-house" cellars. The attention should be focused on distillaries.
Distinctive facilities of the sector	• Despite distilleries represent quite a small part of wine sectors in comparison with cellars, these industries have great opportunities for becoming IBLC's. They own equipment compatible for the processing of solid biomass and the extraction of bioactive compounds.
Degree of innovation	• The most important innovations seems to be are related in the increasing of the efficiency regarding the fermentation and extracting processes, as well the process cost reduction.
	Opportunities for IBLCs
Sector related residues	• Grape marc and prunings.
Potential synergies & benefits	• Storage yards and use of marc for energy and bioproducts production.
Market developments	• In development for bio-products. As for prunings the market is consolidated.
Non-technical barriers	• No non-techinal barriers are forseen.

Table D. Summary sector feed on fodder.

Sector feed and fodder	
	Profile
Production	• Animal feed comes from residues of other agricultural processes, and it is sold in form of pellets.
State of the sector	• No residues seem to be produced by this sector.
Typical size of the companies	• There are large companies that commercialize various products. Of course, they give commissions to third parties.
Degree of innovation	• Mainly the individuation of new protein sources.
	Opportunities for IBLCs
Sector related residues	• To act as intermediate for IBLCs (mainly storage).
Potential synergies & benefits	• Storage.
Market developments	• Not available for confidentiality matters beetween companies.
Non-technical barriers	• Eventual use of additivs.

Table E. Summary sector grain chain

Sector grain chain	
	Profile
Production	• EU is not self-sufficient. The production of cereals (including rice) in the EU-28 was around 317 million of tons in 2015.
Volume of the sector	• Cereals have to be considered as "commodities". Thus, the economic figures depend on the market conjuncture.
State of the sector	• Please take into account geopolitical situation, embargoes, climate, etc.
Typical size of the companies	• All over Europe there are a lot of small mills operating also for large brands.
Degree of innovation	• Technology is consolidated. Reduction of energy consumption is on-going.
	Opportunities for IBLCs
Sector related residues	• Since the most of cereal grains seem to be delivered at mills, already mostly cleaned from residues, the only by-products useful seems to be used is rice hulls. As for cereal straw, due to the structure of its market in which the larger industries are not involved, it does not presents an opportunity for IBLC (just for the moment).
Potential synergies & benefits	• Storage, new technologies for rice husk uses.
Market developments	• Information are confidential and not available
Non-technical barriers	• No important no-technical barries are forseen.

Table F. Summary sector sugar industry.

Sector sugar industry	
	Profile
Production	• EU is the world's leading producer of beet sugar, with around 50 % of the total in terms of tons.
Volume of the sector	• Due to the spreading and.sub-contractroring of production, it is not so easy to individuate the single facility which then may be able to act as a IBLC platform.
State of the sector	• The sector needs more specific analysis.
Typical size of the companies	• The sub-contractor agreements with brand companies does not allows to have a frame of the situation.
Degree of innovation	• Decreasing the energy input of the sugar extraction and refining.
	Opportunities for IBLCs
Sector related residues	• Bagasse and sugar beet vinasse.
Potential synergies & benefits	• Related to animal food market. If developed, bio-products should represent a good opportunuty
Market developments	• Actually, no new market are foreseen.
Non-technical barriers	• No non-technical barriers are foreseen at the moment.

Table G. Summary sector Food processing industry

Sector food processing industry	
	Profile
Production	• More than 285,000 SMEs that generate almost 50 % of the food and drink industry turnover and value added and provide 2/3 of the employment of the sector.
Volume of the sector	• 4,25 million employees throughout the EU, over €1 trillion turnover and a positive trade balance of €25 billion
Typical size of the companies	• Large brands give commission to other small plant. Thus, the specific investigtaion per site needs a deep and thourough analysis.
Distinctive facilities of the sector	• Not available.
Degree of innovation	• The food and beverage industry is investing a substantial amount of money to place new products on the market and to refine them.
	Opportunities for IBLCs
Sector related residues	• Vegetable residues from fruit processing; • Vegetable residues from vegetable processing before their freezing; • Wine husks; • Beer production residues.
Potential synergies & benefits	• Biopower energy production.
Market developments	• New technology needs to be developed in a framework of an IBLCs set up. The use of such by-products in processing/transforming them into bioproducts has to be taken into account (confidential informations).
Non-technical barriers	• No non-technical barrier are foreseen.

DISSEMINATION POTENTIAL (FOR INTERNAL USE ONLY, NOT TO BE SUBMITTED TO EC)

To be filled by the deliverable responsible (lead partner)

What´s the confidentiality degree of this deliverable?	☐ Total	☐ Partly	X Public

Being "Partly" the confidentiality, what are the results that might be disseminated?
1
2
3

Main stakeholders to be addressed by the results of the deliverable			
Name	Type	Sector	Contribution to the project
1			
2			
3			

Main events related to the results of the deliverable			
Title	Date	Press release	Target audience
1			
2			
3			

Dissemination tools: what short of materials can be created to contribute to disseminate the results?				
☐ Photographs	☐ Video	☐ Power point	☐ Papers	☐ Poster
☐ News for project website	☐ Networking opportunities	☐ Training course	☐ Seminar	☐ Social network

Potential Paper	
Title	Authors

Abstract / Public summary (500 words)