



INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Updated conceptual description of an Integrated Biomass Logistics Centre (IBLC)

Deliverable 6.1

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

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Date: 31/5/2017

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 727961



	Document:	D6.1. Updated conceptual description of an IBLC		
	Author:	WFBR	Version:	1.0
	Reference:	AGROinLOG (727961)_D6.1	Date:	31/5/17

DELIVERABLE FACTSHEET

Project start date:	November 2016
Project website:	www.agroinlog-h2020.eu
Deliverable number:	D6.1
Deliverable title:	Updated conceptual description of an IBLC
Lead Partner:	Wageningen Food & Biobased Research (WFBR)
Work Package no. and title:	6. Generic strategies for the development of future IBLCs
Task no. and title:	6.1
Version:	1.0 (final)
Version Date:	adjusted submission date 24-5-2017

Diffusion list


Dissemination level	
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Documents history

Version	Date	Main modification	Entity
0.1	08/02/2017	First draft for discussion	WFBR
0.2	30/3/2017	Second draft for discussion	WFBR, All
0.3	14/4/2017	Final draft for internal review	WFBR
1.0 (Final)	31/05/2017	Version submitted to EC	WFBR, CIRCE

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ABBREVIATIONS

ALC: Agro-industry Logistics Centre

IBLC: Integrated Biomass Logistics Centre

LBPD: Local Biomass Processing Depot

RBDP: Regional Biomass Processing Depot

TRL: Technology Readiness Level

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

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EXECUTIVE SUMMARY

The specific objective of task 6.1 in the AGROinLOG project is to provide an updated conceptual description of an Integrated Biomass Logistics Centre (IBLC). The result of this task will be used as guidance for the next tasks in WP6 and for the rest of the AGROinLOG project.

The SUCELLOG project formed the starting point for the elaboration of the idea to use available agro-industrial capacities as a resource for the processing of biomass as renewable feedstock for energy. In the SUCELLOG project this concept is called Agro-industry Logistics Centre (ALC) concept which is aimed at bioenergy markets. In the AGROinLOG project the ALC concept was extended with a broader purpose of the centre to use renewable feedstock for bioenergy and biorefinery. This extended concept is referred to as Integrated Biomass Logistics Centre (IBLC).


A literature review showed IBLC-like concepts and examples that all address the local or regional function of an intermediary entity for collection and pre-processing of biomass resources. The starting-point can be the availability of biomass resources (biomass push-strategy). The IBLC concept can, however, also be interpreted from a strategic perspective of biorefinery industries to establish a biomass hub for safeguarding the supply of homogeneous biomass resources to the biorefinery plant (biorefinery pull-strategy). The initial approach in the IBLC concept is however to establish connection between the seasonal overcapacity at agro-industries and the regional availability of biomass residues as resources (biocommodities) for biorefinery processing (hybrid strategy: biomass-push- and agro-processing pull-strategy).

An Integrated Biomass Logistics Centre (IBLC) is defined as a business strategy for agro-industries to take advantage of unexploited synergies in terms of facilities, equipment and staff capabilities, to diversify regular activity both on the input (food and biomass feedstock) and output side (food, biocommodities & intermediate biobased feedstocks) thereby enhancing the strength of agro-industries and increasing the added value delivered by those companies. The name IBLC represents four typical characteristics that were further described:

- integrated value approach towards food and biobased markets;
- regional availability of biomass;
- logistic, storage operations and pre-treatment;
- exploiting the central position.

For the European agribusiness (primary and processing sector) the opportunity 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). For existing agro-industries there are three important drivers to develop an IBLC:

- diversification of inputs;
- optimization of available and new capacity;
- diversification of outputs.

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A comparison was made between the basic ALC concept and the updated IBLC concept. One of the differences is that the updated IBLC concept does not only include processing solid biomass but also other types like green (fresh) biomass. Furthermore, the updated IBLC concept does not only include bioenergy but also biobased products with a higher value, which could justify investing in extra capacity.

An IBLC can play an important role as a unit for increasing economic, environmental and social sustainability of agricultural production and processing in the region. In addition the IBLC concept is affected by the governance of the agricultural sector (incl. laws and regulations) as well as by specific policies regarding biomass, waste and valorisation of residues from agriculture into new products.

The following IBLC subtypes were identified based on three drivers:

- input driven concepts - availability of biomass residues/materials is leading;
- process driven concepts - availability of (idle) processing, storage and personnel capacity is leading;
- output driven concepts – market demand for biocommodities / new products is leading;
- combined concepts - multiple drivers are leading.

Some of the biomass resources that have been identified in the studied sectors as being available for biorefinery processing can be used for biobased products other than solid biofuels. Exploring new value chains of these biobased products would be interesting also from the IBLC perspective, in particular when the added value for these other biobased products is higher than for solid biofuels. In that case the economic feasibility of an IBLC may be well within grasp, when the technical specifications of both biomass and biorefinery processes can be met.

The sectors and industries that have been described all have a potential link with the chain of biomass processing for biorefinery purposes (including energy). This link can be either i) as a source of biomass residues, ii) as a partner in the chain of logistics and processing of biomass residues for a specific market, or iii) as a potential buyer of the bio-product that is produced from these residues. In some cases these three links coincide in one business entity.

In some of the described cases the approach is to integrate operations and activities, flows of products, or resources and residues at an industrial level. These physical interconnections that have the potential to create synergy, are referred to with the term industrial symbiosis. The IBLC concept should be interpreted from a wider perspective as an opportunity to integrate operations and facilities also within the scope of the primary sector (and not only from the perspective of agro-industries).

As mentioned the description of the updated IBLC in this deliverable D6.1 is meant to serve as input for the following tasks in WP6 and for the other WPs in the AGROinLOG project. A recommendation is to review the description of the update of the IBLC concept at the end of the project e.g. based on the experiences in the three IBLC demonstrations in the project to see if further modifications need to be made.




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1 INTRODUCTION

1.1 Background


This report forms the output from the AGROinLOG project task 6.1. The assignment for this specific task is to build further on the results from previous projects on the logistics and processing of biomass residues for biobased production. Especially the EU project SUCELLOG (Sucellog, 2017) forms the starting point for the elaboration of the idea to use available agro-industrial capacities as a resource for the processing of biomass for renewable energy. In the SUCELLOG project this concept is called Agro-industry Logistics Centre (ALC) concept which is mainly aimed at bioenergy markets. In the AGROinLOG project an update of the ALC concept will be given which will be referred to as Integrated Biomass Logistics Centre (IBLC) concept. The IBLC concept also includes the physical integration of idle processing capacities with the opportunity to divert unused biomass resource potential in the agrifood sector towards sustainable energy, but also to new biobased applications. Furthermore new drivers will also be taken into account.

Many European agro-industries are characterised by the fact that capital goods and facilities in these industries cannot be used year-round due to the seasonal availability of the primary feedstocks. In the current set-up of an IBLC the goal is to establish an increased utilization of the facilities of these agro-industries. Alternative non-food feedstocks (e.g. crop residues or non-food crops) could fill the idle periods of, for example, the pre-treatment equipment (e.g. compact, dry, etc.) or of the storage capacity at the facility. So in this situation the underutilisation of processing and storage capacity (in the middle of the value chain) is the main driver for the potential developing of an IBLC. However, the drivers of an IBLC could also be considered from two other perspectives, being i) upstream in the beginning of the value chain: the residues that are not being utilized at the moment and ii) downstream at the end of the value chain: new biobased products that need clearly defined feedstocks or biocommodities of a specific quality. The result of this task 6.1 will be a conceptual description that can be used as guidance in the practical development and implementation of the IBLC concept in different sectors in Europe.

1.2 Research questions

The specific objective of task 6.1 is to provide an updated conceptual description of an IBLC. The result of this task will be used as guidance for the next subtasks in WP6 and for the rest of the AGROinLOG project. The method is a literature study combined with the exchange of views, opinions and experiences between the project research partners through telephonic conferences. Important questions related to updating the IBLC concept are:

- What is the definition of an agro-industry logistics centre used in the SUCELLOG project?
- What other IBLC-like concepts can be found in literature?
- What is the updated definition of the IBLC concept?
- What are the main drivers for implementing such an updated IBLC concept?

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- What are the main characteristics/key-features of the IBLC concept?
- What are opportunities that promote the realisation of the IBLC concept?
- What are barriers that impede the realisation of the IBLC concept?
- What are variants of the IBLC concept?
- Which agricultural sectors have the best opportunities for implementing an IBLC?


1.3 Work approach

The following steps were taken to perform task 6.1:

- The first draft description of the updated vision on the IBLC concept was supplied by WFBR to the partners involved in task 6.1. Starting point for this first draft description was the information in the various reports from the SUCELLOG project. The information from the various SUCELLOG case studies on Agro-industry Logistics Centres and methodology reports was reviewed, analysed and processed into an overview of the common characteristics and features of the concept.
- This first draft of D6.1 was discussed in WebEx meeting No 1., which was a collective brainstorm to establish further suggestions for the updated IBLC. Based on this the partners agreed upon further actions.
- Then CIRCE supplied summarized information from the SUCELLOG project on the current Agro-Industry Logistics Centre concept (see Annex A).
- The updated IBLC concept is broader than the current Agro-Industry Logistics Centre concept, so the next step WFBR and ZLC was to perform a review of recent literature sources on IBLC-alike concepts.
- During a parallel literature survey (articles, reports, project websites and expert opinions) the partners CIRCE, CERTH and RISE analysed several sectors to analyse the opportunities for the IBLC concept.
- WFBR composed the second draft by merging all the input from the partners, by summarizing and analysing the extra information and by including extra drivers for updated IBLC concept. WFBR also designed schematic pictures of various IBLC-sub-concepts in this second draft to better transfer the idea of the IBLC concept.
- The second draft was discussed by the partners in WebEx meeting No 2. This meeting was to review and discuss the updated IBLC concept together.
- Then D6.1 was finalized and submitted for a final review by CIRCE.

1.4 Contents of this deliverable

Chapter 2 describes the agro-industry logistics centre concept as developed within the SUCELLOG project. A literature review on IBLC-like concepts is presented in Chapter 3. In Chapter 4 the updated IBLC concept is defined. The main drivers for the development of an IBLC are given and the IBLC concept is compared with the basic agro-industry logistics centre concept. The opportunities of the IBLC concept for a number of sectors are described in Chapter 5. Finally some concluding remarks are given in Chapter 6.

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2 THE BASIC AGRO-INDUSTRY LOGISTICS CENTRE (ALC) CONCEPT (SUCELLOG)

2.1 The basic idea

The SUCELLOG project (IEE/13/638/SI2.675535) was supported from 2014-2017 by the European Commission under the Intelligent Energy Europe Programme (Sucellog, 2017). SUCELLOG aimed at encouraging the participation of the agrarian sector in the sustainable supply of solid biofuels in Europe. The SUCELLOG action focused on a nearly unexploited logistic concept: the implementation of **Agro-industry Logistics Centres (ALC)** in the agro-industry as a complement to their usual activity. This concept demonstrates the large possible synergy between the agro-economy and the bio-economy. Agro-industry facilities can be utilised in idle periods to handle and pre-treat biomass feedstocks (mainly from agricultural residues). That way quality solid biomass is produced which can be introduced into the market (Figure 1).

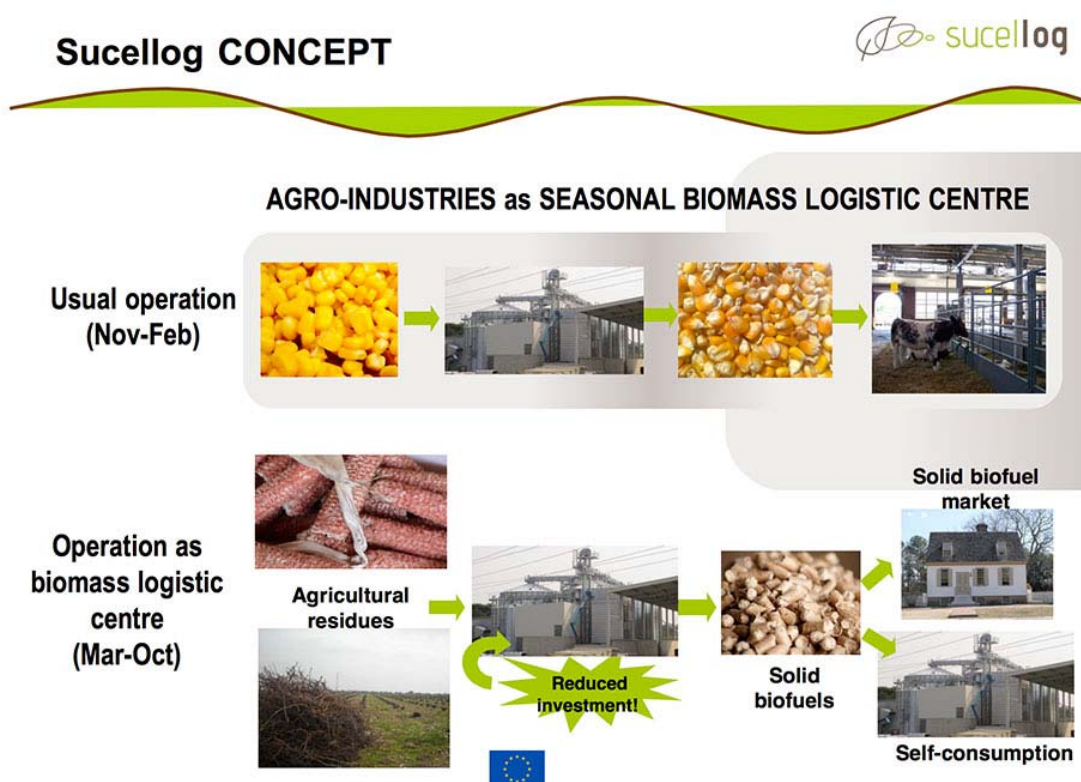



Figure 1. The SUCELLOG concept (Sucellog, 2017).

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2.2 Further details

The SUCELLOG project has achieved its goal by:

- providing technical support and helping the decision-making process of agro-industries that are willing to start operating as a logistic and production centre for solid biofuel;
- building capacity within regional and national agrarian associations for providing support services to their associates and so ensuring permanent capacity in EU beyond the end of the project (Sucellog, 2017).

SUCELLOG's concept is based on the exploitation of the opportunities that agro-industries have to become solid biofuel producers with reduced investment. Annex A contains more detailed information on the main outputs of the SUCELLOG project. This information has been used as starting point for the further description of the agro-industry logistics centre concept (as predecessor of the IBLC concept). In Annex A the following advantages for an agro-industry to become a biomass logistics centre are listed:

- some agro-industries own equipment that can be used in idle periods for the production of solid biofuels;
- agro-industry facilities work under seasonal regime due to crop cycles; some biomass pre-treatment processes can be made compatible with their own original process; that way the agro-industry could diversify their regular activity in the idle period by producing solid biofuels;
- agro-industries having drying equipment may use it directly or adapt it to treat biomass and produce solid biomass with higher quality;
- agro-industries can become new suppliers of mixed biomass pellets;
- agro-industries have experience in handling food products, which are organic materials with similarities to biomass and they know how to fulfil product quality requirements;
- agro-industries are usually involved in commercialization of bulk materials;
- agro-industries already produce biomass residues themselves;
- agro-industries have strong commercial relations with their providers and clients, which may become suppliers of biomass residues;
- agro-industries are surrounded by crop-fields, forests, other agro-industries or activities which can be a source for broadening their offer to produce raw materials for solid biofuels (or other biobased applications);
- sustainability can be promoted by the agro-industry biomass logistics centres if they rely on local agrarian unused resources;
- agro-industries and farmers are already quite concerned about the importance of product quality due to CAP regulations, feed and food law, and the demands and requirements of the market.


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2.3 Case studies

Within the SUCELLOG project, four agro-industry logistics centre case studies were carried out in four different European countries. For each country, target regions were chosen based on an analysis of seasonality and availability of biomass resources in the time when the facility was not in operation (idle period). For each region, a stakeholder was selected. They mainly were agro-industries which already had a solid willingness to start a new business as biomass logistics centre. The final case studies were the following:

- Cooperativa Agraria San Miguel (Spain);
- Luzéal-Saint Rémy (France);
- Società Cooperativa Le Rene (Italy);
- Tschiggerl Agrar GmbH (Austria).

The SUCELLOG project supported them to implement the agro-industry logistics centre by evaluation of their boundary conditions and by the development of a feasibility study. It included different business options. After selection of one preferred option, a complete business model was developed. Synergies and partnerships among agro-industries and relevant local market actors were supported to raise awareness and to create good practice examples. Biomass resources without competing uses were targeted and, in particular, the focus was set on using industrial and field residues owned by agro-industries themselves. Experiences in SUCELLOG project regions showed that, the economic and environmental benefits, saving on time, reducing energy costs, minimising risks and impacts on the environment, and adding value to the field residues were the most important drivers for the implementation of the agro-industry logistics centre concept. An extended summary of each of the above-mentioned case studies can be found in the Annex B of this report.

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3 LITERATURE REVIEW OF IBLC-ALIKE CONCEPTS

3.1 Introduction


This chapter contains the summary of a short review of academic literature on IBLC-alike concepts and examples of biomass supply chains for biorefinery processing (including energy). In general these examples are geared towards the organization of biomass agro-residues for biorefinery (e.g. collection and pre-treatment / pre-processing of biomass and trade of the bio-commodity).

A considerable number of the research papers that were reviewed, deal with the question how biomass supply chains can be organized in an effective and cost-efficient manner to collect, process and transfer available biomass to a specific biorefinery plant. As stated by Lakovou et al. (2010) one of the most critical bottlenecks in increased biomass utilization is the **cost of the logistic operations**. In their study they specifically refer to the utilization of biomass for energy production but this bottleneck issue can also be considered valid for any other biorefinery outlet.

Hong et al. (2016) addressed the topic of sustainable biomass supply chains from the perspective of **supply chain management**. In their study the sustainable biomass supply chain or network of supply chains is referred to as the operational management method and optimization approach to reduce the environmental impact and the cost of manufacturing along the life cycle of the bioproducts: from the raw material to the end product. In Hong et al.'s (2016) opinion, to achieve sustainable development, the biomass supply chain should not only focus on the transportation/logistic task. Special focus must also be given to the conservation of biomass (mass and energy) used in the process, and the possibility of integrating green resources. Also the consideration of **industrial symbiosis** relationship is mentioned and the network synthesis with multi-objectives of environmental, technical, economic, safety and social factors. This is very much in line with the IBLC concept which looks at the synergy effects between existing agro-industries, the (regional) availability of biomass residues and the opportunity to develop value chains for biobased production.

3.2 IBLC-like concepts

Lautala et al. (2015) introduced the concept '**advanced feedstock supply system**' as a system to economically connect biomass feedstock with distant markets. The advanced feedstock supply system incorporates many species and types of biomass that are formatted at **specialized preprocessing depots**. These depots are positioned near the biomass production locations. Typical preprocessing operations at a depot could include particle size reduction, moisture mitigation, densification, and advanced processes such as blending, partial pre-treatment and even fractionation to oil, sugar, or char intermediate products. Biomass leaves these depots as a commodity feedstock that is stable, dense, flowable, and has a defined grade of material specification.


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Eranki et al. (2011) introduced the concept of **Regional Biomass Processing Depots (RBDPs)**. In essence RBDPs are isolated pre-processing and pre-treatment centers which, in their simplest configuration, produce pre-treated and densified biomass. The biomass is then shipped directly to a local biorefinery or, alternatively, transported to a shipping terminal and sold to the global market. A major objective of the RBDP network is to process and pre-treat low-density and often unstable biomass into stable, dense intermediate products compatible with current established commodity logistics systems, allowing the densified biomass to be transported economically over much longer distances. Depending on the configuration or complexity of the pre-processing operations an RBDP can be qualified as ‘advanced’. An **Advanced RBDP** provides intermediates and products beyond those required for biochemical and thermochemical biofuel production, such as higher value animal feeds, nutraceuticals, and biocomposite materials, thereby leveraging the capital and expertise of these well-established industries. In addition Eranki et al. (2011) introduced the concept of tailor-made, or **Enhanced RBDP**: facilities that employ specific technologies that depend primarily on regional feedstock availability and biomass characteristics as well on synergies among these technologies. Given the aspect of regional biomass availability and technology-synergy the Enhanced RBDP can be considered as similar to that of an IBLC.

A similar approach was developed by Bals & Dale (2012): the **Local Biomass Processing Depots (LBPDs)**. In their approach to overcome the difficulty of biomass as a bulky, inhomogeneous, difficult to transport, and perishable product they propose to develop a network of regional or local biomass processing depots. Biomass supplied to these LBPDs can then be processed, homogenized, and densified at rural level prior to shipping it to the biorefinery for conversion into fuels, chemicals or other biobased products. Campbell (2011) describes the LBPDs as a concept for the processing of regional specific biomass streams into densified, stable and transportable commodities. As functions for an LBPD Campbell identified i) purchase of biomass from farmers/growers, ii) short storage, iii) fragmentation and cleaning, iv) pretreatment of biomass, and v) densifying (e.g. pelleting),


In a study by Lamers et al. (2015a and 2015b) the alternative options and configurations of biomass supply systems were reviewed for the U.S. cellulosic biofuel industry. They concluded that decentralized biomass processing facilities, or **Depots**, may be necessary to achieve lower feedstock costs, quantity and quality required. The primary function of a **Standard Depot** is to improve feedstock stability (for storage), increase bulk density (for transport), improve flowability (for stable in-feed rates), and reduce material loss. In addition, a **Quality Depot** actively addresses feedstock quality aspects specific to the end-use market it targets. It produces enhanced feedstock (with lower contamination levels) or even process intermediates and thus reduces the pre-treatment requirements at the client facility. To match its final markets, various kinds of pre-treatment steps are possible within an advanced depot (thermal/ chemical pre-treatment).

Annevelink et al. (2014) described the **Biomass Yard** as a logistical concept in which different types of biomass from different supplying sectors are collected in one location for pre-treatment. Within the Biomass Yard suppliers and collectors of biomass collaborate with biobased processing industries in organizing the efficient regional collection of biomass. When necessary, biomass is pre-treated and processed into a specific biocommodity for the further biobased industrial processing. The purpose of the Biomass Yard is to improve the value chain of biomass residues. For

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this the Biomass Yard has several technical operational tasks concerning the sustainable collection of multiple biomass streams, regional buffering, pre-treatment and densifying, and transportation to market outlets. In addition the Biomass Yard has the task of manager of the various biomass supply chains that convene at the Biomass Yard from suppliers of unprocessed biomass to buyers of specified processed biomass components for biobased markets.

In Austria the regional agricultural chamber Steiermark (Landwirtschaftskammer Steiermark) developed the '**Biomassehof**' as a regional service center for solid biofuels (Loibnegger et al., 2010). The Biomassehof was co-developed and founded in 2011 together with a farmer group within the framework of the BiomassTradeCenter project (2009-2011). This farmer group is now responsible for the operations concerned with the processing and exploitation of woody biomass as a solid biofuel. Purpose of the center is to make available locally grown woody biomass for the bio-energy market and to safeguard the quality standards of both product and services to the market. In 2013 the Steiermark province counted 7 regional Biomassehöfe.

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4 THE UPDATED INTEGRATED BIOMASS LOGISTICS CENTRE (IBLC) CONCEPT

4.1 Definition updated IBLC concept


An **Integrated Biomass Logistics Centre (IBLC)** is defined as a business strategy for agro-industries to take advantage of unexploited synergies in terms of facilities, equipment and staff capacities, to diversify regular activity both on the input (food, feed and biomass feedstock) and output side (food, feed, biocommodities & intermediate biobased feedstocks) thereby enhancing the strength of agro-industries and increasing the added value delivered by those companies. The IBLC concept can be further specified when it is subdivided into the four separate elements:

- **Integrated:** refers to the integration of value adding activities towards food, feed and biobased markets.
- **Biomass:** refers to biomass that is available in the surrounding region of the agro-industry, that is underutilised or unexploited at the moment and that has the potential as resource with an added value.
- **Logistics:** refers to the role of an agro-industry using its available logistics, storage operations and pre-treatment facilities to i) collect and transport biomass residues, ii) to pre-treat and transform these residues into food, feed and biocommodities & intermediate biobased products, iii) to store them and finally iv) to distribute the biocommodities and intermediate products to industrial processing sites elsewhere.
- **Centre:** refers to exploiting the central position of the agro-industry in a specific region.

The schematic position of an IBLC within the value chain is presented in Figure 2. Important parts of the value chain are i) the agricultural production with the suppliers of biomass feedstocks for food and non-food, ii) intermediate food & biomass pre-treatment / pre-processing industry (IBLC), iii) final processing by the food and biobased industry and finally iv) the markets for food and biobased products. The advantages of having an integral view on both food and biobased (non-food) value chains are:

- use economies of scale - because more biomass feedstocks need to be transported and processed;
- decrease idle capacities - because the facilities at an IBLC can be fully used for processing multiple biomass feedstocks for either food, feed or biobased products;
- access to biobased industry - because the IBLC produces not only food or feed but also biocommodities which can be processed into bioenergy, biofuels, biobased materials and biochemicals for industries further on in the value chain.

The four aspects of an IBLC will be further explained in the following subsections.

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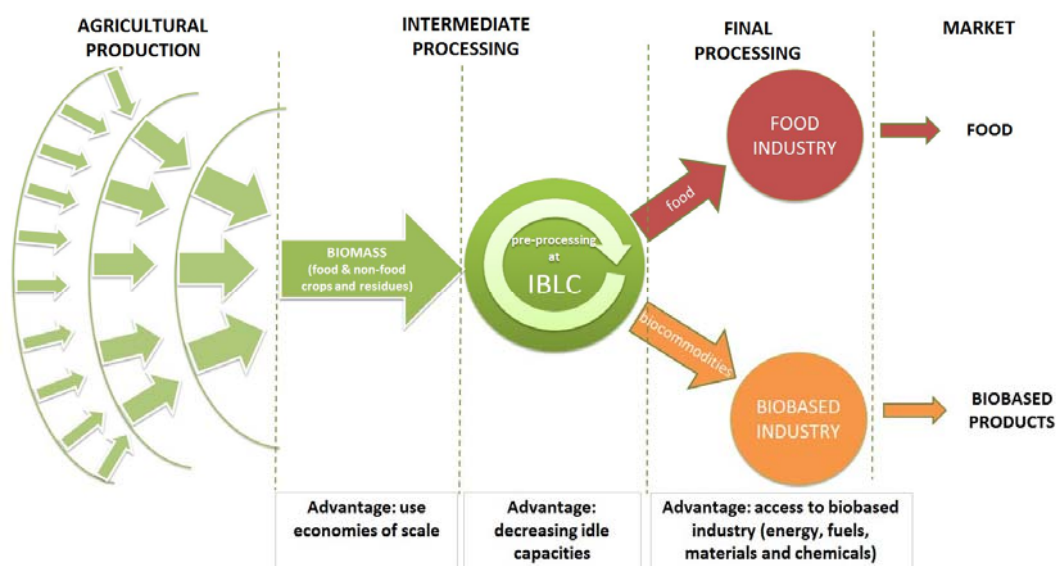



Figure 2. Schematic position of an IBLC in value chain.

4.1.1 Integrated value approach towards food and biobased markets

An integrated value approach towards food and biobased markets means that both market segments are addressed by the IBLC. The existing system for supplying food products is combined with supplying biobased (intermediate) products such as bioenergy (electricity and heat), biofuels, biomaterials and biochemicals to new markets. Of course the availability of profitable new markets for these biobased products is essential for the success of the IBLC concept. A potential biobased market should be analysed regarding several aspects like size, value, developments, expectations/prognosis, radius for supply, etc. Furthermore, a distinction has to be made between three market types viz. the final consumer market (direct purchasing of final products by households), the business-to-business market (purchasing of intermediate products and biocommodities by industry) and the public market (direct purchasing by governments). Predominantly the IBLC concept is directed at the business-to-business market. However, the other two markets can also be served if a specific opportunity arises e.g. the case of selling biomass pellets directly from the IBLC to households or municipalities for heating in biomass stoves or boilers.

4.1.2 Regional availability of biomass

Nearby locations of agricultural production sites offer easier access to biomass resources (mainly residues) for an IBLC due to the short transportation distances. The technical ability to harvest biomass residues with minimal added costs, and without influencing the quality of the primary crop (e.g. in the French cases studied in the SUCCELLOG project: harvesting of rape straw) is very important to increase the availability of biomass. However, often it will also be necessary to leave a certain amount of harvesting residues on the soil for improvement of organic content and to avoid the depletion of soils as a result of the intensified extraction of nutrients. This of course limits the biomass availability to a maximum per hectare.

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The seasonality of harvesting agricultural crops restricts the availability of biomass residues to a specific period of time. The time of the season determines the actual ability to harvest a crop residue (e.g. harvesting of maize stalks in November is not always possible because of wet soil).


Easy-to-access biomass residues from the agro-industry's own food or feed production process that do not have a market, could also be an important source for producing biocommodities and intermediate biobased feedstocks. Furthermore, residues from other agro-industries could also be a source of biomass and should be explored when setting up an IBLC. Using a classification matrix (e.g. based on Figure 3) will help to identify the type of available biomass, competitive current use of this biomass, and hence the available unused biomass for alternative biobased options.

4.1.3 Logistics, storage operations and pre-treatment

The availability of existing transport facilities for the collection of biomass residues from the surrounding fields, and the connection with an existing logistic chain are factors that form a stimulating incentive for developing an IBLC. The logistics from harvesting, handling and collection of biomass residues, as well as the transport to the agro-processing facility (IBLC) have an effect on the quality of the end-product and vice versa. In some cases new transport facilities will be needed to guarantee sufficient supply of a specified quality. After all, the quality of the end-product will be determined by the type, composition and quality of the biomass that is available, and that will enter the processing stage at the IBLC. The quality and composition specifications of the IBLC's end-product will have to fit with the required technical specs for the processes of the user of the IBLC end-product (e.g. the quality requirements and specifications of agro-pellets for specific biomass stoves or boilers).

Quality requirements of the end-product and microbiological / physiological characteristics of the biomass also affect the storability of biomass residues. Storage facilities for the collected biomass will have to minimally comply with safeguarding sufficient biomass quality to meet the end-product requirements. But also safety requirements have to be met, in terms of avoiding unwanted and uncontrolled microbiological (e.g. fungal growth, transfer of pathogens) and physiological processes (e.g. heating) that affect the quality of the biomass and ultimately the quality of the end-product (IEA-ETSAP, 2013). Quality and food-safety requirements (originating from the side of the food production) may place limitations to the combination of food and non-food production in the same agro-processing facility.

The input specifications and handling characteristics of collected biomass are the linking pin with available processing capacities in the IBLC. As mentioned the availability of idle pre-treatment capacity in a certain period is one of the drivers for the IBLC (e.g. the availability of cereal dryers suitable for drying solid biomass if this pre-treatment is needed for the biomass product). Therefore, it is important to know the length of the idle period of the facilities, the capacity of these facilities and the way available pre-treatment and storage capacity can be optimally used for biomass processing. Also, it is very important to assess the technical feasibility of the available capacity, in order to determine if the capacity is really appropriate for processing biomass residues. Furthermore, the available capacity needs to be matched with the volume and timing of the biomass residue availability.

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4.1.4 Exploiting the central position

An IBLC can exploit the benefits of the geographical position of the agro-industry in relation to the existing regional biomass sourcing area. The central position of the IBLC reduces the transportation distances and costs in the value chain both from the agricultural production areas to the IBLC and from the IBLC to the industrial processing locations. But also the location of the IBLC relative to the location of the industrial processing facilities that will take product from the IBLC and will supply the market (local, regional, global) with the end-product is something to consider in the design of operations and logistics within an IBLC (Lamers et al., 2015). The availability of a regional market with sufficient demand is an advantage for both the IBLC and the industrial processing companies that are in the centre of such a market. However, when the regional biomass is transformed to biocommodities at the IBLC even the national and global markets come within reach.

4.2 The main drivers for implementing the IBLC concept


Biomass is an appealing source of energy in the current climate and energy context. It could supply a much higher share of the energy needs in the future compared to now, what will require important investment in new infrastructure for both biomass transformation and transportation (IEA-ETSAP, 2015). Biomass residues will also form an important feedstock in the future for the production of biobased products other than solid biofuels. For the European agribusiness (primary and processing sector) the opportunity 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. For existing agro-industries there are three important drivers to develop an IBLC:

- diversification of inputs;
- optimization of available and new capacity;
- diversification of outputs.

An existing company could expand its operational activities for value creation in various ways:

- by using extra feedstock types (not only food or feed but also non-food biomass residues) on the input side,
- by optimizing its existing processing capacity that already has fixed (capital) costs or by expanding its processing capacity with extra (pre-treatment) capacity with low additional investment costs,
- by obtaining extra revenues from delivering new output types (e.g. not only food or feed but also biocommodities for the biobased economy).

Biocommodities can be produced either by light pre-treatment processes (e.g. densification) or by more intensive pre-treatment processes (e.g. pyrolysis or torrefaction).


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4.3 Comparison basic ALC concept versus updated IBLC concept

The basic ALC concept from the SUCELLOG project and the updated IBLC concept from the AGROinLOG project are compared in Table 1. The updated IBLC concept does not only include processing solid biomass but also other types like green (fresh) biomass. There should be at least one pre-processing step in an IBLC. So looking only at using storage facilities is not enough. SUCELLOG at the beginning did not pay so much attention on the storage capacity. However, storage facilities are really expensive, so they are as important as the rest of equipment. The purpose of pre-treating the biomass at an IBLC is to make it more homogeneous, drier, more compact, etc. There is a difference between supplying to an industrial market that is further processing the intermediate products to final products and supplying to the final consumers. The current basic concept is limited to energy pellets with a high environmental value but unfortunately a low economic value. Therefore the only profitable way of producing them is using machines without extra investment costs. The updated IBLC concept does not only include bioenergy but also biobased products with a higher value, which could justify investing in extra capacity. So the IBLC concept looks at both low-value and high-value markets.

Table 1. Comparison of the basic agro-industry logistics centre (ALC) concept and the updated integrated biomass logistics centre (IBLC) concept.

COMPARISON		
Aspect	Basic ALC concept	Updated IBLC concept
Primary sources of biomass	Residues from agriculture and forestry	Residues from agriculture and forestry
	Organic wastes from agro-industries	Organic wastes from agro-industries
		Energy crops and forest growth
Biomass type	Solid biomass	Both solid and liquefied biomass
Pre-treatment capacity	Existing idle capacity	Both existing idle capacity and new capacity
Investments	Minor investments for adjustments to existing facilities	Also major investments in new facilities
Logistics	Existing transportation network	Both existing and new transportation networks
Biobased processing (industry)	Energy (heat and power)	Energy (heat and power), fuels, materials, chemicals
Market	Supply of end-product (solid biofuel) to user-markets (consumer-/business-/institutional markets)	Supply of biocommodity product as intermediate for biobased industries

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4.4 Opportunities and barriers for the IBLC concept

An IBLC can play an important role as a unit for increasing economic, environmental and social sustainability of agricultural production and processing in the region. In addition the IBLC concept is affected by the governance of the agricultural sector (incl. laws and regulations) as well as by specific policies regarding biomass, waste and valorisation of residues from agriculture into new products. In Table 2 the main opportunities and perceived barriers are listed, categorised by the impact categories (economic, environmental, social, governance and technical).

Table 2. Opportunities & Barriers Analysis of the updated integrated biomass logistics centre (IBLC) concept.

	Opportunities	Barriers
Economic	<ul style="list-style-type: none"> • diversification in feedstocks and end-products: use cheap biomass residues as a resource for bio-energy and biobased intermediate products; • fixed costs reduction through optimal use of existing agro-industrial facilities (increased return on investment of invested capital); • minimise investment costs for biomass processing capacity; • favourable position of the agro-industry within the agro-chain to improve the economic (healthy) situation through investment in new business lines (technical capacity, organisation); • market: diversification of product portfolio to biobased markets; 	<ul style="list-style-type: none"> • price volatility of the available biomass resources (example from the French case study: cereal crop); • some feedstocks might be too expensive at the gate of the IBLC (including logistical costs) • higher operating costs of existing facilities e.g. through increased maintenance; • lack of experience and knowledge regarding the market potential of bio-energy / biobased products; • in some regions there is a surplus of woody biomass in the market, and so impeding the use of alternative biomass resources; • low pricing of fossil product counterparts (oil and gas); • niche markets for biobased and bio-energy products from agro-residues; • lack of appropriate technologies for biomass transformation on the market;


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Table 2 (continued). Opportunities & Barriers Analysis of the updated integrated biomass logistics centre (IBLC) concept.

<div>Environmental</div> <div>Social</div> <div>Governance, laws & regulations</div>	<ul style="list-style-type: none"> contribute to achieving sustainability goals: lowering of GreenHouse Gas (GHG) emissions, efficient use of resources, green & circular bio-economy; GHG reduction (through reduction of the consumption of fossil fuels); supply of renewable energy (bio-energy); 	<ul style="list-style-type: none"> trade-off values: e.g. nutrient cycle, impact on soil depletion; transparency of environmental costs (LCA comparison);
	<ul style="list-style-type: none"> more employment through increased business activity; strengthening the role and function of the agricultural sector in the bio-economy will stimulate the economic development and strengthening of rural areas; 	<ul style="list-style-type: none"> social acceptance / perception of product quality; rooted farming practices impede alternative use of residues; reluctance to change the business as usual in agriculture sector; not enough success experiences (and transfer of knowledge and expertise);
	<ul style="list-style-type: none"> new business activities as rescue for currently declining agro-industries and avoiding exodus from the rural areas; response to changes in the CAP of the EU: e.g. the removal of the sugar quota and its impact on production and processing; positive contribution to the EU / national goals with reference to the use of biomass for energy and for biobased production; current promotion of circular economy needs to be translated into new regulations (in short-term); 	<ul style="list-style-type: none"> contamination food and non-food agricultural residue; uncertainty / different interpretation of national legislations what biomass can be used and if it is waste or not; limited availability of and access to funding resources; low (political) priority for biomass from agriculture in contrast to woody resources; unfavourable taxation regimes for raw material, product and fuel; difficulties in securing signed commitments: integration within supply chains between farms / industries require longer lead-times;



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Table 2 (continued). Opportunities & Barriers Analysis of the updated integrated biomass logistics centre (IBLC) concept.

Technical	<ul style="list-style-type: none"> • Incubator of technical and social innovations for biomass processing and valorisation into bio-energy and biobased products; • IBLC concepts are suitable to energy integration and hence, energy efficiency optimization within existing facilities; • some of the equipment are already well-known (dryers, pelletizers, storage facilities, etc.) but the optimal integration between so different industrial processes (food / non-food) is a technical challenge (maintenance, control system, instrumentation, etc.); • biorefinery processing is an infant-industry with generally low TRLs. Product market opportunities are lagging behind feasibility of processing technology. • lack of knowledge on processing (new) types of feedstock (incl. how to deal with variable quality of raw material); • processing gap: necessity to invest in additional equipment for processing (or for harvesting or transport); • logistic efforts limit upscaling of projects; • increased wear and tear of equipment; • extra cleaning needed between processing of food and non-food feedstocks; • difficult to meet biomass end-product compatibility / quality requirements; • lack of knowledge about the behaviour of agro-pellets in industrial- and household boilers;
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4.5 Subtypes of the IBLC concept


The common denominator for any type of IBLC is that the centre serves as a regional hub for channelling available biomass to a specific biorefinery industry and for creating economies of scale. At the IBLC the biomass goes through a (series of) pre-treatment process in order to guarantee that the biomass resource will meet the required product specifications. One of the purposes of an IBLC is to make biomass residues available as a renewable resource for biorefinery processing. On the other hand, it is the biorefinery industry's interest is to secure the supply of biomass feedstock (i.e. reduce supply uncertainties with regard to feedstock quantities, price and quality). The industry may therefore have a strategic objective to organise the supply of biomass feedstock within the boundaries of the industry itself. In a study on the supply chains of American cellulosic biorefineries, Lamers et al. (2015) use the term biorefinery gate to distinct and specify the level of integration within the supply chain between biorefinery processing and biomass feedstock harvesting / collection and pre-processing. By organising and pre-processing biomass feedstock at central depots (IBLCs) biorefinery processing industries can benefit from benefits that reduce supply uncertainties.

Typifying an IBLC will help to improve the design process of an actual IBLC in practice. In Table 1 in section 4.3 the IBLC concept is presented as an extension of the ALC concept developed within the SUCELLOG project. Based on the listed characteristics of the IBLC concept it is conceivable that different subtypes within the IBLC concept may develop, depending on which factor will serve as a catalyst in a specific setting or (market) environment. Therefore the following IBLC subtypes can be identified based on three drivers:

- input driven concepts - availability of biomass residues/materials is leading;
- process driven concepts - availability of (idle) processing, storage and personnel capacity is leading;
- output driven concepts – market demand for biocommodities / new products is leading;
- combined concepts - multiple drivers are leading.

More detailed ways to typify an IBLC (Figure 3 and 4) can be to look at:

- The type of inputs used, e.g. solid biomass, lignocellulosic biomass, green (wet) biomass.
- The number of inputs: single source, multiple sources.
- The number of steps of the value chain that are incorporated in the IBLC: single-step, two-step or multiple-step, e.g. only pre-treatment or also storage.
- The type of pre-treatment processes that are being used at the IBLC, e.g. only light pre-treatments (Figure 5) or also already more severe pre-treatment (Figure 6).
- The type of outputs, e.g. only bioenergy or bioenergy and biofuels or even biobased products.

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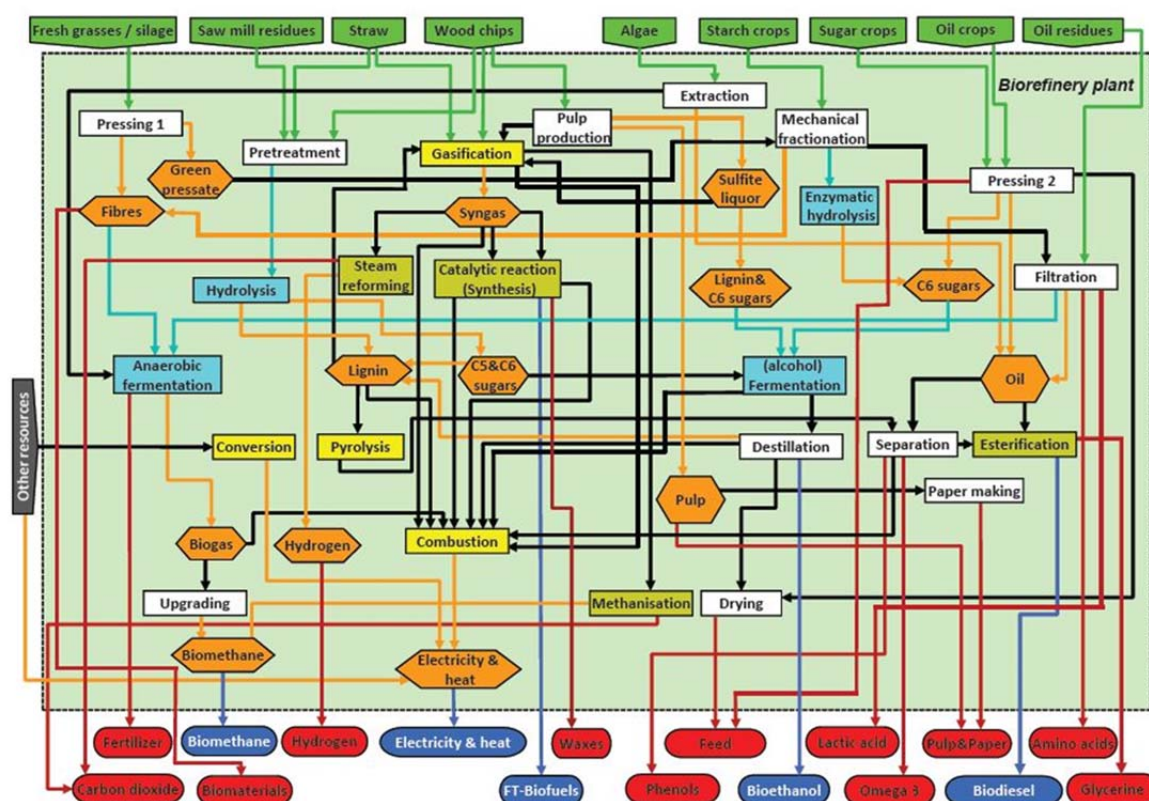


Figure 3. Possible biorefinery processing routes for biomass feedstocks in the biobased economy (IEA Bioenergy Task 42 Biorefining, 2014).

Figures 4, 5 and 6 illustrate possible variants of IBLCs in relation to the pre-treatment activities of biomass for a specific target market (i.e. biorefinery industry) within an IBLC. A value chain will always be case-specific for the type of feedstock(s) that is collected and pre-treated at the IBLC, as well as for the type of market the IBLC will service. These will determine:

- the type and complexity of the pre-treatment activities at the IBLC (IBLC gate);
- the level of integration between the IBLC and the biorefinery plant (biorefinery gate).

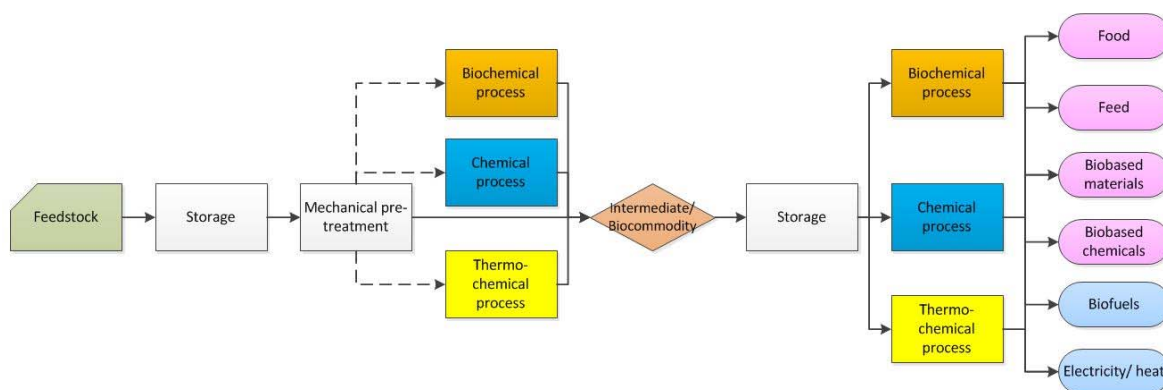



Figure 4. Schematic representation of steps in a simple value chain for biobased product.

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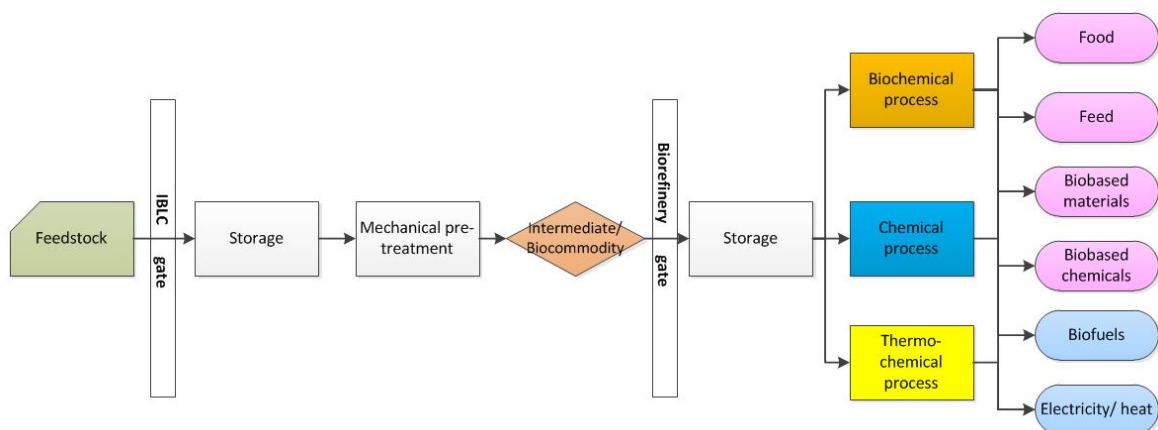


Figure 5. Boundaries of a simple IBLC.

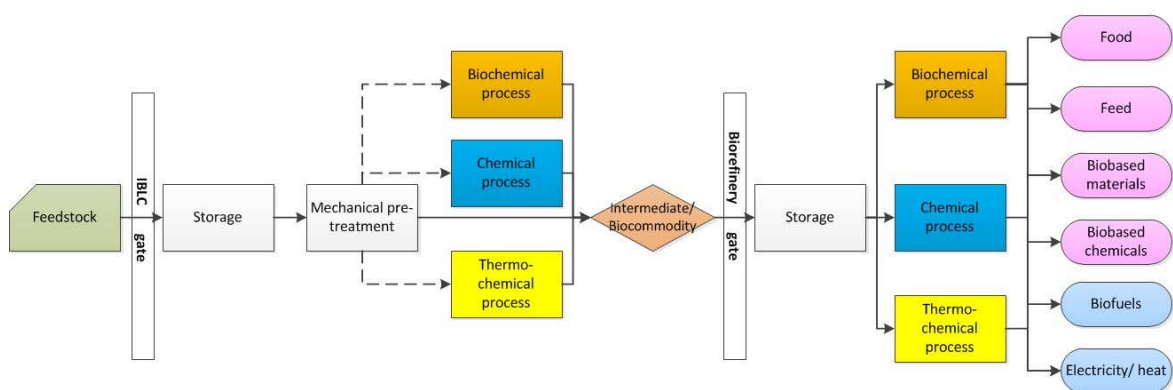



Figure 6. Boundaries of a more complicated IBLC.

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5 EXAMPLES AND IMPRESSIONS OF THE POTENTIAL OF THE UPDATED IBLC CONCEPT FOR SPECIFIC SECTORS

5.1 Introduction

The AGROinLOG partners have performed a quick desk study to identify background from literature citations that provide input for the potential of the IBLC concept for specific sectors. The same sectors that were addressed in SUCELLOG project (see Table 3 and Annex A) were also leading in this quick literature scan (Sucellog, 2017). The review work on these sectors was divided among the partners. The desk study yielded insight in IBLC-like concepts and examples of (potential) IBLCs.

Table 3. Pre-identified agricultural sectors for application of the agro-industry logistics centre (Sucellog, 2017).


SECTOR OVERVIEW					
Sector	Hand book	Spain	France	Italy	Austria
Forage dehydration	X	X	X	X	-
Feedstuff production	X	X	X	-	X
Cereal dryer (winter cereals and corn)	X	X	X	X	X
Rice dryer	X	X	-	X	-
Tobacco dryer	X	X	X	X	-
Wine sector (cellar and distilleries)	X	X	X	X	X
Sugar industry	X	X	X	X	X
Oil extraction industries ¹⁾	X	X	X	X	X
Dried fruits	X	-	-	-	-
Nut industry	X	X	-	-	-
Breweries	-	-	-	-	X

¹⁾ e.g. olive oil pomace industry

5.2 Forage dehydration

The forage dehydration industry was intensively developed at the 1950s (Gordon and Hurst, 2015). Dehydration reduces humidity and stabilizes forage while preserving its high protein content, vitamins and overall nutritive value (Renaud, 2002). Therefore, this technique is frequently used for conservation and preservation of the fresh plant's nutritional qualities. The constant improvement in dehydration, storage and homogenisation processes has led to the diversification of qualities offered, expanding forage consumption to all animal species.

Dehydration requires pre-wilting and chopping in the field, reducing the moisture content by 75 % to 50 %. Then forage is transported to the dehydration plant and it is dried in a rotary drum dryer. A hot air flow between 250 °C and 600 °C is used in order to reduce forage moisture down to 10 % (Désialis, 2017). The lower temperatures are used in conveyor dryers whereas high temperatures

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are used in rotary drum dryers. Sokhansanj et al. (1996) found that the optimum temperature for drying from the stand point of colour and protein solubility was found to be 175 °C.

Drying is essentially performed to reduce alfalfa moisture levels to a safe limit for storage (Figure 7). Siles et al. (2015) reported that moisture concentrations above 200 g/kg can cause negative changes in quality via mould growth which can lead to spontaneous heating within the alfalfa mass and increased concentrations of fungi that produce toxic metabolites.

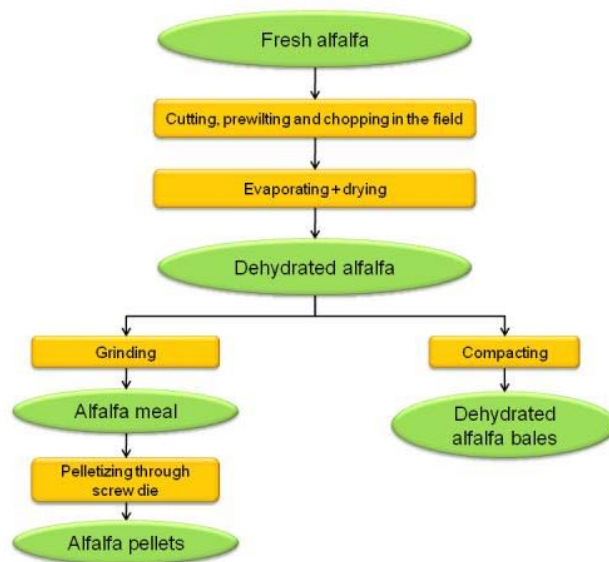



Figure 7. Alfalfa dehydrated process (Feedipedia, 2017).

For the alfalfa, long fibre dehydrated forage may be compacted into big square bales. Alfalfa can also be ground to make alfalfa meal or ground and passed through a screw die to make pellets that can be included in big square bales. The dehydrated forage comes out from the dehydrator at a temperature of 65–75° C and then it is immediately ground, pelleted at about 80 °C and cooled down to a temperature below 20°C, suitable for stable preserving (Cozzi et al., 2002). Pellets are often standardized to a certain protein content (such as 17 or 18 %)

The forage dehydration sector presents an important opportunity to become a logistic sector due to two synergies: it has an important idle period of 5 months (from November to April approximately) and owns compatible equipment (horizontal dryers, pelletisers and silos) for the production of solid biomass (Sucellog, 2017).

Regarding the drying process, the most common dryer used for forage dehydration is the rotary drum type (Adapa et al., 2004; Dalai et al., 2006). Conveyor dryers are also used but in a very minor way and only for low temperatures. Rotary dryers are used in many industrial sectors for solid particle drying because of their simplicity, flexibility in handling a wider range of materials and their high processing capacity (Silvério et al., 2015; Arruda et al., 2009). To this context, the rotary drum dryers are completely suitable for biomass drying. Basically, a rotary dryer which consists of a large rotating drum inclined towards the material outlet. Wet biomass material is introduced from upper end, travels along the drum, gets dried and the dried material is collected from the lower end (Fagernas et al., 2010). The drying medium flows in opposite direction to the biomass material. A

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rotary dryer can be run continuously while solid temperature and moisture can be controlled by controlling the rotation rate, the inlet air temperature and the flow rate (Shahhosseini et al., 2010).

Regarding the pelletizing step, facilities could easily be adapted for biomass production. High temperatures, high screw speed and mechanical pressure in presence of oxygen are usually applied to extrude and pelletize the alfalfa (Carrasco et al., 2016; Colas et al., 2013).

5.3 Feedstuff production

Animal feedstuff production consists of using of grains, cereals, vegetable and animal by-products, oil and fats, molasses, vitamins and minerals to create a balanced formula for different animals in all the life stages to cover all nutritional requirements. After first cleaning, the seed particle size reduction (grinding) is the next step in this process (Figure 8).

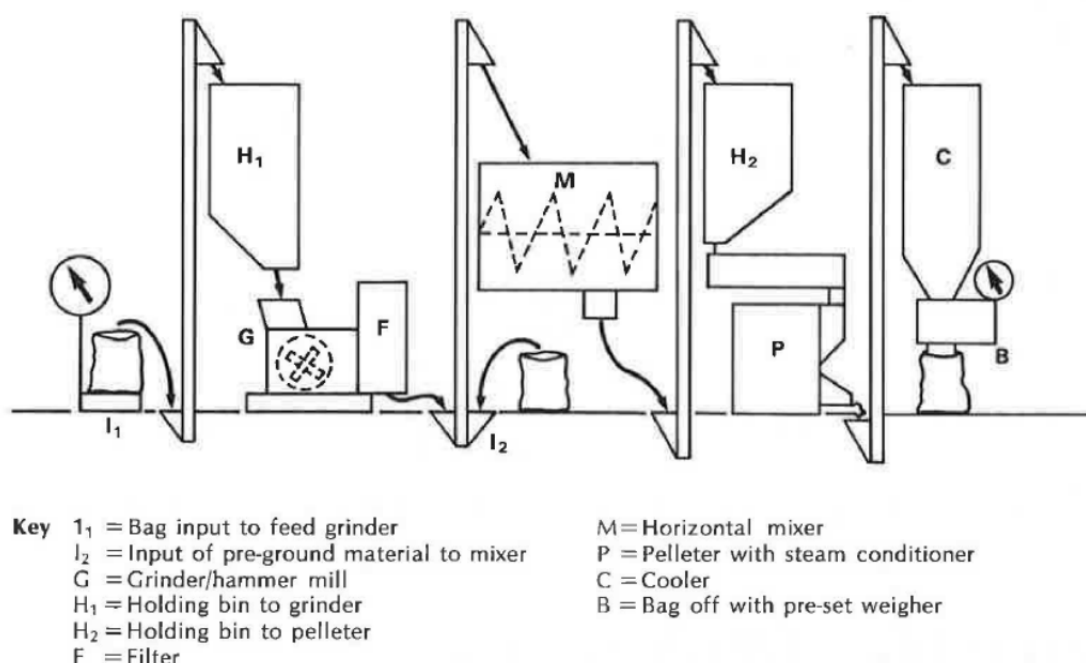



Figure 8. Flow diagram 2 t/h feedmill – industrial scale (Parr, 1998).

All ingredients need to be reduced in size to accomplish a homogeneous process into the mixer. Once ground, the ingredients are stored separately prior to weighing and dosing and then mixing. In the mixer the ingredients remain for a certain amount of time (wet and dry mixing time) and then some liquids are added. From here the mash can go to two different processes, for pelletized feeds or extruded feed, these two processes involve starch gelatinization (total or partial) to create a feed pre-digestion effect and at the same time the bacteriologic level is reduced due to the high temperatures reached at the conditioners where live steam is used. When pellet hardness or durability is lacking, pellet binders may be used to improve pellet quality (Thomas et al., 1998). Once molded (into pellet or collets) the feed is dried (if required), cooled, covered with liquids (fat/oil/enzymes/flavors coating) and then screened to remove fines prior bagging or bulk storage.

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This sector has been identified as a potential one to become a solid biomass logistics centre. Even though it does not have idle periods (e.g. pelletisers have no fixed idle periods, meaning that they start and stop production according to demand), it has many proper equipment types that might be used for processing of biomass such as: pelletizes, silos for storage, screening and chipping equipments (see Figure 9).

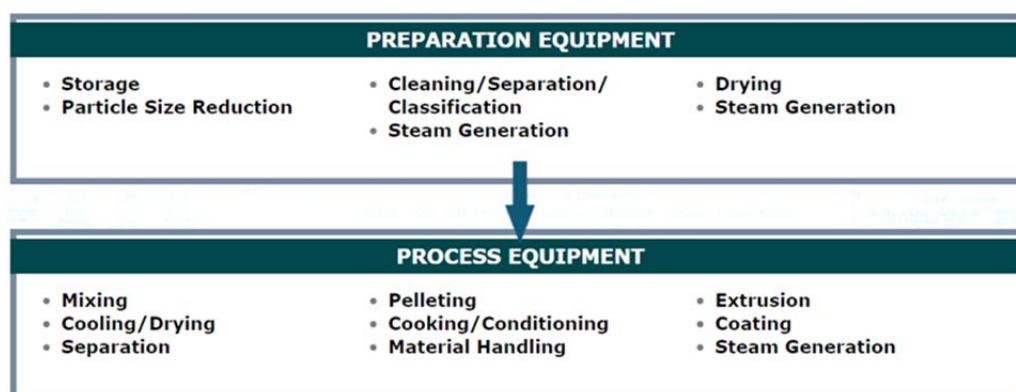



Figure 9. Feedstuff production typical equipment (R&D, 2017).

Additionally, the sector produces interesting amounts of residues, around 2 – 10 % of their production, although some are already formulated feedstuffs which might contain antibiotics. Therefore their use as possible solid biomass source needs to be studied in order to avoid potentially dangerous emissions in the environment. The sector presents a high degree of professionalization and is used to ask for financing. However, the logistics centre should be implemented either in a line not used at the moment or in a line specifically installed for the purpose of biomass processing. In addition, it is expensive and difficult to switch the production from feedstuff to solid biomass processing in short periods. The machines must be re-cleaned due to high hygiene standards and adjusted.

5.4 Cereal dryer (winter cereals and corn)

The removal of moisture from cereal is considered a preservation method (Figure 10). By reducing the water content, the opportunity for microbial deterioration is eliminated and the rates of other deteriorative reactions are reduced significantly. In addition, it reduces product mass and volume by significant amounts and improves the efficiency of product transportation and storage (Singh et al., 2009). Temperature and moisture content are critical in maintaining the cereal quality. Safe moisture levels for storage depend on grain variety, length of storage, storage structure and geographical location. However, it has been reported that mold and insect activity is greatly reduced below 15 °C (Maier et al., 2002; Mrema, 2011).

There are different kinds of industrial grain dryers (Figure 11) and they can be classified according to temperature level, flows directions and batch or continuous process. Nevertheless, most of them are vertical dryers and they are not so suitable for biomass as the rotary horizontal ones. Therefore, a new line for drying may be required since not so many biomass formats are compatible with the dryers (only granulate material but no straw or chip).

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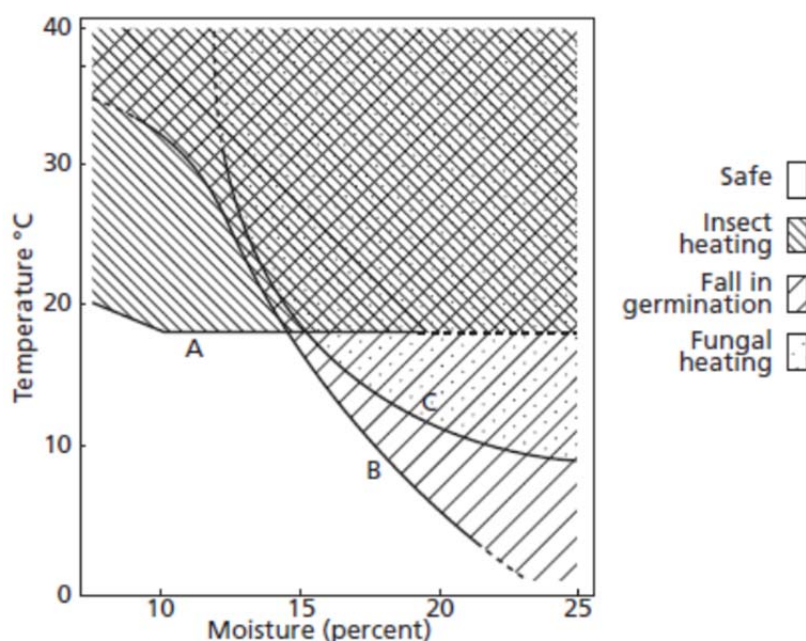


Figure 10. Effects in storage at different temperatures and moisture content (Mrema, 2011).

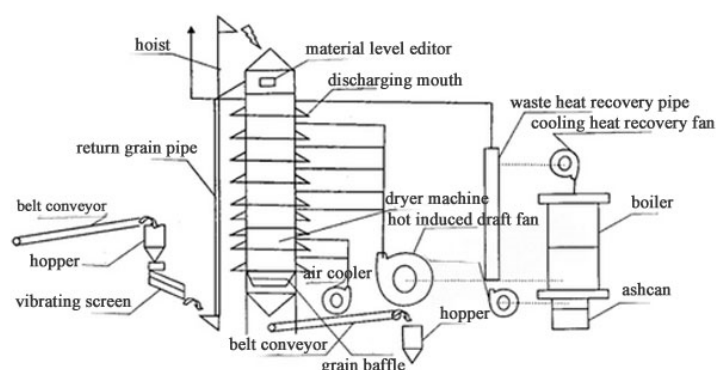
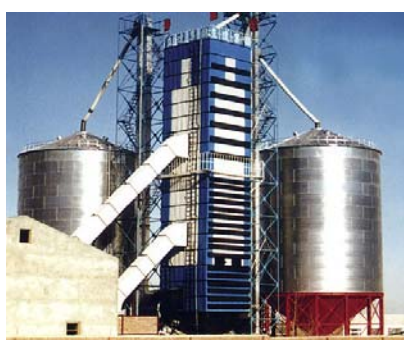



Figure 11. Grain dryer and storage silo (Kefan, 2017).

Besides the dryer system, the sector shows an interesting potential to become a solid biomass logistics centre: long idle periods of around 8 months, screening and handling equipment, silos for storage and in some cases, pelletisers. This equipment could be used without any barrier.

Regarding the raw material available for a possible logistics centre, cereal dryers are located in areas where there are large amounts of cereal crops. Farmers supplying the grain to be dried in the facilities produce important quantities of straw which main market is livestock feeding, bedding and champignon substrate. Depending on the year, a considerable amount of straw is not able to enter the market. Some studies consider that, one year out of three, the straw (of cereals, maize or rape) can be used for energy purposes, and that one third of the total amount of straw should be left on the soil (Sucellog, 2017). Other studies have reported that the available potential (biomass without any other competitive use and therefore with the potential to be totally used as energy biomass) is about 20 % for winter cereals and 70 % for maize, of the total agricultural residues

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produced per year (S2Biom, 2017). Similar numbers, even higher (30-45 %) were obtained by Weiser et al. (2014).

Furthermore, waste heat recovery should be a best practice in order to reduce energy consumption and as consequence, to lower operational costs for an IBLC implementation in a cereal dryer facility. Cocco et al. (2006) carried out a performance evaluation of a small scale externally fired gas turbine fuelled by residual biomass. This could be integrated at an IBLC with a biomass dryer that can be used for cereal or any other product.

5.5 Rice Dryer


Drying reduces grain moisture content to a safe level for storage. It is the most critical operation after harvesting a rice crop. It is important to dry rice grain as soon as possible after harvesting—ideally within 24 hours. Delays in drying, incomplete drying or ineffective drying will reduce grain quality and result in losses. The harvesting period of rice is between September- October and thus the drying period between September-November (IRRI, 2017). The rest of the year the rice dryer is unexploited.

One potential new activity of the rice dryer is to use it for drying various grain types, not only rice. There are several dryers capable of drying various products apart from rice like corn, wheat, sunflowers, etc. (Bühler, 2015).

Another synergy that can be applied in the rice industry in order to reduce the operational fuel costs of the dryer is the consumption of rice husks as fuel. Rice husk is an unexploited by-product of rice milling process and with a low cost of acquiring it (just transportation costs). As a result, by applying a rice husk furnace to acquire the required heat for the drying process, the unexploited products of the rice milling process are used (Gummert et al., 2010). In Sheng & Huang (2014) rice husk furnace applications are presented. The applications refer to rice drying centres and rice mills where rice husk is treated as a fuel for the dryer and not as a waste. In addition, Swastika (2012), investigates the financial feasibility of different type of rice dryers applied in rice mills. The conclusion is that the rice dryer fuelled by rice husks is an economically feasible and profitable option.

Chakma et al. (2015) investigated the potential of using rice by-products like rice husk and rice straws in energy generation and biofuel production via thermochemical and biochemical conversion. In the current paper, thermochemical technologies like combustion, pyrolysis and gasification of rice husks and straws are presented in order to obtain bioenergy. Continuously, biofuels as ethanol, butanol, and biogas can be produced via biochemical routes like hydrolysis, fermentation and anaerobic digestion. The paper includes economic analysis that results in the feasibility of the biochemical and thermochemical methods in converting rice residues into biofuels and bioenergy.

Finally, rice mills with rice dryers can be used as storage facilities to keep rice crop residues that can be exploited for bioenergy and biofuels.

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5.6 Tobacco dryer

In the production of tobacco curing is the final step (Figure 12). Thereafter, the leaves are sold to be transformed into the final tobacco product, e.g. cigarettes, cigars, chewing tobacco and snuff. Through curing, the moisture content over a wet basis in the tobacco leaf is reduced from 80 % to about 20 %, thus ensuring the tobacco's preservability. There are four methods used for curing tobacco grown for commercial purposes related to the four different processes for drying tobacco leaves: flue-curing, fire-curing, air-curing and sun-curing.

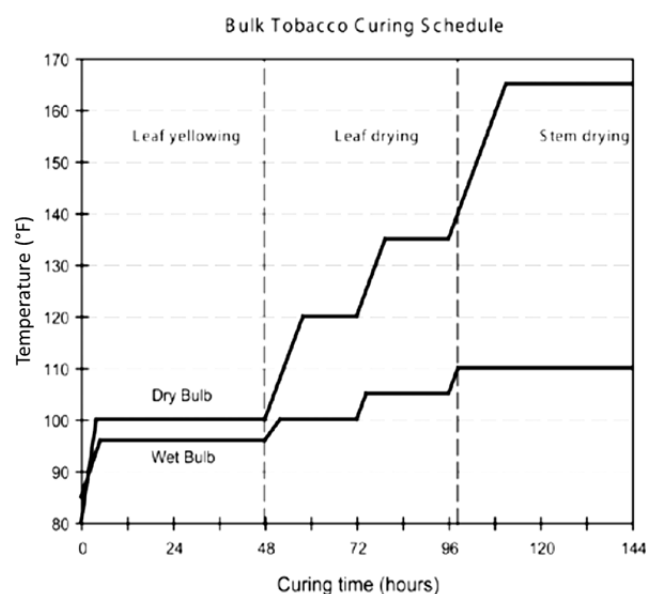



Figure 12. Bulk tobacco curing schedule (Reed, 2008).

Flue-curing and fire-curing are the two methods that include a specific tobacco dryer that is likely to be suitable for biomass drying. Air-cured tobacco is carried out by hanging the tobacco in well-ventilated barns, where the tobacco is allowed to dry over a period of four to eight weeks. In the sun-cured tobacco process, the tobacco is placed in the sun uncovered, and is dried out naturally.

The dryer devices flue- and fire-curing are totally different between facilities. Fire-cured tobacco is dried with low-burning wood fires on the floors of closed curing barns (black tobacco) while flue-cured tobacco is dried with gas-fired dryers (Virginia tobacco). The most common curing process is the flue-curing one. Flue-cured tobacco is dried in a closed building with furnace driven heat directed from flues or pipes that extend from a furnace into the barn. The temperature of the furnace is gradually raised until the leaves and stems are completely dried. Flue-curing takes about a week (ITGA, 2017).

More than 90 % of the energy used for the production of tobacco is used in the curing process. The temperature and humidity curve in the dryer must be followed carefully in order to obtain a satisfactory product. The highest temperature is reached at the end of the process and it is about 74 °C (165 °F).

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An important issue is that this is one of the sectors that significantly impulse research and development. Bao et al. (2016) proposed a novel heat pump concept for tobacco drying process instead of conventional gas- or coal-fired burners. Some authors make use of a CFD model analysis of the curing process. Bai et al. (2017) developed a 3D transient CFD model for temperature and humidity predicting inside the dryer. Gu et al. (2014, 2016) studied the residence time of tobacco leaves inside a rotary dryer and the heat and mass transfer by numerical analysis. Regarding other types of dryers, Geng et al. (2009) carried out a numerical simulation on fluidization characteristics of tobacco particles in fluidized bed dryers.

Despite the fact that tobacco curing facilities may be interesting as drying facilities, tobacco producers present some remarkable restrictions from main buyers of tobacco which are big international companies. They do not allow the tobacco industries to use dryers for different purpose. Therefore, the development of an IBLC based on the use of the tobacco dryer must be carefully studied, case by case.


Concerning biomass residue potential, the agrarian practice of tobacco cultivation produces stem residues that are currently left on the soil because they have no other use. These stems could be studied as a possible biomass source for bio-energy or other biobased product applications. Zi et al. (2013) dealt with the use of waste tobacco stems for biomass material using as granules. In any case, tobacco is a special biomass material, with complex chemical compositions depending on the tobacco fraction, variety and growing condition. It contains over 3,000 compounds and processes such as pyrolysis are very complex and they have been widely studied (Baker et al., 2004; Cardoso et al., 2013; Maskos et al., 2005). Ye et al. (2016) proposed a new selective pyrolysis technique for the production of nicotine from tobacco via low-temperature catalytic fast pyrolysis of tobacco. Nicotine could be considered a kind of biocommodity that is used in the production of chemicals, pharmaceuticals, etc. Furthermore, the sector is highly familiar with biomass issues in countries like Spain, since most of the tobacco facilities use biomass as a renewable resource for fuelling their drying process from 2010 (Decreto, 2010).

5.7 Wine Sector (cellar and distilleries)

In the wine sector several papers present the potential of using wastes from wine distilleries for the production of energy and biobased products. In this sense, wine sector as an IBLC will be further benefited by the exploitation of wine waste products as potential biocommodities.

Zacharof (2016) investigated the valorization of winery wastes and their exploitation as feedstock to produce platform chemicals, biofuels, and energy. Winery wastes can be divided into solid (grape stalks, grape pomace, grape seeds) and liquid wastes (wastewater generated in fermentation, storage, maturation, clarification, etc., that are produced during wining process). 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. The winery residues (wine lees, grape marc, vinasses, and winery wastewater) can be used as feedstock to produce platform chemicals such as lactic acid,

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biofuels including ethanol, enzymes, chemical intermediates, and energy through pyrolysis and anaerobic digestion.

Furthermore, there are additional existing 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.

Moreover, according to Corona & Nicole (2010), Settesoli- a huge winery in Italy- decided to construct a biomass energy plant of 1 MW that would use as feedstock the vine canes from pruning, along with pomaces and wastes from the winemaking process.


5.8 Sugar industry

The European Union is the world's biggest producer of sugar from beet and the principal importer of raw cane sugar for refining. In the sugar industry the product season runs only a certain part of the year, e.g. from mid-September to mid-January. During the product season the sugar factory operates around the clock, seven days a week. The key activities during the off season are maintenance of production equipment and installation of new devices. The sugar industry is already a well-developed biorefinery where sugar is converted to a variety of products. But there are large opportunities to develop IBLCs.

During the sugar beet season when all beets are transported to the sugar factory all is about logistics, a large number of shipping groups are normally involved. At the sugar factory there is equipment for both physical and chemical pre-treatment and also washing facilities. The sugar is dissolved in an extraction facility. The sugar juice is purified by adding lime and carbon dioxide. The liquid is filtered and in large evaporation containers the remaining water is evaporated. The remaining liquid is boiled with under pressure, after that crystallization and centrifugation.

Examples of co-products from the sugar industry are beet pulp and molasses. Beet tops is another by product from the sugar industry, but remains in the field at the moment. Sugar beet pulp contains a third cellulose, hemicellulose and pectin respectively. Beet pulp can be utilized as feedstock for production of biofuels. Also molasses, which contains approximately 50 wt% of sugars, is used as fermentation substrate for bioethanol production (Forster-Carneiro et al., 2013). Sugar beet pulp and molasses can also be utilized as feedstock to produce platform chemicals. Platform Chemicals is a set of chemicals that can be used to produce plastics, paint additives, textiles, personal care products, pharmaceuticals and others products. There are also possibilities to extract arabinose from beet pulp (Suiker Unie, sugar industry in Germany and Holland).

One of the largest co-products in the sugar industry is sugar beet pulp. Europe produces around 13 million tonnes each year. Currently a majority of the beet pulp finds its way into low value feed, bio-fertilizer or is used as substrate for biogas production. In an on-going project, PULP2VALUE, the main focus is to improve the valorisation of side streams from production of sugar beet and demonstration of nine new value chains for the processing sugar beet pulp into bioproducts. The approach is to refine sugar beet pulp that allows the conversion of 65 % of its dry matter into high

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value products such as microcellulose fibers, arabinose and galacturonic acid. The project will be finalized by June 2019 (Pulp2value, 2017).


British Sugar is an example of a sugar industry that in recent years has expanded its core business from only producing sugar, to include the production of animal feed, electricity, tomatoes, and bioethanol. This was accomplished by systematically searching for opportunities to turn waste streams and emissions from their core production useful and positive inputs to new product lines. In an article by Short et al (2014) British Sugar was used as a case study to understand the relationship between industrial ecology and business model innovation. The case study shows how British Sugar enhanced the competitiveness of its core sugar business, while successfully expanding into new and diversified markets, increasing revenue streams, and enhancing business resilience. By focusing on turning all by products into valuable co-products British Sugar created a competitive advantage and helped to ensure the long-term future of the company by presenting new business opportunities.

There will be an abolition of sugar quotas at the end of the 2016/17 marketing year, i.e. from 30 September 2017 (Sugar FAQ, 2017). During the time with the quotas the producers has been guaranteed a minimum price which also will be removed. In short term, it may mean that European sugar production will decrease and imports will increase. This is a great opportunity for the sugar industry to establish an increased utilization of the facilities according to an IBLC.

5.9 Oil Extraction Industries

In oil extraction industries several technological schemes could be introduced as IBLC. Residues from olive orchards and processing like pruning and olive kernels can be used as biomass for solid biofuels (pellets). Furthermore, olive mill residues are treated in the pomace mills. After extracting the pomace oil from the olive mill residues, exhausted olive cake is obtained that is suitable for combustion and for covering the self-consumptions of the mill or domestic demands for heating. Alternatively, it can be used in anaerobic digestion in order to produce biogas and thus, bioenergy.

Moreover, in the olive mill wastes, there is the majority of phenolic compounds that are available in the olives. Thus, a potential exploitation of olive mill wastes is the extraction and recovery of valuable phenolic compounds like hydroxytyrosol, oleuropein that can be used in pharmaceuticals or cosmetics (Fernández-Bolaños et al., 2006). Tsagaraki et al. (2007) present various products that can be retrieved from the olive wastes. Several methods of treatment or production of animal feed can be used by adding special chemical treatments (like sodium hydroxide, ammonia, etc.) to the solid residues. Fernández-Bolaños et al. (2006) proposed a technological scheme (depicted in Figure 13) in order to exploit all the valuable compounds found in the olive wastes. According to his strategy- technology, valuable phenols, chemicals, bioethanol, olive wastes are presented for the production of fertilizers by composting, recovery of antioxidants via liquid-liquid extraction, production of biopolymers, production of biogas from anaerobic 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.

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In the deliverable of the Market of Olive Residues for Energy (MORE) project (Market of Olive Residues for Energy, 2008), several methods for energy exploitation of olive residues are presented. The methods that are proposed are combustion, gasification, pyrolysis for energy production, anaerobic digestion for the production of biogas or alcoholic fermentation of alperujo into bioethanol. On the same report, several existing cases with olive residues exploitation for energy production are presented. In Spain, both of the following two types of energetic applications of the olive solid residues are used:

- 1) The biomass is combusted in domestic or industrial sector for covering the heat demands.
- 2) Olive residues are used in the Rankine vapour cycle for generation or co-generation (heat and electricity) in electrical plants.

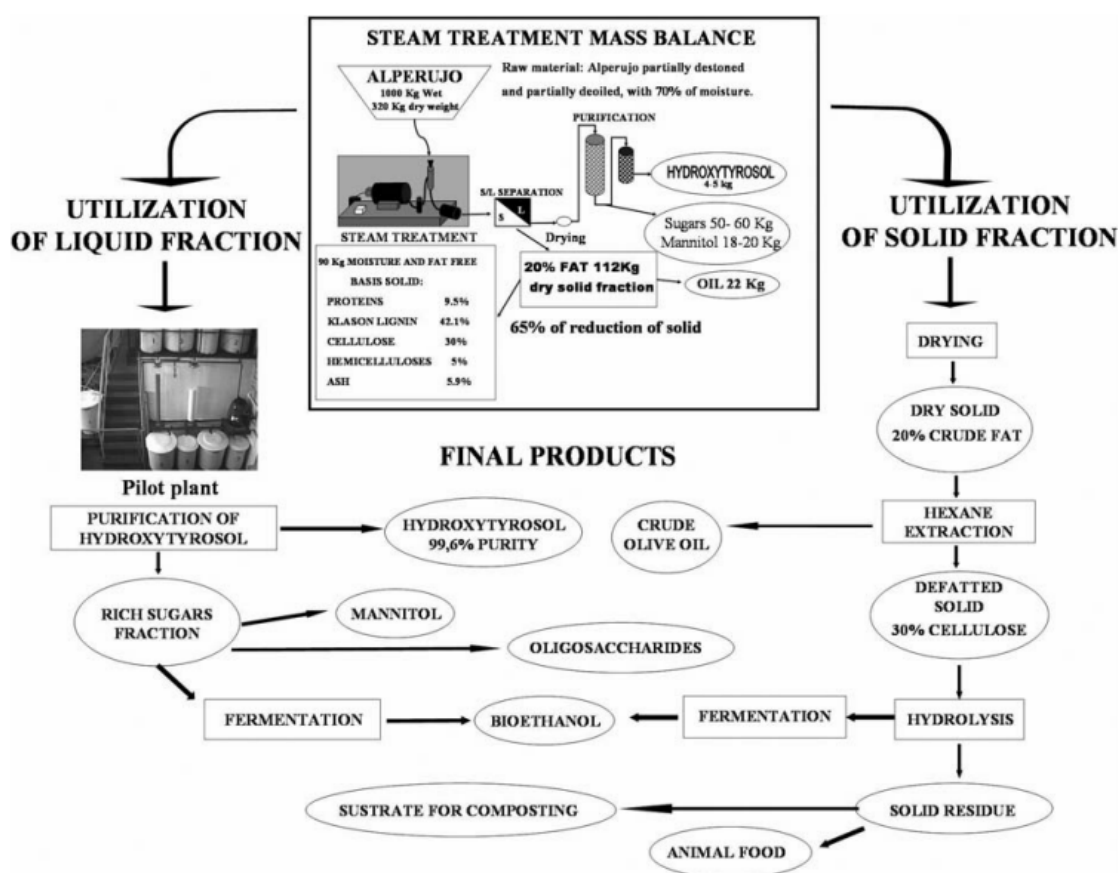



Figure 13. Strategy for an integral recovery and revalorization of olive mill waste- alperujo (Fernández-Bolaños et al., 2006).

5.10 Dried Fruits

Fruit processing (canning, juicing, drying) generates large quantities of both solid and liquid waste. The majority of these operations are often seasonal. Khan et al. (2015), addresses the exploitation potential of waste streams from fruit processing. Heavy water consumption occurs during these processes and the wastewater generated typically contains particulate organics, suspended solids, and various cleaning and softening or surface-active additives. This fruit-processing wastewater

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could be a feasible feedstock for the production of bio-ethanol, biogas, or used as a substrate for the production of enzymes or other value-added products (Figure 14). Thus, the fruit processing industries can exploit their wastes and set up new businesses with the production of such biobased products.

Currently, the wastes produced from canning industries are used for bioenergy. Greece owns one of the biggest shares in the canning industries sector in Europe. Peach kernels are wastes produced by peach canneries and juice production plants. Peach kernels were mostly used by the domestic sector and greenhouses until fairly recent; currently they are mostly self-consumed by the peach canneries in order to produce thermal energy. Any leftover quantities that are available on the market are sold in price ranges of 60 – 80 €/t (Greek Canning Industries, 2017).

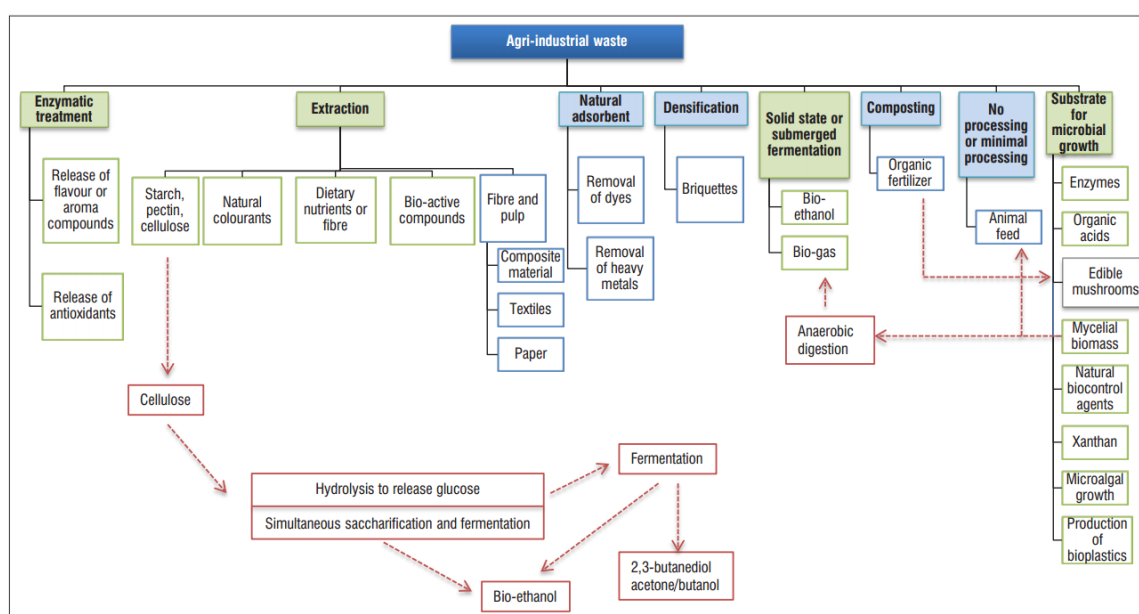



Figure 14. Potential beneficiation of agri-industrial wastes with a focus on fruit wastes. Green blocks indicate possible pathways for beneficiation of liquid waste and/or solid waste, while blue blocks represent possible beneficiation pathways for solid waste (Khan et al., 2015).

5.11 Nut industry

Nut industries produce byproducts (shells, hulls) that can be exploited mainly in energy production. In the report of the Almond Board of Australia (2017), existing cases of technological solutions were investigated for using byproducts from nut industries as a biomass resource to cover the energy demands of the nut industries (nut crusher etc.). Nut shells and hulls are woody wastes with high calorific content (16-18 kJ/kg) and with low moisture content. In the report several real cases are presented where byproducts from nuts are exploited. In Queensland, AGL's Biomass cogeneration facility converts 5,000 tonnes of shell waste from macadamia nut into a biofuel to generate renewable energy. In the facility, shells from the macadamia nuts are used as biomass fuel and burnt in a 6 MW steam boiler. The produced steam is used for drying the nuts and also to

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power a steam turbine. The energy that is generated from this renewable source is used for the production site, with excess electricity exported to the national grid.

In addition, Dixon Ridge Farms, California, grow and process organic walnuts. Recently, the farm invested in an on-site energy production solution in which walnuts shells are used as feedstock for the production of heat, electrical power and synthetic diesel fuel. In the technology used at the farms, the walnut shells are processed into syngas (through gasification) which fuels a gas fired generator for the production of electricity.

Furthermore, there are other options for the nut industries by-products to be used. The report proposes the use of shells as biomass resource in briquettes, pellets, in compost or in the production of anti-oxidants for the food industry.


Nut industries can further exploit their byproducts in producing bio-chemicals as a new production line in an IBLC concept. Demirbas (2006) suggests the possibility of using shells from nut industries as feedstock for the production of chemicals such as furfural, glucose, extractives and biochar for combustion.

5.12 Breweries

The main by-product from the brewery industry is spent grains (78 %). Other residues are yeast residues (9 %), hot and cold break (9 %). The main application of spent grains is in animal feed, due to its high content of protein and fibre. Because of the chemical composition is rich in sugars, proteins and minerals several attempts have been made to use them in biotechnological processes (Mussato, 2009). Spent yeast is partly processed in pharmaceutical products and human nutrition.

From a case study in Austria in the SUCELLOG project it was concluded that breweries have the capacity to reach residues, but lack the compatibility of equipment for the processing of these residues for production of solid biomass. The available barley straw (with no market or sustainability uses) could be considered as a potential biomass source for agro-fuel pellet production, but was not further considered as a viable case study for investment by the brewery industry (SUCELLOG, 2014).

Expectations are that in case of a decrease of the livestock sector the prices for spent grains will decline. Breweries are therefore investigating alternative processing routes and markets for spent grains, specifically for food, feed, fibre and bio-plastics (Elbersen et al., 2011).

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6 CONCLUDING REMARKS

The specific objective of task 6.1 was to provide an updated conceptual description of an IBLC. The result of this task will be used as guidance for the next subtasks in WP6 and for the rest of the AGROinLOG project.

The SUCELLOG project formed the starting point for the elaboration of the idea to use available agro-industrial capacities as a resource for the processing of biomass for renewable energy. In the SUCELLOG project this concept is called Agro-industry Logistics Centre (ALC) concept which is mainly aimed at bioenergy markets. In the AGROinLOG project an update of the ALC concept was given which is referred to as Integrated Biomass Logistics Centre (IBLC) concept.

A literature review showed IBLC-like concepts and examples that all address the local or regional function of an intermediary entity for collection and pre-processing of biomass resources. The starting-point can be the availability of biomass resources (biomass push-strategy). The IBLC concept can, however, also be interpreted from a strategic perspective of biorefinery industries to establish a biomass hub for to safeguarding the supply of homogeneous biomass resources to the biorefinery plant (biorefinery pull-strategy). The initial approach in the IBLC concept is however to establish connection between the seasonal overcapacity at agro-industries and the regional availability of biomass residues as resources (biocommodities) for biorefinery processing (hybrid strategy: biomass-push- and agro-processing pull-strategy).


An Integrated Biomass Logistics Centre (IBLC) is defined as a business strategy for agro-industries to take advantage of unexploited synergies in terms of facilities, equipment and staff capacities, to diversify regular activity both on the input (food, feed and biomass feedstock) and output side (food, feed, biocommodities & intermediate biobased feedstocks) thereby enhancing the strength of agro-industries and increasing the added value delivered by those companies. The name IBLC represents four typical characteristics that were further described:

- an integrated value approach towards food and biobased markets;
- regional availability of biomass;
- logistic, storage operations and pre-treatment;
- exploiting the central position.

For the European agribusiness (primary and processing sector) the opportunity 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. For existing agro-industries there are three important drivers to develop an IBLC:

- diversification of inputs;
- optimization of available and new capacity;
- diversification of outputs.

A comparison was made between the basic ALC concept and the updated IBLC concept. One of the differences is that the updated IBLC concept does not only include processing solid biomass but

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also other types like green (fresh) biomass. Furthermore, the updated IBLC concept does not only include bioenergy but also biobased products with a higher value, which could justify investing in extra capacity.

An IBLC can play an important role as a unit for increasing economic, environmental and social sustainability of agricultural production and processing in the region. In addition the IBLC concept is affected by the governance of the agricultural sector (incl. laws and regulations) as well as by specific policies regarding biomass, waste and valorisation of residues from agriculture into new products.

The following IBLC subtypes were identified based on three drivers:


- input driven concepts - availability of biomass residues/materials is leading;
- process driven concepts - availability of (idle) processing, storage and personnel capacity is leading;
- output driven concepts – market demand for biocommodities / new products is leading;
- combined concepts - multiple drivers are leading.

Some of the biomass resources that have been identified in the studied sectors as being available for biorefinery processing can be used for biobased products other than solid biofuels. Exploring new value chains of these biobased products would be interesting also from the IBLC perspective, in particular when the added value for these other biobased products is higher than for solid biofuels. In that case the economic feasibility of an IBLC may be well within grasp, when the technical specifications of both biomass and biorefinery processes can be met.

The sectors and industries that have been described all have a potential link with the chain of biomass processing for biorefinery purposes (including energy). This link can be either i) as a source of biomass residues, ii) as a partner in the chain of logistics and processing of biomass residues for a specific market, or iii) as a potential buyer of the bio-product that is produced from these residues. In some cases these three links coincide in one business entity.


In some of the described cases the approach is to integrate operations and activities, flows of products, or resources and residues at an industrial level. These physical interconnections that have the potential to create synergy, are referred to with the term industrial symbiosis. The IBLC concept should be interpreted from a wider perspective as an opportunity to integrate operations and facilities also within the scope of the primary sector (and not only from the perspective of agro-industries).

As mentioned the description of the updated IBLC in this deliverable D6.1 is meant to serve as input for the following tasks in WP6 and for the other WPs in the AGROinLOG project. A recommendation is to review the description of the update of the IBLC concept at the end of the project e.g. based on the experiences in the three IBLC demonstrations in the project to see if further modifications need to be made.


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ANNEX A. SUCELLOG'S AGRO-INDUSTRY LOGISTICS CENTRE CONCEPT - INFORMATION SUMMARY

Introduction

The SUCELLOG project has yielded the following deliverables:

- Agro-industry logistics centres: i) four new agro-industry logistics centres, ii) direct technical support to 44 European agro-industries for starting new agro-industry logistics centres and iii) more than 1,320 advice services provided to the agrarian sector.
- Training of staff from agricultural associations: 15 regional and four national skilled teams to carry-out auditing and dissemination activities in Spain, France, Italy and Austria. Training of agricultural associations in other three countries in EU28.
- Awareness creation: 88 workshops and engagement events in participating countries to create awareness about opportunities for the agrarian sector.
- Supporting materials: elaboration of three handbooks and two technical guidelines to provide support beyond the project.


In this Annex the main outputs of the SUCELLOG project are introduced in order to describe and define the agro-industry logistics centre concept (a preliminary IBLC concept). The regional situation of the main countries involved (Spain, France, Italy and Austria), including biomass resources and priority actions, is summarised in the next section. Finally, the main conclusions that have been collected in the preparation of some useful Handbooks are summarized.

Current situation of main agro-industry sectors in Spain, France, Italy & Austria

SUCELLOG focuses on the implementation of biomass logistics centres into agro-industries as complement to their usual activity with minor investments. Agro-industry facilities can be utilised in their idle periods to handle and pre-treat biomass feedstock (mainly from their own residues or agricultural residues nearby) to produce solid biomass to be introduced into the market. This is the situation of the main agro-industry sectors analysed in the SUCELLOG's framework: Spain (SP), France (FR), Italy (IT) and Austria (AU).

Forage dehydration

The forage dehydration sector presents an important opportunity to become a logistics sector due to two synergies: it has an important idle period of five months (from November to April, approximately) and owns compatible equipment (horizontal dryers, pelletisers and silos) for the production of solid biomass. In some cases (FR), the implementation of the SUCELLOG's concept is something that is already happening in this sector since they dry other materials different from forage in order to diversify their activity (sugar beet, wine residues or cereal). The forage

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dehydration facilities do not produce any important biomass residue, but they have easy access to the residues produced during the agrarian and processing phases. The sector thinks that there are no social or technical barriers to start this new activity within their installations. However, there is a lack of knowledge on finding possible financial schemes.

Feedstuff producers


This sector has been identified as a potential one to become a solid biomass logistics centre. Even though it does not have idle periods, it counts with many proper equipment that might be used for the new activity such as: pelletisers, silos for storage, screening and chipping equipment. The sector presents a high degree of professionalization and is used to ask for financing. However, the logistics centre should be implemented in a line not used at the moment or in lines specifically installed for this purpose. The machines must be re-cleaned due to high hygiene standards and adjusted. Additionally, the sector produces interesting amounts of residues not able to enter the market although some are already formulated feedstuffs which might content antibiotics. Therefore their use as a possible solid biomass source needs to be studied in order to produce no dangerous emissions for the environment. However, SUCELLOG considers that this sector has a potentiality to become a logistics centre.

Cereal dryers

This sector shows an interesting potential to become a solid biomass logistics center from a technical point of view, offering a long idle period of around 7-8 months as well as proper equipment such as vertical dryers, screening equipment and silos for storage. Regarding the raw material available for a possible logistics centre, cereal dryers are located in areas where there are important cereal extensions. Farmers supplying the grain to be dried in the facilities produce important quantities of straw. Depending on the year, a considerable amount of straw is not able to enter the market for animal feeding. These industries think that a new line for drying may be required since not so many biomass formats are compatible with the vertical dryers (only granulate material but no straw or chips). Nevertheless, these industries are familiar in using biomass as a fuel during their process and no legal or practical incompatibility to become a biomass logistics centre has been observed. However, in some regions (IT), the situation of the sector is not the best, not being able to afford large investments in the next years, so there is not too much interest to start a new activity.

Rice dryers

The rice dryer industry has an idle period of around 8-9 months and counts with vertical dryers presenting an interesting synergy to become a logistics centre. In what concerns the residues associated to this type of agro-industry, the straw is not harvested due to the technical difficulty of working in waterlogged areas in which rice is produced. New regulations will make the situation even more delicate than it is now, reducing the production (SP). Sector could see in the development of a logistics centre an opportunity to diversify the activity and maintain the employment. Although no technical barriers for the development of a logistics centres in rice dryer have been detected, the resistance to innovation and the extreme reluctance to perform investment from the agro-industries should be overcome to start this new activity in this sector (IT).

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Tobacco dryers

The agro-industry of the tobacco remains open the whole year but their dryers have an idle period of 7-9 months per year presenting a good opportunity to become a biomass logistics centre. The sector is highly familiar with biomass issues since most of the tobacco facilities use biomass during their drying process from 2010, when specific regional aids (83/2010) for the sector fostered the investments for the use renewable energy sources (SP).

The agrarian practice of the tobacco generates residues stalks that currently are left on the soil because they have not found other use for them. They could be studied as a possible biomass source. The sector is in a strong decline and restructuration (FR). In addition, although the tobacco producers showed interest in the project, they have some restrictions from main buyers of tobacco which are big international companies since they do not allow the tobacco industries to use dryers for different purpose, therefore they will not be considered as a target industry of the project (IT).

Wine sector

The wine sector includes the cellars and the distilleries, the latter processing the residues obtained from the cellars. From both, it is only the distilleries the ones owning equipment (horizontal dryers) compatible with the production of solid biofuels. The idle period of these dryers is short compared to other agro-industries, 4 months approximately.

Nowadays many of the by-products produced during the wine elaboration (grape marcs and grape stems) are already used as animal feeding or for methanization purposes. Regarding the residues from the distillation process, they are sold for animal feedstock and biogas production. Vineyard prunings could be commercialised once chipped and dried in the same drier of the distillery or in a new production line implemented in the cellar. However, prunings are most commonly burnt or left on the soil mainly because its collection is difficult and expensive (AU, IT, SP).


Technically and socially they do not see any trouble for initiating a new activity as a logistics centre. Although they find it as an interesting opportunity since it might help to create employment in the area, investments should be carefully studied.

Sugar industry

The sugar industry presents, on the one side, an important idle period of approximately 7-9 months and, on the other side, compatible equipment for the production of solid biomass such as horizontal dryers and pelletisers. It can be a good sector to implement logistics centres as an opportunity for diversification. However, it depends on the region. Some sugar industries are closing (IT) since they are not competitive and the industry has an important uncertainty due to the end of the quota in 2017 involving changes (FR). More effort should be paid in order to engage sugar industry since they are not familiar with bioenergy issues (SP) and it has not shown a great interest for initiating a new activity as biomass logistics (AU).

Olive oil sector

The olive oil sector includes oil mills and oil pomace extraction industries. Similarly to the wine sector, the latter processes the residue obtained in the oil mills owning horizontal dryers and pelletisers for this purpose. Even though the idle period is reduced (4 months approximately), it is

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considered an interesting sector to develop biomass logistics centres due to the capacity of using own residues. In France and Austria, oil extraction industries are dedicated to rape, pumpkin and sunflower seeds mainly working all the year and residues are not used for energy purposes.

Both the olive mill and the olive pomace industry do not see technical or social incompatibilities to become biomass logistics centres. In the case of the olive mill, a drying system should be implemented since the facility does not normally present this type of equipment.

Nut industry

The sector of the nut industry performs their activity during the whole year but their dryers are not working from December to August approximately (9 months idle period). Dryers are the main equipment compatible with the production of solid biomass they usually own, apart from silos and handling systems.

Nut industry produces nut shell during the months of September to June, a valuable residue that can be used as solid biomass and nowadays is really appreciated for that purpose. Therefore they are not only target industries from SUCELLOG but also producers of residues to be considered in a resource assessment. Apart from that, fruit tree prunings are an important wood source to be taken into consideration.


The sector has not perceived any technical or legal incompatibility if cleaning processes are correctly applied. In the case of the almond sector, their situation is highly unstable and subject of variation according to the international market (more concretely depend on the prices fixed by the Almond Board of California). The creation of a logistics centre can be seen as a good opportunity although the sector is not in the best conditions to make high investments.

Breweries

As it happens with the cellars, the breweries do not own compatible equipment for the production of solid biomass but they have the capacity to reach residues. A completely new line for the production should be built in case they would be interested in becoming logistics centres.

The residues of beer production, 78% spent grains and yeast residues 9% hot and cold break (9%) are currently used exclusively as animal feed. The still available barley straw (with no market or sustainability uses) could however be a source of biomass for agro-fuel pellet production.

They have shown interest in the project concept but an analysis of possible biomass to be used and investments to be made should be studied. For this reason, they will not be considered as main target for SUCELLOG project.

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Summary of the situation in Spain

A. Regions

SUCELLOG has evaluated the situation of the different target regions in Spain (Aragón, Castilla y León, Cataluña, Extremadura and Galicia) to host agro-industry logistics centres in terms of barriers/opportunities for their development and available agrarian biomass resources.

B. Biomass resources


Regarding biomass resources and according to the criteria of competitiveness and availability, **the maize stalk and the woody prunings appear to be the most interesting agrarian sources** to be taken into account in general with the exception of Galicia. A large number of types of residues do still not have a real market and are left on the soil or just given for free to avoid the costs of disposal. On the contrary to what happens in other regions, whose logistics centres could be entirely based on agrarian resources, **the creation of a logistics centre in Galicia should rely on the supply of the important forest resources of the region together with woody prunings.**

C. Sectors

The **main potential sectors for the creation of biomass logistics centres are: forage dehydration facilities, cereal dryers, rice dryers, sugar industry, nut industry, tobacco dryers, distilleries and oil pomace industries.** They have been selected due to the existence of **compatible equipment** for the pre-treatment of raw material (dryers and/or pelletisers) with **idle periods** and because no technical barriers for the development of the new activity as biomass logistics centre have been detected. Those sectors owning **horizontal dryers (forage dehydration, sugar industries, distilleries and oil pomace industries) present most versatile facilities** able to process a greater variety of raw material formats whereas vertical dryers are more limited to olive and grape pits and crushed almond shells. Additional sectors like cellars and oil mills have also been taken into account, even if they do not present compatible equipment, because of their important capacity to gather agrarian biomass resources as well as their high interest in the project. In this sector, a new line for the production of biomass should be implemented. Finally, the animal feedstuff producer sector has also been considered in Galicia, even though their dryers and pelletisers work all the year, since a possible decrease in their production could generate the existence of a free line for the production of solid biomass.

D. Opportunities & barriers

All target regions present potential areas for the creation of logistics centres and the **interest of the sectors is high in general since they see this alternative as an opportunity to consume their own residues (reducing fuel acquisition) and to diversify their activity.** However, even if the agro-industry sector is the one of the largest consumers of solid biomass in Spain, being familiar with bioenergy issues, the **most limiting barrier** to be overcome in this country is the **mistrust to changes in regulatory frameworks** that could generate the stop of an industrial activity. Renewable energies arose as a good solution for the rural development and in some cases (like electricity production with solar systems) failed due to regulatory framework. **The emission legal limits to start being**

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applied in the next years are one of the reasons that stop the sector from starting operating as solid biomass logistics centre.

Summary of the situation in France

A. Regions

SUCELLOG project has evaluated the six target regions in France (Auvergne, Centre, Champagne-Ardenne, Ile-de-France, Picardie and Rhône-Alpes) in terms of agrarian resources and agro-industry sectors for the development of biomass logistics centres.

B. Biomass resources


Regarding the quantity of available resources, the **straw from herbaceous crops** (cereal, rape and maize) is the most interesting resource to be taken into account in France. However, to be able to upgrade the quality of the resulting fuel, a woody source should be acquired, being in some regions possible to come from agrarian sources (prunings from vineyards) but in others only forest residues would be available. Residues from the agro-industry could be a complement for a **mixed pellet** although they do already have a market, which in some cases is even bioenergy (biogas production from sugar or distillery process residues for example).

C. Sectors

Concerning the agro-industry sectors, the ones evaluated within the project in France have been: **forage dehydration facilities, cereal dryers, sugar industry, distilleries, tobacco dryers, cellars**, oil extraction industries and feedstuff producers. All of them have been considered target for the project except the two last ones, since the extraction industries and the feedstuff producers, even if they have compatible equipment for the production of solid biomass, work during the whole year having no idle period for this new activity, unless a new line is installed or their current production decreases due to market issues. From the rest, **forage dehydration facilities are already a very integrated industry**, working in many cases as logistics centres to diversify their activity for the production of animal feed or even to produce woody pellets coming from forest sources. **Cereal dryers, due to their vertical drying system, are not really compatible with the majority of available residues in France** (with no granulated format) and therefore their strength as logistics centres rely on their **handling and storage equipment**. In the case of **the cellars**, they have been included as target, even if they do not own compatible equipment both because their easy access to an agrarian woody residue (**vineyard prunings**) and the interest shown by the sector.

D. Opportunities & barriers

Potential areas for the development of logistics centres have been identified in all the regions except in Ile-de-France but this does not imply that they could be not placed in that region. Association among nearby industries should be promoted in France in order to take advantage of the different idle periods and equipment, this issue won't be a barrier since the agrarian sector is used to it.

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Summary of the situation in Italy

A. Regions

The situation of the five target regions in Italy (Emilia-Romagna, Marche, Puglia, Sardegna and Toscana) have been analysed in order to evaluate their potentiality to set an agro-industry logistics centre. The evaluation has been carried out not only from the perspective of the available resources but also by the existing agro-industries compatible with this new activity according to SUCELLOG's concept.

B. Biomass resources


Regarding the resources, the potential feedstocks could be: **straw from cereal and maize mainly, prunings from olive tree and vineyards and agro-industry residues coming from the olive and wine sectors**. A large number of types of resources do not have a market (or do not have a place in the market because there is less demand) and are left on the soil or burnt to avoid the cost of harvesting/disposal.

C. Sectors

The agro-industries evaluated by the project have been the following: forage dehydration facilities, cereal dryers, rice dryers, tobacco dryers, distilleries, oil pomace industries and sugar industries. They all own equipment that can be used for the production of solid biomass like **dryers and/or pelletisers and have idle periods in their regular activity (not working the whole year)**. All of them were considered as a target for the project since no important technical barriers for the development of logistics centres in their facilities have been detected. More concretely, from all of them cereal and rice dryers are the less versatile installations because of their drying system, which can be only compatible with granulated products (like olive pits, grape pits and crushed almond shells). The rest of sectors could be able to **pre-treat a large variety of resources format (straw, chips or granulated) since they have horizontal dryers**. Cellars and oil mills have also been considered as target industries since, even if not owning compatible equipment, their easy access to biomass residues (from the agrarian practice of from the industrial process) make them interesting for the project. Therefore, in their case, investment in a new pre-treatment line should be done. The tobacco dryers have been also considered for the project even though now they are not allowed to using their dryers with other resources due to commercial restrictions. Due to the fact that the sector is in decline and a restructuration will be needed, it can be a good possibility to include it as a possible new business line using existing equipment.

D. Opportunities & barriers

The situation of Italy is promising in terms of available resources and amount of agro-industries. However, it should be highlighted that there **still** are **barriers** to be faced up when developing the project and which have come up during the interviews with the sector. The first can be the **lack of trust** that the society has in services that are provided for free (even if the project will not finance any investments or analysis, giving only technical support) which can lead to a lack of compromise. The second barrier is that, in some cases, the **law is different according to the region** and often

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differently interpreted within provinces. The best example is the definition of residue, whereas in Puglia the olive pomace is considered as a by-product and it can be used as a biomass resource, in other regions (*i.e.*, Tuscany) it is considered as a waste, and it can't be used as biomass resource because of the chemical treatment to extract oil using hexane. Different provinces can give an own more or less strict interpretation of the rule, allowing or not to consider the raw material as a by-product. The third barrier can be the **target consumers** since the main market for SUCELLOG, which is the agroindustry sector, is not really familiar with biomass being highly dependent on natural gas whose network is really developed in Italy. However, the project considers that these barriers will be overcome with a good pilot example that can show that developing a biomass logistics centre can be a good business line for the agroindustry to diversify their activity. Association among industries (even if from different sectors) can be a good option to avoid high investment costs that could discourage possible entrepreneurship.

Summary of the situation in Austria

A. Regions


The situation of the four target regions in Austria (Carinthia, Lower Austria, Styria and Upper Austria) was evaluated by SUCELLOG in order to see the potential of the agro-industries to become solid biomass logistics centres.

B. Biomass resources

In contrast to what happens in other countries, in Austria the **main biomass feedstock available** to be used in a future logistics centre is clear: **corn cobs**. In the case of cereal straw, even if some part is sold in the feed market and some is left on the soil there is still a 33 % of availability. Maize straw has no availability mainly since it is used to increase the amount of organic content in the soil, which is currently a problem in the country. Residues produced in the agro-industries are also used for animal feed having an important market. In the cereal dryers, a new drying line should be implemented in the facility to be able to process this kind of biomass, but handling equipment as well as storage and transport means (and in minor cases also pelletisers) could be utilised in the idle period (9 months). The feedstuff producers own a drying system that works all the year but their pelletisers work according to demand, having the possibility to be adjusted for the production of agro-pellets. Even if both industries could work as logistics centres on their own, it is considered that an association among them, taking advantage on the synergies of available equipment and periods of work, could play an important role in the success of the new business activity.

C. Sectors

From all the agro-industry sectors evaluated in Austria (cereal dryers, animal feedstuff producers, sugar industry, oil extraction industries, cellar and breweries) the project considers **the cereal dryers and the animal feedstuff industry the only two sectors able to implement the SUCELLOG's concept**, although with minor modifications. Sugar industry has been discarded since there is only one present in the target Austrian territory and their interest in starting this new activity has been low, even if their potential is interesting. The rest, either do not have compatible equipment or do not have idle period in the production.

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D. Opportunities & barriers


Although the agro-industries see the idea as a good opportunity to diversify their activity, their **main concern is the market of the product** (reduced to large consumers or also to households), which will depend on the **legal aspects of the combustion** of agrarian biomass in Austria, currently under discussion. The situation in some regions, where corn cobs are already allowed to be used in households makes the sector being optimistic about this new business line.

Handbook for agro-industries interested in starting a new activity as biomass logistics centre: the basic demand of information

Agro-industries use modern equipment for the processing of agricultural products for intermediary or final consumption. The products can be used for feed and food or for non-food purposes (textile fibres, chemical extracts, etc.). Some agro-industries like alfalfa dehydration, grain drying or seed oil extraction industries among others, are equipped with pelletisers, drying systems, silos and conveyors, working in most of the cases under seasonal regime. These facilities can be utilised during the idle periods to handle and pre-treat biomass feedstock obtained from different sources existing in the area and, therefore, offer a great opportunity to become a solid biomass logistics centre.


Advantages for an agro-industry to become a biomass logistics centre

- *Agro-industry facilities work under seasonal regime due to crop cycles; they can make some biomass pre-treatments compatible with their own process:* in order to start a new logistics centre in the existing facilities of an agro-industry, **it is necessary to have biomass resources available during the time the facility is not operating**. In this way, the idle period of the year can be utilised to compile, treat and distribute the biomass.
- *The agro-industries having drying equipment may use it directly or adapt it to treat biomass and produce solid biomass with higher quality:* dryers in forage dehydration, sugar industries, distilleries and oil pomace industries own usually **horizontal dryers** able to process a greater variety of raw material formats. Cereal dryers are equipped with vertical dryers (also called tower dryers), which are compatible with granulated biomass like olive and grape pits and crushed almond shell.
- *Agro-industries can become new suppliers of biomass mixed pellets:* feed industries and forage dehydration are usually designed to **produce densified goods in pellet format**. Other industries, like wine or sugar extraction industries, may be equipped with pelletisers for treating their residues, and produce dry, compact and stable pellets, which are later commercialised as dietary complement for cattle. Idle periods of such production lines **can be utilised for the production of biomass pellets**.
- *Agro-industries have experience in handling food products, which are organic materials with similarities to biomass:* both food-products and solid biomass are organic materials which need to be stored and treated to avoid deterioration. Agro-industries work on agricultural feedstock, usually received as bulk material. They hence **already own handling machinery and facilities that could be utilised to handle biomass feedstock**, as for example: shovels, cranes, storage bays, belt conveyor stackers, hoppers or silos. Therefore agro-industries, even not having compatible equipment for moisture reduction and for grinding or pelletising biomass,

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have an advantage as they have expertise and means for establishing a new activity as biomass provider.


- *Agro-industries are usually involved in commercialization of bulk materials:* agro-industries **have commercial networks** for the distribution of their goods. Some agro-industries even have own control of their logistics. The goods they produce already have organised logistics chains. Both the existing networks and the own capacities are a competitive advantage for agro-industries to start new business in the distribution of biomass.
- *The agro-industries already produce biomass residues:* **agro-industries produce by-products** which can be used to produce solid biomass. This is a competitive advantage since it offers more independence with respect to usual biomass centres, which have to deal with external providers.
- *Agro-industries have strong commercial relations with their providers and clients, which may become providers of biomass residues:* the **agrarian residues up-stream and down-stream** the agro-industry facilities are great opportunities for starting new business in biomass treatment and/or distribution. Agro-industries have already commercial relations with both farmers providing agricultural feedstock and clients of their transformed agricultural goods. Agro-industries are in a unique and a strategic position with respect to a regular biomass dealer. Therefore they have a competitive **advantage to purchase agricultural residues from their usual providers and clients with favourable synergised contracts**.
- *Agro-industries are surrounded by crop-fields, forests, other agro-industries or activities which can be a source for broadening their offer:* as an additional advantage to own biomass residues and contracts with usual providers and clients, **agro-industries may find additional biomass resources** to broaden their offer and increase the quality of their mixed products when necessary.
- *Sustainability can be promoted by the agro-industry biomass logistics centres if they bet on local agrarian unused resources:* agricultural residues from harvesting and from agro-industry processing do not always find a local market. It is not unusual that olive oil extraction cake becomes object of international trade, especially from Spain. Local consumers may make use of wood pellets, which may be imported from other regions in the country, other EU member states or even from other continents. Agro-industries can play a role to **purchase, transform and combine multiple local agrarian residues to produce bulk or pelletised mixtures with balanced properties**. This can be an opportunity to further promote local markets.
- *The agro-industries and farmers are already quite concerned about the importance of product quality due to CAP regulations, feed and food law, and the demands and requirements of the market:* adapting to handle and transform biomass to bring to market a product of quality is in line with their current work. Agro-industries are already concerned about product quality requirements. They must adapt to the specific **requirements of the biomass quality regulations, quality labels or market demands**, which is a translation of their usual work into a new parallel supply activity.

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Handbook for agro-industries interested in starting a new activity as biomass logistics centre: carrying out a feasibility study

This handbook has been elaborated for agro-industries interested in starting a new activity as biomass logistics centre. It presents a methodology to build a technical and economic feasibility study to evaluate the relevance for an agro-industry to produce and sell solid biomass. Since each case has its own particularities, this methodology can be adapted depending on the specific context. Main messages are:


- As in any other project, the success of the development of a logistics centre depends both on its technical and economic viability.
- The availability of raw material and the existence of market demand for the type of solid biomass aimed to be produced are two boundary conditions that represent essential points for the viability of the project.
- Regarding the availability of resources, using the residues produced by the agro-industry with no current market is a competitive advantage. If the agro-industry does not have enough own biomass resources, the project developer will have to evaluate the possibility to obtain them in the surrounding area, taking into account both the current competitive uses of the resources and the supply risks.
- The project developer has to take into account logistics issues to be faced when harvesting biomass from agrarian sources. Not all biomass residues produced are technically available because of difficulty to be harvested-collected.
- The project developer should evaluate the market in which the product would be placed in terms of price and quality. Competitors should be analysed in order to check the competitiveness of the new solid biomass produced.
- The raw material and product quality should be assessed by a specific lab, analysing their chemical and physical characteristics in order to ensure with the compliance with consumers quality demand.
- Households do normally have high quality requirements whereas big industries are less restrictive. However, the former usually are used to pay higher prices compared to the latter.
- Several equipment already existing in the agro-industry may be used for the project, reducing investment needs. The seasonality of solid biomass production should match both with the consumer needs and with the equipment availability in order to reduce storage costs.
- Raw material, pre-treatment processes, personnel costs, investment needs may be estimated to build the economic assessment. In order to be competitive in the market, the estimated price of the product should be lower than the market price for a product with similar quality.

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Handbook for agro-industries interested in starting a new activity as biomass logistics centre: lessons learned and good practice examples

This handbook has been elaborated for agro-industries interested in starting a new activity as a biomass logistics centre. It presents lessons learned in the SUCELLOG project and good practice examples from several European countries. The main points to be analysed while performing the feasibility study have been highlighted.

- The project has to be evaluated as a whole. It is important **to avoid focusing on one specific point**, but to keep a general overview in order to evaluate the interaction between all elements
- When evaluating the assets of the agro-industry, **different business models may be analysed** before choosing the best one for the company.
 - **Agro-industries** have several advantages for becoming biomass logistics centres – they produce **residues on their site**, they have **equipment for biomass processing**, they know the **local market** and possess the necessary personal skills. All these strengths should be acknowledged and integrated in the success of the overall concept.
 - Creation of **partnerships** in the territory should be sought to improve the economic performance of the biomass logistics centre. As the production of solid biomass from agrarian resources is not developed, **local support is essential** to start a new solid biomass business.
 - Interactions with other activities of the agro-industry or neighbouring companies should be analysed to find new opportunities and to improve the profitability of the project. Principles of **circular economy** and positive externalities may be analysed in order to convince local partners.
 - Considering the difficulties in making agro-pellets competitive to wood chips, an alternative scenario can be assessed: the agro-industry may become a **heat supplier for final consumers**. It installs the energy equipment (multi-fuel), takes care of their performance and also of the supply the solid biomass – namely, **operates as an ESCO**.
- To find a market, the price of agricultural solid biomass has to be competitive with fossil fuels. That is why production cost should be reduced. Several solutions exist:
 - Agricultural residues are rarely available for free. They are generally already used in different markets such as for biogas production, animal feeding of bio-based materials. To reduce production costs, currently **unused residues can be mobilised** (chaff, wood prunings, plantation removal, corn cobs, etc.). New logistics chains to mobilise and collect this biomass may need thus to be created.
 - To reduce investment, the **use of already existing equipment** may be necessary. The agroindustry can adapt its own facilities with specific modifications. Another solution is finding another company on the territory already owning the needed equipment and to organise a partnership.

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ANNEX B. FOUR AGRO-INDUSTRY LOGISTICS CENTRE CASE STUDIES WITHIN SUCELLOG

In this Annex four specific case studies from different countries are summarized. The case studies are:

1. Cooperativa Agraria San Miguel (Spain);
2. Luzéal-Saint Rémy (France);
3. Società Cooperativa Le Rene (Italy);
4. Tschiggerl Agrar GmbH (Austria).

For each case study the current situation, the results of a feasibility study and the proposed business model are described.


B1. Cooperativa Agraria San Miguel (Spain)

Development of a new business line as an agro-industry logistics centre

Cooperativa Agraria San Miguel is an agro-industrial cooperative whose current activities are: production of fodder pellets and bales from alfalfa; cereal drying and production of fodder pellets from agro-industrial food residues. The cooperative is interested in creating a biomass logistics centre from the agriculture residues of their associates, selling the final products to local consumers (even their own associates who own pig farms). Additionally, the cooperative is currently consuming 1000 t/yr of biomass for one of the alfalfa dehydration lines. The cooperative would like to explore the possibility of installing a biomass burner in the second alfalfa dehydration line so their consumption of biomass would increase. Currently, solid biomass consumed includes a mixture of olive pomace and olive pits, almond shells and grape marc, but the cooperative buys what is more accessible (in price) every year.

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

- The agrarian residues available for the logistics centre are **cereal straw and maize stalks**. Their yearly quantity produced by their associates, in a radius of **18 km**, is significant.
- The potential **consumers** are expected to be **pig farms**. Other consumers could also be other dehydration facilities, sport centres and a residence for elderly consuming biomass (e.g. wood pellets, almond shells, wood chips).
- The **current alfalfa production lines can be used for the pre-treatment of the solid biomass**: Line 1 (**drying** heat produced from burning almond shells, olive pomace and grape marc) and Line 2 (drying heat produced from burning natural gas; more efficient but with a higher fuel cost and some additional environmental impacts).

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The techno-economic feasibility study has shown that the most interesting raw material is **straw**. Although the purchasing price is higher compared to maize stalks, **no drying is required** before pelletization. Line 1 should be used for the production since the pre-treatment cost are cheaper compared to Line 2 unless a new biomass burner is installed (which will incur investment costs that will be paid back after 6 years).

Additionally, the study has shown that **a blend with wood is required** and that the most competitive product to be generated by the logistics centre is agro-pellet Class B with a **maximum share of straw in a mass basis of 70 %**.

Intensive **product quality evaluation** will avoid unexpected dissatisfaction from consumers. Initial combustion **tests with some target boilers** are also highly recommended. In comparison with the large variety of market competitors, the **product does not offer the best price-quality**. Therefore the **current situation** is somehow **risky** and purchasing or pre-treatment costs should be reduced if possible. No social and environmental negative impacts have been found.

Business model


Marketing policy of the agro-industry is to put a new product (mixed straw and wood pellets) in an established market: this, however, does not aim to replace a solid biomass of choice (*i.e.*, "preferred by consumers") but to fit in a range of solid biomass fuels which have different prices that vary from year to year. While trying to pursue a pricing policy, the cost of production cannot go below certain values and, for that reason, the price of **the product offered by the logistics centre is positioned in the middle of the range of prices of solid biomass in the local market**.

Considering the cost of production and the income the Cooperative wants to achieve, the main **target customer segment should be the consumer of wood pellets and olive pits**: on them the Cooperative may exercise a commercial policy of low price while maintaining sufficient quality of the product. In fact, the cost of production and the profit that the Cooperative wants to achieve lead to a selling price of the product that is competitive only with the price of wood pellets and olive pits. This customer segment is **made up in part by consumers not farmers and in part by pig farmers** associated, or not, to the Cooperative.

However, compared with wood pellets and olive pits, the amount of **ash produced is almost doubled** even if, for an average consumer farmer, their agricultural use in their own fields is certainly not a problem. Additionally, **higher emissions of chlorine** compounds can be reached and the **corrosion effects** on the metal components of the boiler are unknown.

The larger share of these pig farmers, however, prefer to choose, every year, the solid biomass that offers the best compromise between price, quality and availability in the market. Taking into account that many products (almond shell, olive pomace, grape marc for instance) are often available at prices lower than the product offered by the logistics centre, it is evident that the **consolidation of sales in this customer segment presents considerable difficulties**.

Considering that inside the Cooperative the number of farmers that are also straw suppliers is very representative, **the best Business Model forecast a chain of self-consumption inside the association itself** and the logistics centre should purchase the straw from pig farmers only under the condition of an annual or pluriennial agreement of agro-pellet supply.

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B2. Luzéal-Saint Rémy (France)

Development of a new business line as an agro-industry logistics centre


Luzéal-Saint Rémy is a cooperative located in Champagne-Ardenne whose main activities are the production of fodder pellets from alfalfa as well from beet pulp and corn. Luzéal-Saint Rémy also produces bales of dehydrated alfalfa. Luzéal-Saint Rémy is interested in starting a new business as a biomass logistics centre producing and selling **10,000 t of pellets from agricultural residues mainly cereal straw**. It is possible to **mix** these residues with **miscanthus, sawdust and wood chips in order to produce standardised agro-pellets**.

The aim of initiating this new activity is **to reduce the fixed costs of the site by using the existing equipment for the new activity**. Consequently the income of the associates would increase. The cooperative would **use its current facilities during the idle period** from 1st November to 30th April, taking into consideration that 6 weeks for the maintenance are required and that the facility is closed for 2 weeks at Christmas. An assessment of both the boundary conditions (biomass resources and market) and the company conditions (equipment and management) has shown that:

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

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

It is important to highlight the necessity to make a **previous quality analysis** (mainly determination of moisture content, calorific value, ash content and Chlorine percentage) of a representative

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sample of the straw to be used as a raw material for the logistics centre is strongly advisable before starting the new business activity. Intensive product quality evaluation will avoid unexpected dissatisfaction from consumers. Initial **combustion tests** with some target boilers are also highly recommended to test the viability of the product during conversion (evaluation of slagging formation for example). Both can therefore change the share of straw vs other materials and, consequently, the costs associated to the production. The use of straw and miscanthus for the production of Class A mixed agro-pellets has **no social and environmental negative impacts**.

Business model

Marketing policy of the agro-industry consists in including a **new product (mixed straw and sawdust pellets) in an established market already controlled by big wood chips consumers**.

According to the results of the assessment, the feasibility of the marketing policy looks **difficult**: the agro-pellets that should be produced, in fact, do **not show any competitive advantage** compared to the fuel that it is supposed to substitute (wood chips). The higher energy cost and the lower quality of the product, considering just a temporary advantage in the storage space, do not foster a wood chips consumer in choosing this alternative fuel for his heating needs. Acting on the selling price up to reaching the competitiveness with wood chips causes **negative profits**, unless a reduction of the production costs is promoted.


After the difficulties highlighted by the market survey on the customers represented by wood chips consumers, an **alternative scenario** has been proposed: it defines the **households wood pellets consumers** as target customers, because this is the product to which the agro-pellets can effectively be a competitor. The scenario foresees that the **Cooperative** does not **provide** just the biomass but also **the heating system**, through pluriennial free loan for use contracts. The Cooperative will sell the fuel increasing the price to recover the expenses for the purchase and the maintenance of the boilers and considering an average consumption of fuel.

B3. Società Cooperativa Le Rene (Italy)

Development of a new business line as an agro-industry logistics centre

Società Cooperativa Le Rene is an agro-industrial cooperative whose current activities are: harvesting, treatment and trading of sunflower; cereal drying (mainly maize); pine nuts and olive oil production. Le Rene cooperative is interested in starting an activity as a biomass logistics centre. For this new business line, the cooperative would like to explore the possible synergies between its plant and the agricultural raw materials in the area (**industrial residues from its own activity, olive pomace, corn cobs and agro-prunings**) with three main purposes:

- To become a **consumer of their own biomass for the drying processes** with the aim of increasing the added value of its maize or sunflower production.
- To produce **good quality olive pits** from the olive pomace supplied by the oil industries in the area.
- To produce **corn cob grits** to be sold in the area.

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- To produce good quality “agro-chips” and/or **hog fuel from prunings with a competitive price**, since in the last years the cooperative received several requests in this sense from possible consumers.

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

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

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


The study has shown that all the possible products are feasible from the techno-economic point of view, meaning that the **production costs are lower than the minimum acceptable market price**. The profit is higher in the case of the **mixed agro-prunings and agro-pellets** due mainly to the low purchasing cost of the raw materials. It should be highlighted that the **high investment scenario**, which considers a wider variety of products and an important transformation of the facility for that purpose, is **not feasible** from the economic point of view, having a payback of more than 10 years.

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

Business model

The business idea consists in improving the manufacturing process of the agricultural pruning which is currently carried out and in re-using the residues from other processes (proper or connected with the agro-industry) in order to manufacture a new product (agro-pellets). These agro-pellets represent the top product of the logistics centre and the sub-products from agro-pellets production (chips and hog fuel resulting from the agro-prunings chipping process) would be secondary products also offered in the new business line.

The improvement of the chipping process of agricultural pruning consists in enhancing the finest fraction, which typically lowers the commercial value of chips themselves; depending on the commercial success of the new product, a part of the fine fraction – greater or lesser – will be

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deducted from the standard production lines of agro-chips and hog fuel; these lines will remain active in any case, in order to allow total cost covering.

The commercial policy of the agro-industry is to estimate the possibility of introducing the new product (agro-pellets) in the solid biomass market, offering a low cost alternative to the fuels which are used in pellet boilers/stoves.

Thanks to low production costs, it is possible to pursue an aggressive price policy: prices will be definitively stated after assessing the quality of the manufactured product through specific analysis (ashes and chlorine content mainly).

With regard to literature data, the ash content is presumably rather higher compared to the currently used alternative fuels. However, since potential consumers are those in isolated or rural contexts, this problem would be easily manageable.

According to the different specifications regarding fuels stated by boilers producers, the consumer who may decide to use agro-pellets could lose the guarantee: this is certainly not a problem for owners of old boilers; on the contrary in this case the achievable savings by using agro-pellets may represent an incentive for the subsequent purchase of multi-fuel powered boilers.

It is important to highlight that both the project idea and the commercial policy inherent to the new product (agro-pellets) must be precisely verified and stated through:

- production of test lots;
- implementation of analysis on samples of the test lots in order to establish the content of chlorine and sulphur and the content and composition of ashes;
- definition of the selling price, on the basis of the analytical results;
- production of launch batches.


B4. Tschiggerl Agrar GmbH (Austria)

Development of a new business line as an agro-industry logistics centre

Tschiggerl Agrar GmbH is an agro-industry whose current activities are: corn harvest, treatment and trading; logistic operator of straw; and pelletizing for animal feeding and bedding. The company is interested in making the agro-industry activity compatible with the production of solid biomass, initiating therefore a new business activity as a biomass logistics centre. New business as a biomass logistics centre producing and selling: 750 t/yr of cobs grits, 1,500 t/yr of loose cobs (750 t/yr for own consumption of the agro-industry), 830 t/yr of pellets of cobs + hay and 2,120 t/yr of pellets of cereal (wheat and barley) straw + hay

For the new business line as a logistics centre, Mr. Tschiggerl will use his **current facilities during the idle periods**: the drying facility that is currently used for the cobs used for animal bedding and the pelletising facility from the association “Heu and Pellets”.

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

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- The agrarian **residues** available for the logistics centre will be: **cereal straw, hay and corn cobs**. The latter being the most interesting raw material due to the lack of competitive uses.
- The main **consumers** of the biomass products are expected to be **farmers with own corn fields**, who currently are using wood chips for heating their houses and farms. Households consuming woody pellets should also be considered. **Wood chips and wood pellets** are consequently the market **competitors**.
- The Company does **not require any investment** in equipment and will be able to work with the drying facility that is currently used for the cobs used in animal bedding and the pelletising facility from the association “Heu and Pellets” placed in the Company facilities.

The techno-economic feasibility study reported in this document has concluded that from all possible **products** to be generated by the logistics centre according to the available raw material, only **corn cob-derived (loose, grits and pellets)** are recommended by the SUCELLOG project. In other words, only the production costs of cob-derived products are lower than the market price (estimated according to quality characteristics and current price of competitors) generating a benefit for the company. In particular, **cob grits are by far the most profitable products**.

However, it should be highlighted that the economic feasibility of the new business line is subject to **quality characteristics** (mainly to **Chlorine** percentage). This is especially important in the case of the cob pellets: if the pellet generated does not accomplish Chlorine levels stated by the quality standard ISO 17225-6 class A, no profit will be attained for the company. Therefore, a previous quality analysis (mainly determination of moisture content, calorific value, ash content and Chlorine percentage) of a representative sample of the corn cob to be used as raw material for the logistics centre is strongly advisable before starting the new business activity. Intensive product quality evaluation will avoid unexpected dissatisfaction from consumers. Initial combustion tests with some target boilers can be a good option to test the viability of the product during conversion (evaluation of slagging formation, for example).

Business model

The analysis shows that from all the **corn cob grits line offers the chance for a large potential market and maximum profits** and the **target customer** segment is the one that may have convenience in **replacing wood pellets with corn cob grits**. However, the best strategy would be to also produce a small amount of **corn cob pellets** to be proposed to the consumers as test products in order to **facilitate the transition to grits**. Moreover, loose corn cob products showed a low commercial potential and a negative gross operative margin: therefore, it's advisable to abandon this production line keeping the quantity for self-consumption in the agro-industry boiler.