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

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

Co-funded by the Intelligent Energy Europe
Programme of the European Union

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Published: © 2015, SCDF - Services Coop de France
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Co-funded by the Intelligent Energy Europe
Programme of the European Union

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Acknowledgements

This handbook was elaborated in the framework of SUCELLOG project (IEE/13/638/SI2.675535), supported by the European Commission through the Intelligent Energy Programme (IEE). The authors would like to thank the European Commission for the support of the SUCELLOG project as well as the Co-authors and SUCELLOG partners for their contribution to this Handbook.

SUCELLOG Project

The SUCELLOG project - Triggering the creation of biomass logistic centres by the agro-industry - aims to widespread the participation of the agrarian sector in the sustainable supply of solid biofuels in Europe. SUCELLOG action focuses in an almost unexploited logistic concept: the implementation of agro-industry logistic centres in the agro-industry as a complement to their usual activity evidencing the large synergy existing between the agro-economy and the bio-economy. Further information about the project and the partners involved are available under www.sucellog.eu.

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Introduction

SUCELLOG supports the creation of biomass logistic centres inside agro-industries, covering the gap of knowledge faced when willing to start this new activity.

This second SUCELLOG's handbook, titled "*Carrying out a feasibility study",* is a guide to be used by a project developer (the agro-industry itself or an external agricultural organisation for instance) when setting up a biomass logistic centre. It is targeted to medium-aware biomass users. It aims to make the reader understand the information to be gathered to perform a techno-economic feasibility study, including the methodology to determine it. Furthermore, all important technical aspects of the new business line are also described in this document.

This handbook is linked to two other supporting documents, which can be downloaded on the SUCELLOG´s website (http://www.sucellog.eu/en/):

- *The auditing guide* to be used by the auditor or by the agro-industry itself when performing an economic feasibility study of the new business line. This document provides information on how to calculate the minimum selling price of the produced solid biomass and helps to assess the overall viability of the project from an economic point of view.
- Feasibility studies of 4 existing agro-industries in Europe implemented during SUCELLOG project as practical case studies. Examples, experiences and lessons learnt from these case studies carried out in 2015 in Austria, France, Italy and Spain are included in these documents.

This guide is organised in 3 different sections:

- **Boundary conditions to be considered in the assessment:** resources and market. Estimations of available, accessible and affordable biomass resources in the agroindustry's surrounding area and their price as well as information about characteristics of the existing bioenergy-market, is essential before evaluating the techno-economic feasibility of a biomass logistic centre activity. Moreover, the identification of the potential consumers' needs allow selecting the best material to be produced in terms of both - quality and quantity.
- **Technical and non-technical factors related to the new activity assessment:** need for investment, capacity of the existing facilities to manage biomass raw materials, organisation of logistic to supply and process biomass and finally, social and environmental impacts influencing the organization of the whole value chain and thus the final price of the solid biomass.
- **Economic assessment:** gathers and links previous information to adequately carry out the economic assessment and proposes the best scenario for the biomass logistic centre.

A summary of all the information presented along the document is proposed in page 7.

Document organisation

BOUNDARY CONDITIONS ASSESSMENT

AVAILABILITY OF BIOMASS RESOURCES

This section provides information about the most important factors that should be considered regarding supply and use of raw materials for bioenergy. It shows how to identify the available resources in the surrounding area and explains the most important issues to be faced when building a supply chain.

BIOENERGY MARKET POTENTIAL

This section provides information about the most important factors related to the bioenergy market that should be considered in the assessment. It shows how to analyse the heat demand and the most important competitors. Furthermore, it takes a look at different customer segments and provides counsel on how to identify the most promising consumer group in each case, taking into account quality criteria.

TECHNICAL AND NON-TECHNICAL FACTORS ASSESSMENT

TECHNICAL ASSESSMENT OF THE FACILITY

This section provides information on how to identify already existing facilities in the agro-industry, which could be used for the biomass logistic centre. It shows how to assess the usable equipment depending on the type of resources to be used and the final product to be produced.

SOCIAL AND ENVIRONMENTAL REQUIREMENTS

This section provides information about the most important social responsibility requirements that should be taken into account when building a biomass logistic centre, including the pillars of sustainable development: environment preservation, social impact and contribution to the local economy.

ECONOMIC ASSESSMENT

DETERMINATION OF THE MINIMUM SELLING PRICE

This section gives information on how to calculate the minimum price at which the product should be sold by the agro-industry. It takes into account production costs, equipment amortization and expected minimum profit margin.

EVALUATION OF COMPETITIVENESS IN THE LOCAL MARKET

This section shows how to compare the calculated minimum selling price to prices of competitors in the market.

IDENTIFICATION OF THE BEST SCENARIO

This section provides information about parameters which are used for the assessment and evaluation of economic performance and how to select the best scenario from an economic point of view.

1. Boundary conditions assessment

A biomass logistic centre activity, as other businesses, depends on both – upstream and downstream supply chain processes. On the one hand, factors related to raw materials (e.g. their properties, harvesting operations, market prices, etc.) have strong influence on the final product (e.g. resulting production cost and quality of the product); on the other hand, the market is influenced by needs of consumers and activities of competitors, thus the new product has to be competitive both in terms of price and quality. Acknowledging these conditions is the first step in assessing the feasibility of a biomass logistic centre.

The first step to be taken by the project developer is to determine the amount, price and quality of resources that are available in the surrounding area and that could be used by the biomass logistic centre. Available biomass raw materials strongly vary among different locations. Therefore, it is impossible to provide a general picture of the usable biomass resources at national or European level suitable for every case. In the same line, the structure of heating market and prices strongly vary among countries and even among regions. Due to these reasons, the next section proposes a methodology which allows assessing these boundary conditions for each particular project.

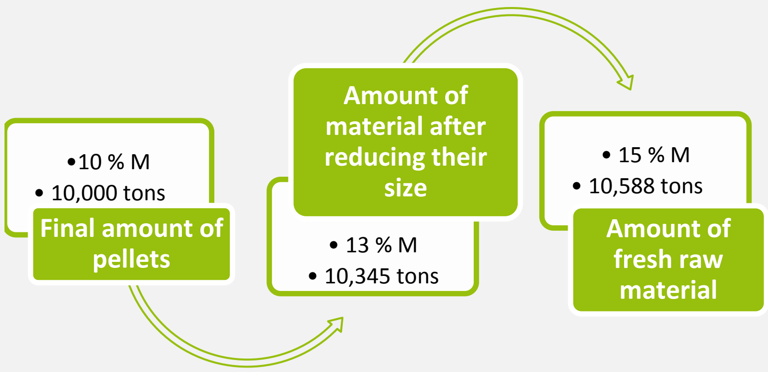
1.1. Review of the availability of biomass resources

The entire project will be affected by the availability of agricultural biomass in the surrounding rural areas. When assessing the available biomass sources, the following main points have to be evaluated: available quantity, seasonality (times of availability), biomass composition - quality (moisture content, particle size, content of exogenous matter) and transportation distance to the processing site. Costs for the raw material purchase, transportation and processing represent a significant share in the price of the final product and depend on the quantity of raw material. In general, the more biomass is purchased, transported and treated, the lower the specific costs (related to the volume or mass of the biomass) are. Required pre-treatment operations depend on the properties of the used raw material and on the desired quality of the final product.

Therefore, it is important to determine the **amount of raw material and the total costs that its procurement and processing would imply considering the desired amount of final product to be sold**. A methodology for relevant data collection is proposed hereafter.

How to estimate the quantity of the needed raw material?

First, the required quantity of the raw material to produce a certain amount of the final product, for example, 10,000 tons with 10 % moisture content (M), has to be estimated. The quantity of the resulting end product will not be the same as the initial quantity of the raw material because of different moisture contents. Biomass processing - chipping, storing, drying, pelletising – reduces the moisture content compared to the one in the raw material. Once the desired moisture content of the final product is known, it is possible to calculate the amount of raw material to be purchased. The calculation is done on the dry matter basis which is the same for the raw material and the final product and does not change during the biomass processing process. In the previously mentioned example, 10,588 tons of raw material (15 % M) is needed to produce 10,000 tons of pellets (10 % M). The box placed belowprovides some formulas for the calculation. Depending on the available information and needs (raw materials needed for a certain amount of products to be obtained or viceversa) one or other formula can be used.



$$Initial\ Dry\ matter = Final\ dry\ matter$$

$$\Leftrightarrow Dry\ matter = total\ amount\ (100 - M)$$

Being M the moisture content

$$\Leftrightarrow \boldsymbol{Final\ amount} = \boldsymbol{Initial\ amount}\ \frac{(\boldsymbol{100 - Minitial})}{(\boldsymbol{100 - Mfinal})}$$

$$\Leftrightarrow \boldsymbol{Initial\ amount} = \boldsymbol{Final\ amount}\ \frac{(\boldsymbol{100 - Mfinal})}{(\boldsymbol{100 - Minitial})}$$

1.1.1. Identification of biomass resources in the territory

Not only the amount of required biomass resources, but also who owns it, is an important issue to be aware of. In order to guarantee the raw material supply for the logistic centre, the most convenient case would be to use a resource that has none or marginal competitive uses. If the agro-industry does not own enough biomass resources, procurement in the surrounding area might be considered.

Inventory of the available resources of the agro-industry: if the agro-industry generates unused biomass resources in its processes, they can be used by the biomass logistic centre. This opportunity provides certain advantages, e.g. lower cost of the raw material, shorter transportation distances, increased supply security, etc. Indeed, in this case, to ensure successful operation of the concept, the agro-industry does not depend on other biomass suppliers and does not need to organise sophisticated logistic chains with participation of external stakeholders.

Using its own residues allows to have access to cheaper raw materials:

- If the residue is not used, it can be considered as free. Then in the economic assessment only the eventual transportation costs will be considered as raw material related expenses.
- If the agro-industry has to pay for the disposal of residues, when building a biomass logistic centre, these costs will be avoided. Then, in the economic assessment, the cost of raw materials will be negative, meaning it is a gain for the project developer.
- If the residue already has a market and is being sold at X €/t, then the construction of the logistic centre will make the agro-industry lose a part of current income which has to be compensated with the new product.

The agro-industry needs to identify all the residues produced in its activities and collects the information needed for a further feasibility study.

- ✓ Quantity available
- ✓ Moisture content
- ✓ Months of availability
- ✓ Current use and current selling price
- ✓ Current site of production and distance to the agroindustry (processing site)

Assessment of the territory by using theoretical data: If the agro-industry does not have enough own biomass resources, the project developer will have to identify the possibility to obtain them in the surrounding area. To identify the main biomass crops in a territory, the project developer can refer to official databases. Surveys, GIS databases, national or regional inventories or Eurostat can be used to obtain a first estimation of the quantity, localisation and surfaces and thus, by extrapolation, the availability of residues (see, as example, the document developed by the project *D3.2d Summary of the regional situation, biomass resources and priority areas of action in Austria*).

From this information, the project developer will be able to list the most likely usable residues and the theoretical available quantity.

⚠ Keep in mind that these regional databases represent theoretical data. Their starting hypotheses are not always similar and may not include competitive uses of biomass resources.

Identification of the competitive uses

Current uses of residues have to be identified in order not to distort competition of markets or endanger the soil sustainability, as well as to secure supply and to get competitive prices. To get a better estimation of available resources, the project developer has to include these competitive uses in addition to the theoretical data. For example, if 1,000 tons of straw are potentially available but 40 % of them are used for cattle and 30 % as soil nutriment, only 300 tons would be actually available for the project.

The existence of competitive markets depends highly on the area. For example, in Spain there are some regions in which cereals straw is usually sold for animal feeding and bedding with no availability for further uses, while in some other regions no use is given to straw and the farmer burns it on the field in order to avoid a problem. Other uses as biogas production, bio-based materials or industrial applications have also to be taken into account.

Interviews to collect real data from the field: to have information about the real quantity of available resources, interviews with farmers or logistic operators should be conducted. The aim of the interview is to evaluate if they are interested in supplying the raw material and how much would it cost.

⚠ This field work will allow the project developer to get the information about the effectively available biomass and the purchasing conditions. It is impossible to know the amount and type of residues without meeting logistic operators, farmers or other industries and to estimate their interest in supplying the materials. A list of some information needed is given hereafter.

- ✓ Type of residues produced, quantity (t/ha), months of production, distance to the processing site;
- ✓ Current market for these residues and prices. Is it a stable market?
- ✓ Logistic issues: existence of a harvesting operator, transportation (and prices);
- ✓ Type of contracts (including duration) and price (it has to include at least the treatment and harvesting prices).

This step allows the project developer to gather all the information needed for the economic assessment (see part 4). A second step consists in analysing the technical feasibility of the logistics chain. Some information explained below has to be considered to effectively organise the biomass supply.

1.1.2. Logistic issues to face when building a logistic chain

This section will guide the project developer through the identification of the main issues to face when planning the biomass supply. The identification of residues without any use does not mean that these residues are actually available for the project. As mentioned before, biomass residues may be left on the field because farmers do not have any market option, want to use it for fertilisation/preservation of soil or because conditions do not allow using appropriate agricultural machinery in the particular field. This section will help the project developer to identify technically available resources for the project.

Think global: **thinking the logistic chain is not only thinking step by step. It has to be considered in its entire organisation, from the procurement in the field until its use in the agro-industry.** For instance, the use of straw bales will imply the use of a bales shredder or unpacker on the processing site. In this example, the good effect of saving costs on transportation due to the compaction of the resource (handling of a higher bulk density biomass) could be sometimes outbalanced by the need of further investment for dismantling or disaggregation of bales.

Identify the non-existing logistic chain: **logistic chains for pruning, rape or corn cobs do not exist in some areas. On the contrary to herbaceous residues, where logistics chains for supplying the demand of farms have been developed long ago, there are no harvesting experiences and/or no companies organising the logistics of these types of residues.** To be able to use these residues, the project developer will need to organise completely new logistics chain. This task can significantly increase required efforts and cause risks of delays. The project developer will need to find farmers interested in testing the logistics chain and the new/adaptable machinery, before defining the purchasing price and the type of contract.

Diversify suppliers: **diversifying suppliers helps to guarantee the supply with competitive prices and to ensure the correct working mode of the logistic chain.** The type of agro-industry (cooperative, logistic operator, trader, etc.) will influence this multi-actor organisation. For example, for a cooperative, it is relatively easy to get in contact with its members or, for a logistic operator, to contact several farmers when already providing services for their usual operations.

Forecast the seasonality impacts: **Sometimes the farmers would not accept to collect residues because of the weather conditions causing damages like soil compaction.** Some difficulties can arise, for example, while working on a wet soil in autumn.

Face the technological issues: **depending on the crop, several issues have to be faced when harvesting the raw material. Even though some logistic chains are already efficient (as for wheat straw), others still have to be consolidated.**

For example, in some cases maize stalks offer important potentials in some areas but it has to be considered that procurement of maize stalks is more difficult than straw collection: first a chopper has to be used, then a windrower and finally the baler. Normally, these operations are implemented under wet conditions which can lead to higher compaction of the soil, especially due to the number and intense of the machinery use. Due to its specific collecting conditions, sometimes maize stalk can be considered as undesired raw material for the production of solid biomass, because of the high amount of soil particles and stones that it might contain. One step operation would simplify significantly the logistics.

In order to harvest also the corn cobs, the regular machinery used for harvesting the corn grain should be adapted.

Optimise the transportation chain: **Generally, it is recommended not to exceed 30 - 50 km distances from the collection point to the processing sites. Transportation for pelletised, baled or loose raw material will not be considered in the same way. Depending on the density of the resource, the transportation cost can change significantly.**

Besides purchasing of raw materials, pre-treatment and personnel, transportation implies one of the most important cost items of the complete chain. The impact of those costs might even increase when transportation distances exceed 50 km (more than 10 €/t). Therefore a commercialization on local scale is highly recommended. When the distance from the resource to the agro-industry is less than 10 km, transportation can be most probably performed by the farmer with his/her agricultural vehicles. Moreover, in the case of herbaceous resources, short distances to the agro-industry might avoid the need for bailing process, which helps to significantly reduce the purchasing costs of the material.

Moreover, if biomass resources are spread on the territory, the costs for their harvesting and procurement can become critical for the economic feasibility of the whole project. Using tractors or trucks to collect small amounts of materials is many times unprofitable, particularly when the distance between plots is wide and far away from the location of the logistic centre. For example, to collect 100 tons of pruning from vineyard, collecting 1 ton per plot with a distance of 5 km between each plot and to the logistic centre would dramatically increase the cost of transportation, and this might turn the project to be unprofitable.

When asking for the purchasing price of the raw material, it is important to understand if transport is included. When the raw material to the agro-industry is delivered by the supplier, sometimes the costs of transportation are included directly in the purchasing cost of the raw material. If transportation is done directly by the logistic centre using its own equipment and employees, or is out-sourced to specific transportation company, costs are treated separately from raw material purchasing costs. This has to be defined during the contract negotiations with biomass suppliers.

Manage the storage issues: **due to the seasonality of biomass residue production, often there will be a need of storage capacities. This is an important issue to be taken into account before estimating the production costs. Storage costs, along with other logistic cost items, have to be included in the feasibility study.** Storage can be done in the trader site, in farms or in the agro-industry facility. The agro-industry may have storage places available all year around, however some storage capacities might be available only during the idle period. Some biomass residues require initial drying and covered storage, while others can be stored outside. To avoid the need for storages within the facility, the agro-industry may opt for contracts of biomass supply on demand. Costs related to storage will depend on the selected option. Therefore, during the feasibility study, the project developer has to consider each possible alternative and to select the best one.

Figure 1 provides a summary about under which conditions the biomass resource can be considered as actually available for the agro-industry or for the project developer.

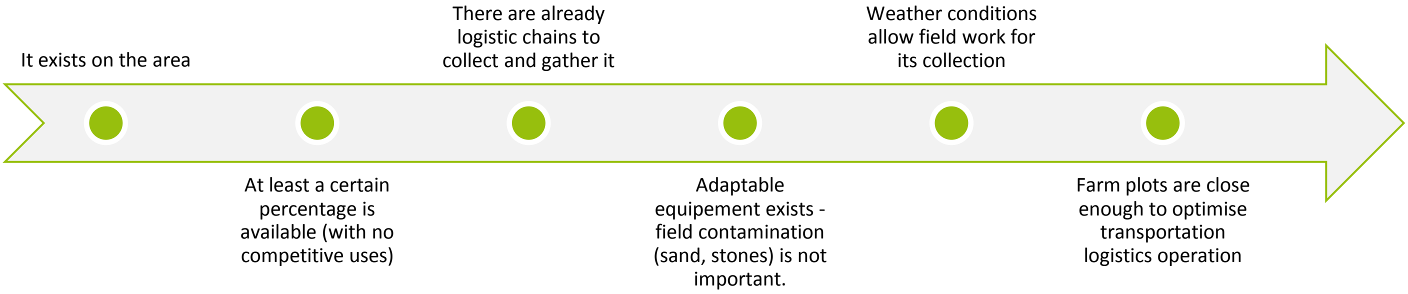


Figure 1 : Conditions that make a resource to be considered as available.

1.2. Bioenergy market potential

Before assessing technical and non-technical factors for the development of the new biomass logistic centre, another important issue requires attention of the project developer: the study of the market in which the new product will compete.

1.2.1. Identification of the energy supply characteristics in the region

In order to be able to position its own product in the energy market, the agro-industry first has to understand which type of energy resources and which amounts are used to satisfy the local heat demand. Fuel supply and energy demand satisfaction is significantly different from one area to another so specific conditions of each particular project should be assessed individually.

Diversity of the biomass market depending on the area – Example of Tschiggerl Agrar

Tschiggerl Agrar is an Austrian agro-industry located in the south-east of Styria. It is currently developing a biomass logistics centre with the support of SUCELLOG project using corn cobs as a raw material. In a radius of 30 km around the biomass logistics centre about 60 % of the heat demand is covered by solid biomass (forest biomass: wood chips, firewood or pellets), 30 % by oil and 10 % by electricity. The local energy supply situation is very different from the Austrian one. On the national level only 30 % of heat demand is covered with solid biomass. The most used fuel for heating in Austria is natural gas with a share of more than 35 %. There is no gas pipeline crossing the area of the agro-industry and therefore the regional energy supply is more dominated by solid biomass. This information about local conditions is essential for understanding the market in which the new product will have to compete and thus it

Theoretical data from literature research: to identify the characteristics of the energy demand in the region/area, searching for already published data is recommended as a first step. The following aspects should be considered:

- ✓ How is the biomass sector positioned in the region?
- ✓ What is the current production (annual amount)?
- ✓ Which is the main type of fuel (*e.g.*, chips, pellets, briquettes, corn cobs, etc.) consumed? Prices?
- ✓ Who are the main consumers (*e.g.*, households, industries, etc.) depending on the type of fuel?
- ✓ What is the long term prospect? How the market is expected to develop in the future?
- ✓ Is there any national or regional financial support available for development of the project?
- ✓ Are there any national or regional regulations regarding quality requirements?

⚠ Once the region where the agro-industry wants to operate as a logistic centre is defined, it should either choose a certain radius around the facility (*e.g.*, 30 km) or may focus on one or more political or geographical regions (*e.g.*, the area of the municipality where the facility is located).

Interviews with experts about the energy supply of the targeted region: to collect information about **which types of solid biomass** are currently used. It makes a significant difference if solid biofuels used have a forest origin, an agricultural origin or come from (agro-) industrial processes. Experts can also give important feedback about the **format in which biomass is consumed** and the **type of boilers** installed.

These experts could be boiler manufacturers, producers of solid biomass and providers of other types of fuels used for heating, logistics operators, municipalities and energy agencies.

1.2.2. Markets / customers' needs

After identifying the available biomass resources, the general energy supply structure and the possible competitors in the target region, it is crucial to have a closer look at possible customers and their needs. **Each group of possible consumers might have different needs (seasonality, format, quality, etc.).** Furthermore, some consumers just look at the price of fuels and boilers, whereas others prefer higher quality both in equipment and fuels even they have to pay more. Types of boilers used differ strongly among customer groups and it is a critical point to bring together the right fuel with the right boiler.

Classify possible customers in the region or target area:

- ✓Households
- ✓Farms
- ✓Public buildings
- ✓Local district heating
- ✓Other agro-industries or other industries
- ✓The agro-industry itself (self-consumption)

Quality requirements

Each customer group mentioned above has different needs in terms of quality. **As a rule of thumb, it can be stated that the smaller the demand is, or the smaller the output of the boiler is, the higher the quality needs are.** This means that households normally demand higher quality, whereas large industries and district heating units often have lower quality needs. This information is important for the identification of the target customer groups for the agro-industry biomass logistic centre. For raw materials from which only medium quality solid biofuel could be produced, medium to large-scale consumers and not households should be targeted.

Demand and dependence

Another important aspect to be determined is the different amount of fuel needed by each different customer group. The amount of fuel required per household might be quite small (normally lower than 10 tons of solid biomass per year) whereas the demand of agro-industries, industries and local district heating units can be relatively high (even more than 1,000 tons of solid biomass per year). In general terms, many of customers with little demand or a few of ones with high demand are needed to reach production's feasibility.

A logistic centre should bear in mind that both, having many customers with a small demand or just a few significant customers have advantages and disadvantages:

- Having just a few big customers reduces organisational and logistical efforts compared to organising small supplies. Furthermore, marketing activities in this case are not so relevant.
- On the contrary, having just a few of large consumers might imply having a significant dependence on each customer. Real trouble would appear if the main customer decides not to buy the agro-fuel at the logistic centre anymore. Moreover, large customers also have a greater negotiation power and therefore they want to get lower prices by trend.
- Small customers do not have as significant negotiation power due to the dependence on one customer is quite low, however, the effort to sell the required amount is much higher in comparison to having just a few big customers. Also the organisational, logistics and marketing efforts in this case are higher.

Self-consumption

The self-consumption of a self-produced agro-fuel could be a good chance for an agro-industry and can lead to significant cost savings. The huge advantage of self-consumption is that no customers have to be engaged. The higher the energy demand of the agro-industry is, the more profitable the investment in the new boiler will be in case it is required. More information is provided in Annex 2.

Example: Tschiggerl Agrar GmbH, Austria

The Tschiggerl Agrar GmbH is an agro-industry located in the south-east of Styria. Treatment of corn is one of the main activities of the company. This treatment process includes drying and is very energy intensive. Initially, the dryer was operated using natural gas, which was very expensive. Therefore the Tschiggerl Agrar GmbH decided - instead of natural gas - to use corn cob residues as a fuel. The company made a significant investment in a new industrial boiler but the annual cost savings were so that the investment has been paid back in less than 2 years.

Delivery format

Another important issue to know about the customers is how they need the fuel to be delivered (package size, which amount and how often do they need a delivery, etc.). It is crucial for a logistic centre to adapt the packaging and the transportation to the targeted customer group and to determine these costs.

Boiler characteristics

The use of agro-fuels in conventional boilers for woody biomass could imply performance risks because they have, by trend, higher ash contents, lower ash softening temperatures and higher sulphur and chlorine contents. These facts can cause sintering, slagging and corrosion phenomena in existing woody biomass boilers. The boiler guarantee can also void when using different products than the ones specified in the boiler. **Therefore, it is absolutely necessary to ask the boiler manufacturer whether the boiler of a specific consumer can be operated with agro-fuels or not.** It is also important to evaluate boiler's compatibility with different fuel formats. A target consumer with a pellet boiler would normally not be able to use chips unless it changes the feeding system. Customers' boilers should be evaluated to determine if they can handle size, moisture content and calorific value of the new fuel.

Some manufacturers produce special boilers which can use different types of solid biomass. These boilers normally have moving grate, an automated ash removal system and are made of corrosion-resistant materials to avoid the problems which can be caused by some agro-fuels.

1.2.3. Bioenergy Competitors

When the general assessment of energy supply in the target region is completed, it is crucial to identify the possible competitors of an agro-industry biomass logistic centre. An agro-industry willing to create a logistic centre has to bear in mind that strong competition in the area may significantly influence their project's feasibility. The closer the competitors are, the stronger the competition would be and the more attention should be focused on these companies. Knowing all relevant competitors in the target region is a great advantage for the project developer and for the agro-fuel logistic centre.

Interviews to identify competitors: to identify which other fuel suppliers are active in the target region, it is recommended to talk to consumers of different fuels and to ask them about their suppliers. Also boiler manufacturers, energy agencies and municipalities are good contacts for this process. The most important information a logistic centre should know about their competitors is:

- ✓ Type of offered fuels
- ✓ Format of those fuels
- ✓ Quality aspects (calorific value, moisture and ash contents, bulk density)
- ✓ Price (€/t or €/kWh, check if transportation and VAT are included)
- ✓ Main customers

Furthermore, it is crucial to identify:

- ✓ The main customer group for each competitor;
- ✓ The way how competitors deliver fuels to their customers;
- ✓ The costs of this transportation, especially if the competitor charges a certain price for the delivery.

Classify competitors: The identified competitors can be class-divided depending on how close to the logistic centre the business activities of those competitors are.

⇨ **Another company producing and selling agro-fuels close to the planned agro-industry biomass logistic centre**: this could be a disadvantage, because there is already a company selling agro-fuels. However, it could also be an advantage, because a new logistic centre can benefit from their experiences and learn from their mistakes. Another possible advantage of such a close competitor could be that customers are already familiar with agro-fuels.

- **A logistic centre for wooden biomass close to the planned agro-industry logistic centre**: the relevance of such a competitor for the agro-industry logistic centre also depends on several aspects: the type of wooden biomass offered, the quality of these fuels and therefore the target customers of the competitor in comparison to the logistic centre. A competitor providing cheap, low quality wood chips mainly for industrial consumers, for example, has quite similar activities and goals than the logistic centre whereas a competitor selling high quality wood pellets mainly to households would not be a real competitor for the agro-industry logistic centre.
- **Competitors selling fossil fuels:** they are normally not close competitors of an agro-industry logistic centre; however, it is also good to know about the price, type, format and the quality of the offered fuels are relevant aspects which can affect the operation of the logistic centre for agro-fuels.

Comparing the price of different fuels

When the competitors in the target region of the agro-industry are fully identified and analysed, a comparison of fuel prices in the market can be and should be carried out. Comparison of prices related to the mass (t) or volume (m^3) of the fuel should be avoided because fuels have different energy contents and densities. In order to be able to objectively compare prices, they should be normalised in the relation to the energy content of the fuel. The price of a ton of each fuel (€/t) should be divided by its energy content (in kWh/t, kcal/t or MJ/t). Results in €/kWh, for example, can be then objectively compared.

It is essential to make the comparison on the same base concerning VAT and transportation costs. When carrying out the calculation, these two items should be deducted from the total price of the fuel (if they were initially included). This will allow homogenous comparisons among fuels in the market and later, with products that the agro-industry biomass logistics centre plans to commercialise.

1.2.4. Biomass quality assessment

Before developing a biomass logistic centre, it is essential to test the quality of the biomass to be used as a raw material because it conditions the quality in the final product (this section complements the Section 3 of the Handbook *for the basic demand of information*).

Quality analyses of the raw materials

The agro-industry should test the properties of its raw materials. Biomass tests normally are done by a specialised lab. Project developer should be aware of biomass properties and should use this information to optimise the quality of the product. The final product should comply with the quality standards and both its chemical and physical characteristics are important information for potential consumers and fuel distributors.

- ✓ Lower heating value (LHV) (kWh/kg)
- ✓ Moisture content (w-% ar)
- ✓ Ash content (w-% db)
- ✓ Mineral contents (N, Cl, S mainly, w-% db)
- ✓ Ash melting behaviour (optional)

Mixing biomass to improve the quality of end-product

Blends of two or more biomass fuels, each of them with different properties can improve quality, pelletising behaviour, emission values. The information presented below can be used to propose a theoretical blend of biomass resources. Validation tests should be performed with these blends.

- ✓ **Blend of residues**: negative effects of two biomasses with different properties can be compensated. For example, silos dust, emitting NOx and SO_2, with low Ca content but high N content can be mixed with rape straw, emitting particles, with high Ca content and low N content. Nevertheless, complementary tests would be necessary to validate these theories.

- ✓ **Blend of residues and other biomass**: a blend between residues (cheaper material) and good quality biomass (more expensive material) such as wood or miscanthus reduces the above-mentioned negative effects. This can also be observed when mixing straw and wood in the pelletising flow.
- ✓ **Blend with inorganic components**: for example, in case of a high Cl content in the biomass, the addition of lime would limit the formation of HCl.

Example on biomass quality assessment

Properties of the final product should always be adjusted according to the needs of the customers. Example given below describes how two types of resources can be mixed to get as the end-product an agro-pellet of class A corresponding to the quality standard ISO 17225.

REMINDER – BIOMASS QUALITY STANDARDS. ISO 17225 normalises every category of solid biomass:

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

Required quality

AVAILABLE RESOURCES	LHV ar (kWh/kg)	Ash content (w-% db)	Ash fusion (melting) temperature (°C)	N (w-% db)	Cl (w-% db)
Agro-pellets ISO 17225-6 A	≥ 4	< 6.0	To be declared	< 1.5	< 0.1
Cereal straw (results from chemical analysis)	4.33	5.0	800-900	0.5	0.4
Cereal straw has too high Chlorine content compared to the standards limit. In order to produce an agro-pellet according to ISO 17225-6 A (max Cl content 0.1 w-% db), it is proposed a mixture with wood. A minimum content of 80% is required in this case for the quality of straw for the table (not necessarily all straw present this quality)					
Mixed straw (20 %) wood (80 %) pellets	4.48	2.7	To be declared	0.9	0.10

Figure 2 : Example of quality assessment according to ISO 17 225 A

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Quality of the final product

Testing is necessary to ensure compliance with regulations and to optimise related biomass processing and combustion processes (see part 2.3). There are several factors that might change depending on the biomass properties:

- ✓ **Pelletising behaviour:** biomass silicate concentration, high content of soil particles and sand in the agricultural material create friction during pelletising process resulting in high dust emissions and low production yields.
- ✓ **Atmospheric emissions:** under the same working conditions, higher Nitrogen or Sulphur contents in biomass will raise NOx and SOx emissions, respectively. It is essential to work below the concentration limits set by regional/national or European regulations.
- ✓ **Dust (particle) emissions:** Particle emissions (PM) have to be controlled to comply with the limits set in the European and national regulations. Biomass composition also affects this parameter.
- ✓ **Mineral content and ash melting temperature:** relative concentrations of minerals (Si, Ca, Mg, S and in particular, Cl and alkali metals – K and Na) might lower ash melting temperature and cause typical ash related problems in the boiler – slagging, agglomeration and corrosion. Compared to woody biomass, agricultural residues contain more Si and K, but less Ca. Even for the same type of biomass,

different planting environments, harvest seasons, or use of different parts of the same plant can result in different ash contents and compositions.

The next figure provides a summary of the steps that project developer has to take to identify potential consumers for his/her products.

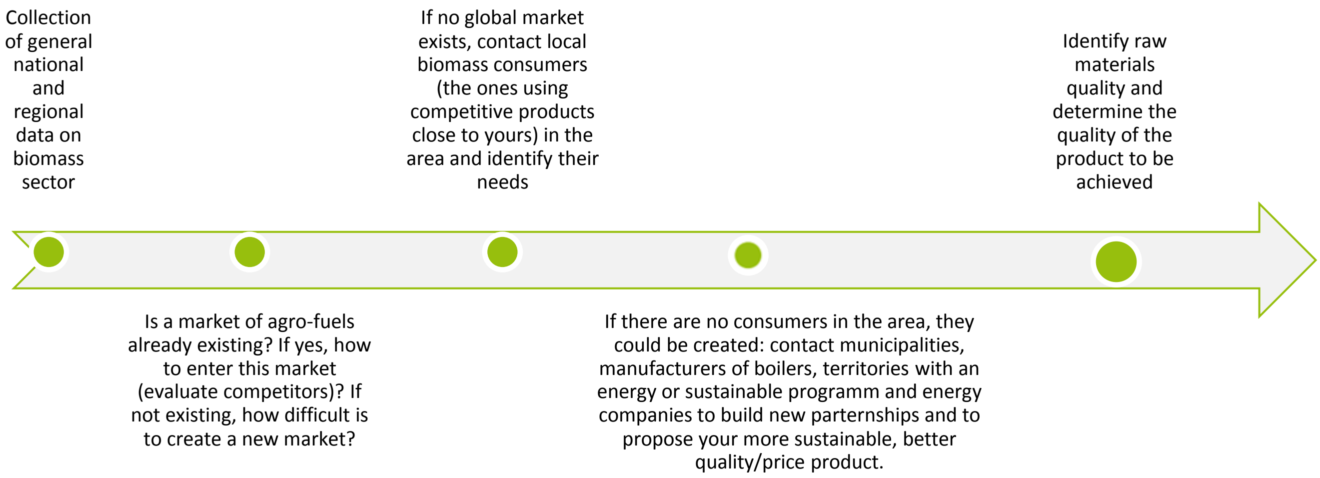

Figure 3 : Identification of consumers for the project

2. Technical and non-technical assessment

2.1. Technical assessment of the facility

The next issue that the project developer should evaluate in the feasibility study is the capacity of the equipment existing in the agro-industry to handle and to process the available biomass. Using existing devices would be beneficial, since it would allow avoiding additional costs for purchasing new equipment or for setting-up new process lines. In this case, the agro-industry could take advantage of significant competitive benefits. However, as it was also mentioned in the SUCELLOG's *Handbook for the basic demand of information*, not all equipment is compatible with all types of biomass resources. The necessity of new facilities would increase costs and risks due to the required investment, quite high in many cases, especially if a new pelletiser or a dryer is needed (though it depends on its drying capacity, the cost of the rotatory dryer can be more than 1,250,000 € for a 4 t/h of product).

To complete the feasibility study it is essential to estimate the investment that would be needed and to figure out how the logistics operation (idle period, storage availability, capacity of facilities to manage the raw material) should be organised.

During pre-treatment processes, the properties of the raw materials are changed in order to adapt to consumers requirements. This chapter gives information about important points of the pre-treatment stage.

As an example, pre-treatment steps of pelletising process are given in Figure 4.

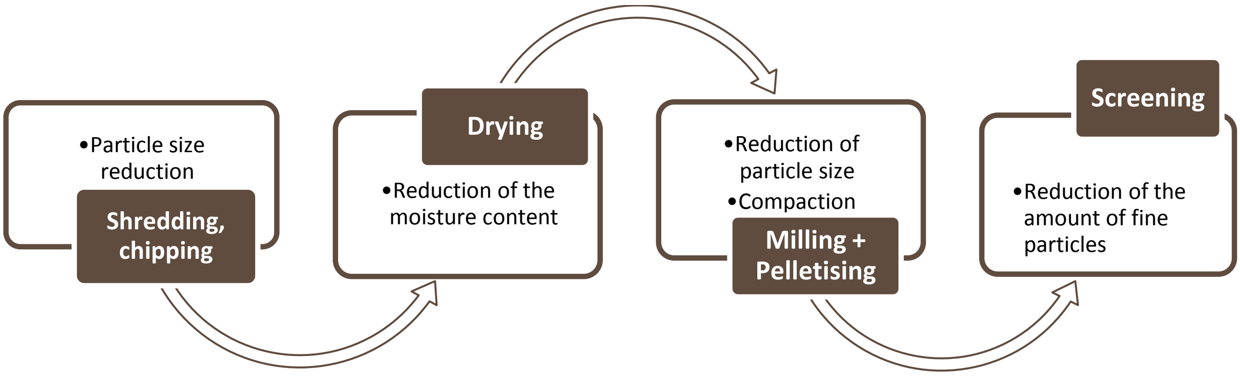

Figure 4 : Pre-treatment stages in pelletising process and their influence on biomass characteristics

Particle size reduction

Particle size reduction

to be considered depending on drying, pelletising processes or final product format needed

Compatible with all products

Particle size of wood, straw bales, prunings or corn cobs grits may have to be reduced (to be sold loose or as pellets). Therefore, if the logistic centre does not have appropriate equipment for carrying out these processes, most likely new wood chippers or tube grinder will have to be installed.

Though it can be stated that nearly all particle sizes can enter the drying system (normally the maximum particle size for herbaceous materials is 100-150 mm and 3 cm^2 for wood chips is acceptable), initial particle reduction process, in some cases, is needed. Moreover, further particle size reduction is generally required before pelletising which implies in most of the cases that the material has to be previously milled before entering the pelletiser (less than 3.15 mm for herbaceous and smaller than 2 mm for woody biomass).

Dryers

Moisture content affects many of the processes in which biomass is used as a fuel.

•The amount of energy that biomass releases in its combustion, normally expressed as its lower heating value (LHV), increases when its moisture content decreases (see the following expression). According to this, as biomass prices in the market strongly depend on its LHV, moisture content is an important property that the agro-industry should control.

$$LHV = higher\ heating\ value(HHV) - latent\ heat\ of\ vaporization \times moisture\ content$$

•Moisture content affects milling and pelletising processes. Milling consumption, yield, pelletising performance and durability of pellets are strongly influenced by moisture content.

•Moisture content will also affect the stability of the raw materials and final products. Wet material is a good environment for fermentation and development of molds (see *SUCELLOG Handbook for the basic demand of information*).

Drying processes are the ones which may involve the highest operational costs. It should be assessed whether the raw material needs to be dried or if it can be directly used in the following stages without initial drying. For example, in the pelletising process, before entering the pelletiser, the moisture content of the raw material should be around 13-14 % (w-%, ar). This ensures a final moisture content of 10 % (w-%, ar) in the resulting pellets, optimal to ensure compaction and to avoid storage degradation. Cereals straw usually left on the soil before harvesting dry naturally down to 15 % moisture content (w-%, ar) whereas corn cobs that are going to be sold like grits, need chipping and drying until they reach 20 % (w-%, ar) moisture content.

If the drying process is required, it has to be considered that not all biomasses are compatible with all dryiers. Figure 5 summarises some possible uses depending on the type of the dryier owned by the agro-industry.

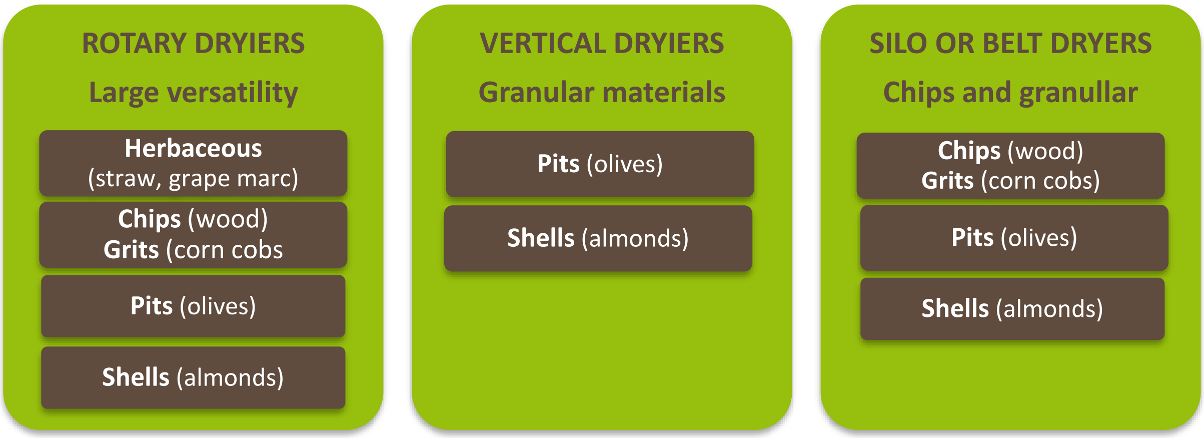

Figure 5 : compatibility of biomass and dryers[1]

Milling system and pelletiser

Milling and pelletising systems are compatible with all biomass products. Some resources with low lignin content do not easily compact, being required the addition of an additive.

• **Maintenance and operation costs may increase** depending on the abrasion properties of the raw material (silicate content, important in corn cobs for example). This fact has to be taken into account in the economic assessment.

• **The flow capacity may decrease** when working with different products than the design ones (for example, in an alfalfa dehydration facility the pelletiser could also work with wood or straw but the flow had to be reduced by 1/3 or 2/3 of the alfalfa production flow respectively). This would imply more energy consumption to process the same amount of biomass.

Screening system

A screening system is not considered essential but as it can increase the quality of the product (since it allows achieving a specific size distribution and on the other hand reduces the amount of fine particles that creates dusty atmospheres), its inclusion should be evaluated in the economic study.

Storage

The necessity to store raw materials or products and the type of storage should be also considered. Several storage places are possible, e.g. silos, outdoor storage or covered storage. In general, storage places are not available during the usual activity of the agro-industry. That is why a good matching of the seasonal biomass production with the idle periods of the agro-industry is recommended in order to decrease the storage period (which could moreover incur in matter loss due to fungi activity). Working according demand is therefore highly recommended for the logistic centre.

Seasonality

Seasonality is an essential variable that should be considered as it affects the whole supply chain. In the best case the period of biomass demand would be just few months later after harvesting of residues or after the idle period. In this ideal case the existing storage capacities of the product in the agro-industry could be optimally used and the need for additional ones would be minimised.

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[1] This list presents the most common dryers in European agro-industries, other dryers such as container or solar dryers are not specified here.

Some equipment does not have any idle period, therefore even if it belongs to the agro-industry, it is not available for the biomass logistic centre. In that case a further investment will be necessary.

⚠ Additionally, it should be taken into account that, from the moment when the logistic centre stops production, a cleaning process should be performed before turning back to the regular activity of the agro-industry. Cleaning is necessary to avoid the risk of contamination.

2.2. Social and environmental requirements

Any project developed according to SUCELLOG concept should contribute to sustainable development of agricultural sectors, involving farmers, traders and cooperatives in the supply chain, and facilitating regional development. **The agro-industry should therefore ensure that its activities comply with regulations and with the three pillars of sustainable development.**

Contribution to local economy

- **Competitive uses of raw materials:** a biomass logistic centre uses agricultural residues with no added or limited value as raw materials, having a positive effect on farmers' incomes. To be sustainable, they should not compete with food agriculture or structured sectors (as animal feeding, bio-sourced materials).
  The raw materials planned for the logistic centre should be accepted by the regional/national law point. For example, Styria is the only region in Austria where corn cobs are not allowed to be used by households as fuel (this condition should be changed soon).
- **Local supply chain**: local distribution is highly recommended. It has positive impact on the development of local economy and reduces transportation related cost. Moreover, the revenues from the new economic activity remain in the region.

Environmental preservation

- **Soil preservation:** addition of crop residues to soils affects fertility, structure and bulk density of the soil, water infiltration, water holding capacity, and sustains microbial activity, which is the major source of organic carbon and nutrients. Depending on each soil and climate conditions, a certain percentage of the residues has to be left on the soil during the harvesting operation to avoid negative impact on properties and structure of the soil.
- **Air pollution:** gaseous and particulate emissions have to be controlled to minimise the pollution during storing or handling of materials and during biomass combustion processes. The emissions limits to be accomplished when using biomass in the combustion systems can be found in SUCELLOG D2.2 "Guide on technical, commercial, legal and sustainability issues for the assessment of feasibility when creating new agro-industry logistic centres in agro-food industries".

Social impact

- **The new business line**, as any other activities of the agro-industry, should ensure the respect of the International Labour Convention for working conditions and human rights.

3. Economic assessment

The first two chapters of this handbook describe how to assess the technical feasibility of the project (needs for investment depending on equipment or logistic chain, need for pre-treatment depending on the consumers demand etc.). This section describes how to evaluate the project from the economic point of view.

The aim of the economic assessment is to select the most promising product to offer in the market by evaluating its competitiveness in the regional market.

Economic feasibility study includes the assessment of capital costs (e.g. investment in new equipment or processing lines), operational and maintenance costs (e.g., purchase of the raw material, transportation and pre-treatment costs, staff costs, repair and maintenance of machinery, marketing costs etc.) and potential revenues (e.g. income from the sales of the new product in the market or avoided costs/saved energy in case of using the product for own consumption) and is usually made on the basis of cost-benefit analysis.

The auditors guide and the *Auditors guide – Economic assessment* elaborated within SUCELLOG project are available on the SUCELLOG website (www.sucellog.eu). They support the project developer on building an economic assessment step by step and to establish the best scenario, comparing different hypothesis.

3.1. Cost analysis and determination of the minimum selling price

There are several costs categories which should be considered for the new business activity. The first cost is associated to production and includes costs related to raw materials, pre-treatment costs and staff costs from to the personnel involved in production. In addition, the depreciation of investment should be calculated in the price of the final product. A margin of profit should be also included. The three mentioned cost categories determine the minimum selling price of the product in the market (see Figure below).

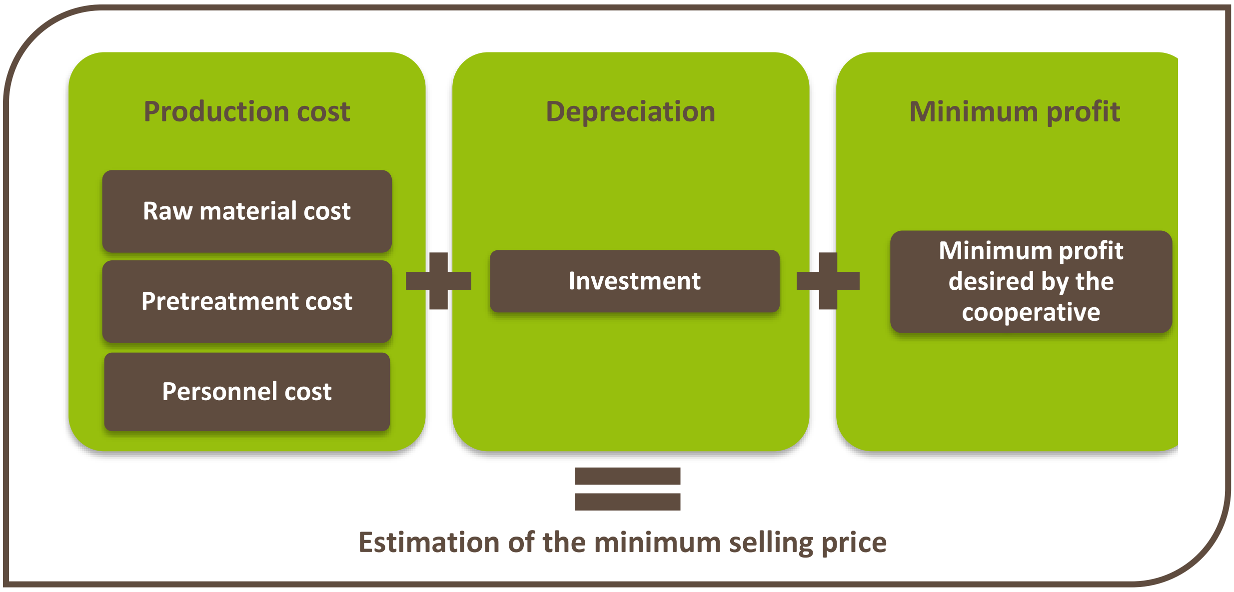

Figure 6 : Cost categories for the estimation of the minimum selling price of the product

Raw material costs

Raw material costs

- **Cost of raw materials (€/t):** depend on the biomass suppliers
- **Transportation cost:** depend on the distance and density of the material

Raw material related costs include the cost of the raw material itself, cost of transportation and depending on the organisation of the supply logistics, eventually also the material storage costs can be included.

As described in previous chapters, the cost of raw material can be zero (if agro-industry uses their own residues which presently have no market value) or can even be negative (if the agro-industry is paying for its disposal). However, if biomass resources have to be purchased, the raw material costs usually plays very important role in the overall economic feasibility of the project and there are limited options to influence/decrease these costs: by negotiating long-term contracts with the biomass suppliers, by reducing biomass collection distances or by increasing the density of the resource to save on the transportation costs.

Pre-treatment costs

Pre-treatment costs include operational, maintenance and eventually rental costs. Pre-treatment costs should be calculated **for each type of raw material** and **for each phase of the production process**.

Operational costs

- **Electricity cost (€/t of material at the inlet):** It is necesary to know or to estimate the cost of the electricity that each treatment process consumes
- **Heating cost (€/t of material at the inlet):** Depend on type of fuel, its consumption and price. These costs are mainly relevant for drying operations.
- **Personnel cost (€/h):** Depend on the number and hourly rate of the persons in charge of operation.

Maintenance costs

- **Hours used for the maintenance (h/t):** Number of hours spent for the maintenance of the equipment used in each operation.
- **Cost of replacement parts of the equipment (€/t):** This cost should also be considered. For example, the knives in the milling system or the die in the pelletiser should be periodically replaced.
- **Personnel cost (€/h):** Depend on the hourly rate of the person in charge of the maintenance.

Rental costs

- **Rental cost (€/t):** If that is the case, the cost derived from the rental of a machinery has to be included as part of the pre-treatment cost.

Personnel cost

Personnel cost

- **Personnel costs for support :** personnel required for the new business line except for usual operation and maintenance (administration, manager, marketing ...)

Personnel costs depend on the qualification and salary of employees involved in the operation of biomass logistic centre. Part of the personnel costs (related to operational and maintenance works) are already included in the pre-treatment costs.

Depreciation of the investment

Investment

- **Depreciation rate (€/year) :** Depend on the years of depreciation (lifetime of the equipment) and the total investment costs done by the agro-industry

Depreciation is an accounting term that refers to the process of allocating the cost of an asset over a period of time. The payment is distributed into multiple cash flow instalments. Investment costs are spread over the years which correspond to the expected lifetime of the equipment or the project.

Investments may for example include new equipment or facilities or adaptation of current equipment.

Minimum profit margin

Minimum profit margin

- **Minimum profit (€/t):** depends on the agro-industry statment

Profit margin is calculated as net income divided by revenue. Net income is determined by deducting all expenses (raw material costs, operational costs and taxes) from the total revenues of the company. A minimum required profit margin may be set by the agro-industry for a new business line to start the operation and to cover possible risks. …

Minimum selling price

As explained before, **the minimum selling price for the product (€/t)** is the sum of the production costs, the depreciation rate and the minimum desired profit.

Depending on the project, other costs may have to be included such as tax payment. Other revenue can also be added, for example if the project developer asks for financial support from development programs.

3.2. Evaluation of competitiveness in the local market

Once the minimum selling price of the product is calculated and the quality of the final product is known, it should be compared to prices and qualities of other products in the market. This comparison is essential to understand the competitiveness of the product. **The minimum selling price should not be higher than the market price of a product of similar quality in the market.**

If the product is new for the local market and there is no market price to compare, the price of the new product has to be set depending on competitor prices. Table 1 below gives an example of how to interpret the market information.

- The competitor 1 offers a better quality product (higher calorific value and less ash content) but more expensive. Depending on the type of boilers used by local consumers, if they can operate with this type of fuel, the new product of the biomass logistic centre might be competitive in the market.
- The competitor 2 has better a quality product at lower price. The new product of the biomass logistic centre is not competitive with it.
- The competitor 3 offers better price, but the fuel has lower density. The new product of the biomass logistic centre can be competitive because, compared to the product of the competitor 3, the needs of storage capacities and the frequency of supplies will be reduced.
- If the price of the new product can be further reduced, it would be fully competitive with the competitor 3.

Table 1 : Evaluation of competitiveness

	New product	Competitor 1	Competitor 2	Competitor 3
Price (€/kWh)	0.04	0.05	0.03	0.03
LHV (kWh/kg ar)	3.90	4.90	4.90	3.5
Ash content (w-% db)	5.00	1.00	1.00	5.00
Moisture content (w-%, ar)	10	10	10	25
Bulk density (kg/m³)	600	600	600	300

3.3. Identification of the best scenario

After the evaluation of the technical feasibility (see Chapters 1 and 2), the project developer should be able to identify several possible scenarios of the new business activity. Scenarios will differ from each other in terms of raw materials which might be used, the way that logistics and treatment operations are organised, the type and quality of the end product, the need for additional modifications to existing equipment or new investments but also the amounts of production (sharing of fixed costs). The number of the technically possible scenarios might probably decrease once the economic feasibility of them is evaluated. Scenarios which are not only technically, but also economically feasible will remain and will be further analysed. The best scenario among technically and economically feasible options has to be selected.

The *Auditors guide – Economic assessment* and case studies (D4.3) from the SUCELLOG project available on the website www.sucellog.eu can be used as support to compare the different scenarios from the economic point of view.

To identify the best scenario from the economic point of view, it is essential to be aware of several economic indexes like the Net present Value, the Discount rate, the Internal rate of return, the Return on sale and the payback period.

The value that the agro-industry places on the results obtained for each index will depend on the own agro-industry. For example, one agro-industry can consider that 10 years payback is acceptable while others cannot. In general terms, it can be considered that:

- **Net Present Value (NPV):** the higher is the NPV, the more profitable is the project.

- **Discount rate:** a higher discount rate imply greater uncertainty of future cash flows.
- **Internal rate of return (IRR):** an investment is a good option if its IRR is higher than the rate of return that can be earned by investing the money elsewhere at equal risk.
- **Return on sale (ROS):** the higher is the ROS, the most profitable is the scenario.
- **Payback period:** the shorter is the payback period, the lower is the risk.

4. Key messages for the reader

This handbook has been elaborated for agro-industries interested in starting a new activity as biomass logistic 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 each context.

Main messages are:

- As in any other project, the success of the development of a logistic 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 logistic 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 while big industries are less restrictive. However, the former is usually used to pay higher prices compared to the latter.
- Several equipment already existing on 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, personal 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.

Is the project technically feasible?

The decision tree hereafter proposes simple questions based on boundary conditions and technical and non-technical assessments to evaluate if the project would be technically feasible or not. It can be used for each scenario proposed to the agro-industry.

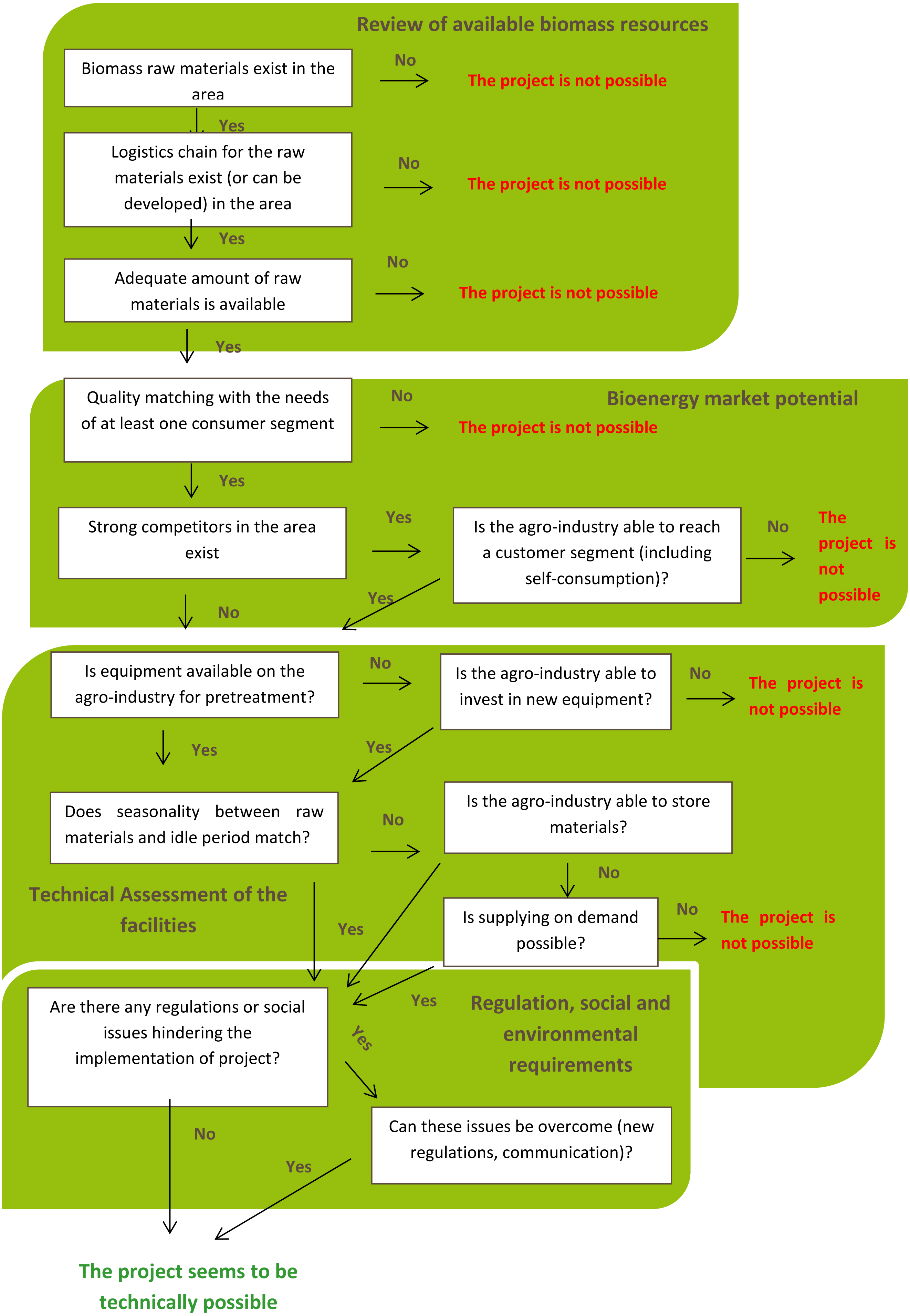

Figure 7 : Decision tree for technical and non-technical issues

Annex 1 - Economic indicators

Net Present Value – NPV:

NPV (unit: €) is the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in budgeting to evaluate the profitability of an investment.

A positive Net Present Value indicates that the projected earnings generated exceed the anticipated costs. Generally, **the higher is the NPV, the more profitable is the project.**

$$NPV(i,N) = \sum_{t=0}^{N} \frac{Net\ Cash\ Flow_t}{(1+i)^t}$$

That is meant that $NPV = PV(Benefits) - PV(costs)$

Where

- i is the discount rate
- t is the year of the cash flow
- the net cash flow is cash inflow – cash outflow, at time t
- Net Cash $Flow_0$ commonly represents the investment

The general concept is that the value of the money **now** is higher than the same amount of money **later on**. This can be illustrated by the following simple example: Let us assume that one can get 8 % yearly interest. So €1,000 now could earn €1,000 x 8 % = €80 in a year: €1,000 now would become €1,080 by the next year. So €1,080 next year is the same as €1,000 now (because of interests earned or inflation).

Discount rate

Discount rate is the rate used to discount the future cash flows to the present value. The discount considers not only the value of the money for the period, but also the risk of future cash flows. The greater the uncertainty of future cash flows, the higher discount rate is used.

Sometimes firms are using weighted average cost of capital (after taxation) to calculate the appropriate discount factors, however, often higher discount rates are used to adjust for risks, opportunity cost and other factors.

Internal[2] Rate of Return – IRR:

Internal rate of return (% per year) on an investment or project is the discount rate that makes the net present value of all cash flows (both positive and negative) from a particular investment equal to zero (Finenco, 2013).

Internal rate of return is used to evaluate the attractiveness of an investment, or compare different possibilities. As a general concept, if the IRR of the new project exceeds the rate of return required by the company, the project is profitable; if IRR is lower than the required rate of return, the project is not enough profitable and likely will be rejected. **An investment is a good option if its IRR is higher than the rate of return that can be earned by investing the money elsewhere at equal risk** (ex: bank investment).

$$NPV = \sum_{t=0}^{t=N} \frac{Net\ Cash\ Flow_t}{(1+IRR)^t} = 0$$

Where

- n the year of the cash flow
- the net cash flow is cash inflow – cash outflow, at time t
- Net Cash $Flow_0$ commonly represents the investment

Assuming a firm must decide whether to invest money for a new machinery for € 300 000. The machinery

[2] The term internal refers to the fact that its calculation does not incorporate external factors (interest rate, inflation …)

would only last three years, but it is expected to generate an annual profit of € 150,000 during its working time. The firm also foresee to sell the equipment at the end of the period for about € 10 000. Using IRR, the manager of the firm can determine whether the equipment purchase is a better use of its cash than its other investment options, which should return about 15 %.

Here is how the IRR equation looks in this scenario:

0 = -€300,000 + (€150,000)/(1+IRR) + (€150,000)/(1+IRR)2 + (€150,000)/(1+IRR)3 + €10,000/(1+IRR)4

The value of IRR equal to 0.2431 (24.31 %) makes the equation 0. From a purely financial standpoint, the Company should purchase the equipment since this generates a 24.31 % return for the firm --much higher than the 15 % return available from other investments.

Return on sales - ROS

Also describe as operating margin, ROS (in %) is a ratio generally used to evaluate the operational efficiency of a company, as profit made by the activity after paying for any production cost, such as labor, raw materials, etc. (but before interest and tax).

Higher is the ROS, performer is the project.

$$ROS = \frac{Operating\ income}{Revenue}$$

This measure is helpful to management, providing the profit produced per Euro of sales. Return on sales (operating margin) can be used both as a tool to analyse the real performance against the potential, or to compare the company to competitors.

As an example, a firm with net sales of €100,000 and pretax profit of €20,000 would have a return on sales ratio of 20 percent. This would mean the firm is earning a pretax profit of 20 cents for each Euro of sales.

Payback period

Payback period estimates the number of years necessary to ensure that the net cash flow from investment (the difference between revenues and annual costs) covers the amount invested[2].

It is usually assumed that the longer the time required for covering funds, the more uncertain are the potential returns. Shorter is the payback period, lower is the risk. Furthermore, when investment or action costs are recovered sooner, they are available again for further use.

$$Payback\ Period = \frac{Initial\ Investment}{Cash\ Inflow\ per\ Period}$$

For example, if an investment costs €100 000 and is expected to return €20 000 annually, the payback period will be €100 000/€20 000, or five years.

However, there are two main problems with the payback period method:

1. It ignores any benefits that occur after the payback period and, therefore, does not take into account profitability.
2. It ignores the time value of money: money available today is worth more than the same amount in the future due to its potential earning capacity.

Abbreviations

%: percent

€ : euros

°C: degree Celsius

ar: as received, meaning wet base

db: dry base

EC: European Commission

EU: European Union

EU-27: European Union with 27 members states (Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom).

EU-28: EU-27 + Croatia (from 1st July 2013)

ha: hectare

kg: kilogram

kt/yr: 1000 tons per year

kWh : kilowatt hour

m^3 : cubic meter

M : moisture content

MWt : Thermal Megawatt

NOx: Nitrogen oxides

SOx: Sulphur oxides

w-%: percent by weight

w: weight

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