Final Degree Project

Industrial Technologies and Economic Analysis

STUDY OF THE PRODUCTION SYSTEM OF A CRAFT BEER FACTORY IN MANLLEU

Memory

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Resum

En aquest projecte s'estudia el comportament econòmic d'una empresa que fabrica cervesa artesana a una fàbrica situada a Manlleu. El projecte va començar fa una mica més d'un any i l'objectiu actual és augmentar el nivell de producció per tal de consolidar nous mercats.

Per aquest motiu, el projecte estudia el sistema de producció actual de la cervesa, així com l'estudi de tots els costos relacionats amb la seva producció. Posteriorment, s'analitza l'estudi i es proposen diverses millores per augmentar l'efectivitat de producció, i per reduir el cost final de la cervesa.

Finalment, s'estudia en profunditat cadascuna de les diferents propostes de millora, i també s'elabora una anàlisi de viabilitat per veure la repercussió econòmica que tindrien les millores en l'empresa.

Resumen

En este proyecto se estudia el comportamiento económico de una empresa que fabrica cerveza artesana en una fábrica situada en Manlleu. El proyecto empezó hace un poco más de un año y medio, y el objetivo actual es aumentar el nivel de producción para consolidarse en nuevos mercados.

Debido a esto, en el presente proyecto se realiza un estudio del sistema de producción actual de la cerveza, así como también se estudian todos los costes relacionados con su producción. Posteriormente, se analiza el estudio realizado y se proponen diversas mejoras para aumentar la efectividad de producción, y reducir el coste final de la cerveza.

Finalmente, se estudia en profundidad todas las diferentes propuestas de mejora, además de realizar un análisis de viabilidad para ver la repercusión económica que tendrían las mejoras en la empresa.

Abstract

This project studies the economic behaviour of a company that manufactures craft beer in a factory located in Manlleu. The project was born a little bit over a year and a half ago, and the current objective is to increase the level of production to consolidate in new markets.

Considering this goal, in the present project a study of the current beer production system is carried out, as well as all the costs related to the production of the beer are studied. Subsequently, the study is analysed, and various improvements are proposed to increase the effectiveness of the production, and to reduce the final cost of the beer.

Finally, all the different proposals for improvements are studied in detail, in addition to conducting a feasibility analysis to see the economic impact that the improvements would have on the company.

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It could not finish this section without mentioning my family, who has always given support in all the chapters of my life, and without them, I could not be writing this.

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1. Introduction

In this section of the project an introduction to it will be done. It will acquire remarkable importance to properly establish the goals of the project, in order to, once finished the project, be able to check it they have been fulfilled with this work.

1.1 Motivation

The motivation of this project is to provide to a handmade beer company a solution for an easy and fast method to calculate the price of the beer they produce, considering the costs involved in each section of the production process.

Furthermore, the results obtained will be analysed to check at which stages of the process improvements could be made in order to reduce the calculated cost.

1.2 Scope

The solution given for the problem to be solved, and explained in the motivation section, is valid for the upcoming years if the company does not change the location of the factory. Regarding the forecasts for production of the upcoming years, it is reasonable to discuss the results in the current factory.

The project consists of a theoretical study of the proposed situation, but regarding the short duration of the project, although it is intended to implement such improvements soon, it is not possible to include the results of the implementations and compare them with the theoretical results obtained in the project.

1.3 Prerequisites

Regarding the nature of this project, although it is not essential to know the process of crafting beer, it is of great help to know how the process works, since it helps to understand better all the stages and potential costs involved in the process.

Moreover, it is important to have some EXCEL knowledge since all the calculations involved in the project have been done with this tool. To analyse the results some economic tools have been used, which were seen in the subject called ‘Productions and Operations Management’ taught at the school.

1.4 Objectives

The objective of the project is to analyse the process of producing craft beer in order to determine all the costs related to the production of it. This allows to create a tool that will help the company to determine accurately the cost related to the production of each beer.

The creation of such an automatic tool is the first part of the project, and it is important to consider that up to now, KOM does not have any tool to determine the cost of the beer, making it impossible to determine the gain and losses of their activity.

From the analysis of the costs of the different beer since the beginning of the project, some improvements to reduce this cost are proposed. The improvements are the following:

1. New canning machine particular objectives

- Do an exhaustive market research to determine the best alternative to KOMs needs.
- Compare the different alternatives with the current machine.
- Compute a viability study to check for the rentability of the investment.

2. Reverse osmosis industrial plant particular objectives

- Contact the most specialized companies in Spain to ask for a budget.
- Compare the different alternatives with the current solution.
- Compute a viability study to check for the rentability of the investment.

3. Refrigeration equipment study

- Understand the different types of thermal loads.
- Create a tool to calculate the thermal loads of the factory.
- Provide accurate results to substitute the current antiquated machines for new and updated ones.
- Propose current market models and a budget for the installation.

2. Theoretical background

In this section, an explanation of the activity performed in the factory will be given. For this purpose, it is necessary to understand where and when does the origin of craft beer begin, as well as to know in detail the type of beers produced at KOM.

Steps followed to create the final product take special relevance since it is crucial to analyse each of them in detail in order to understand the costs related to them.

2.1 Introduction

The art of creating handmade beer has become increasingly popular over the last decade, with more and more people opting for these unique and artisanal brews over the large-scale company producers that are dominating the market.

Crafting beer is both a science, since it requires taking careful attention to detail, and an art, allowing the brewer to experiment with different ingredients and brewing techniques. It is highly important to carefully select the type and amount of each of the ingredients required for such a creation, playing all of them a crucial role in determining the flavour, aroma, and appearance of the final product.

Handmade beer, also known as craft beer, is typically brewed in small batches by independent breweries, which they often give prior to aspects such as taste, flavour, and experimentation over consistency and efficiency. Producing handmade beer implies the use of traditional techniques as well as high-quality ingredients, resulting in a diverse range of beers with complex and interesting flavour profiles.

A key advantage of handmade beer is the opportunity for brewers to put into practise their creativity and experimentation. Unlike large brewery companies, who focus on large-scale production of a small range of reliable and consistent beers, craft brewers have the freedom to experiment with different malts, hops, and yeasts, as well as adding extra ingredients such as fruits, spices, and herbs, making the consumer experience reach another level.

It is important to mention the several health benefits that handmade beer have, mainly related to the larger amount of nutrients and antioxidants compared with the mass-produced ones. This difference comes for the usage of high-quality ingredients such as hops, that normally are rich in antioxidants and anti-inflammatory properties.

This type of beer also stands out as a sustainable alternative to mass-produced beer. Many craft breweries prioritize sustainability and environmental stewardship, using local ingredients, reducing water usage, and minimizing waste over production and exposure, they prioritize quality over quantity. This commitment can also be extended to the packaging and distribution, with many local breweries using stunning packaging designs related with the local history and using reusable or recyclable containers.

One may think about the difficulty of creating beer. Indeed, it is a quite challenging activity, not only because a little mistake in the cooking process can spoil thousands of litres of beer, but also because of the demanding physical activity. Normally, the process of creating handmade beer require brewers to spend long hours on their feet and engage in repetitive and physical tasks. However, many brewers feel that this physical effort and a sense of accomplishment that comes from creating something with their own hand is highly rewarding.

The main characteristic of handcrafted beers is the community-oriented nature of their brewers. Many of these breweries serves as gathering places for beer enthusiast, hosting events such as tastings, brewery tours and educational workshops. This, alongside with collaborations between small breweries, promotes a sense of community among beer lovers.

Overall, handmade beer offers a unique and rewarding experience for those seeking something beyond the typical mass-produced options. With its emphasis on quality, creativity, and community, it is not surprising that craft beer has become favourite among those beers enthusiasts around the world.

2.2 The process of creating craft beer

The process of creating handmade beer is similar to creating other types of beer, but it has some features that help to create a distinctive final product. In this section the basic steps to create craft beer, from raw materials to the end product, are explained.

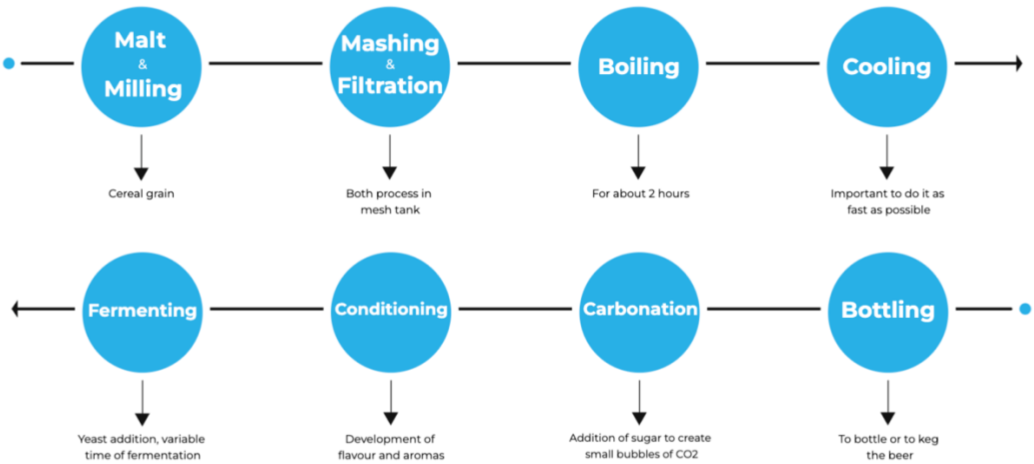


Figure 2.1. *Illustrative roadmap of the process of crafting beer. Source [7]*

1. Malt. The cereal grain is soaked in water to germinate and then it is roasted to produce the malt, which is the base for the elaboration of beer, giving it the unique taste and flavour.

2. Milling. The malt is milled to create a coarse powder. Usually, the malt is made of barley, but in some cases other grains like wheat or rye can be used.

3. Mashing. The milled grains are mixed with boiling water in a large tank, called mash tun. This process lasts for about one hour and it is important to recirculate and to stir the mixing, making easier to extract the fermentable sugars and nutrients of the malt.

4. Filtration. The mixture, called wort, is then strained to separate the solid residues from the liquid mixture. Normally this step is done at the same mash tun.

5. Boiling. The wort is transferred to a large kettle, where it is boiled with hops and in some cases with other flavourings for a period between one or two hours. The hops are the key element in the elaboration of beers, giving them bitterness and aroma, while other ingredients like fruits, herbs, or spices, may add additional flavour. This step is important to sterilize the mixture and concentrate the flavours.

6. Cooling. The wort then needs to be cooled down quickly to the optimal temperature for yeast fermentation. It is important to do this step as fast as possible, since it will avoid the growth of undesired bacteria that would spoil the beer.

7. Fermentation. Once obtained the optimal temperature, the wort is transferred to the fermentation vessel and the yeast is added. The process of fermentation consists of the yeast consuming the sugars in the wort and producing alcohol and carbon dioxide, turning the wort into beer. This process will vary in time, depending on the yeast used. Later on, it can be found an explanation of the different types of beer, explaining the times of this step for each of them.

8. Conditioning. Having complete the fermentation process the beer is transferred to a secondary vessel which allows the flavours to develop and the beer to clear. This process can take from few days to several weeks.

9. Carbonation. Once the beer achieves the optimal flavour, aroma, and consistency, it is carbonated by adding a small amount of sugar to initiate a secondary fermentation, creating small bubbles of carbon dioxide in the beer.

10. Bottling. Finally, the beer is bottled or kegged and labelled for its selling. Sometimes, once the beer is bottled, it can be aged for a few weeks or months to allow the flavours to further develop and become more complex.

In general, these are the principal steps to follow for handmade beer creation, but they can be adjusted depending on the brewery size and machinery, and also when experimenting with new processes.

Craft brewers may use different types of yeast, hops, and malts than traditional breweries do, allowing them to experiment with new flavour combinations or using local ingredients to create unique beers. Compared with traditional beer, the process of cooking craft beer is often more hands-on and laborious, paying off at the final product.

2.3 Types of beer

There exist many different types of beers, each with its own unique characteristics in terms of colour, flavour, aroma, and alcohol content. The main difference between beers yields on the yeast used to produce the beer, the temperature and duration of fermentation, and the taste.

Usually, beer lovers distinguish between three main groups mainly determined by the type of yeast used: lagers, ales, and speciality beers.

Lager is a type of beer that is fermented and conditioned at low temperatures, usually between 5ºC and 13ºC. By using these conditions in the fermentation process a crisp, clean, and refreshing beer is achieved, with a smooth mouthfeel and light body.

A key characteristic of this type of beer is the usage of bottom-fermenting yeast strains, called saccharomyces pastorianus. The yeast in the fermenting process is settled at the bottom of the vessel, and added to the lower temperatures, it results in a slower fermentation process and a cleaner and crispier taste profile. Depending on the specific recipe of the beer, the fermenting time can vary from several weeks to a few months.

Lagers are also known for having a low level of hop bitterness and aroma, with a focus on a subtle sweetness. The malt profile of lagers is normally light and grainy, with a dry finish, making them a highly refreshing and drinkable beer.

Typically, lagers are the group of beers with the lower alcohol content, but since there exists dozens of lager styles, including Pilsner, Helles, Vienna Lager, Oktoberfest, etc., it may vary, as well as the colour, flavour, and aroma.

All in all, lagers are known for having a milder taste and for their crisp and clean taste, making them a popular choice between those beer-lovers. Whether enjoyed on a hot beach on a summer day or paired on a hearty meal, it is a refreshing and versatile option for any occasion.

Figure 2.2. *Typical appearance of a Lager style beer. Source [6]*

Ale is a type of beer that is fermented and conditioned at high temperatures, typically between 15ºC and 25ºC. Under these conditions, a full-body beer with usually fruity or spicy flavours and aromas is created.

One of the key characteristics of ales is the use of top-fermenting yeast strains, called saccharomyces cerevisiae. This type of yeast float at the top of the fermenting vessel during the process, which, thanks to the temperature characteristics, results in a faster fermentation process, which usually takes from one to two weeks, and a more flavourful and aromatic beer.

Ales tend to have a higher level of hop bitterness and aroma than lagers. The malt profile is always more complex and robust than that of the lagers, so it is easily to distinguish between them just by their appearance.

There exist many different styles of ale, each of them with unique flavour and aroma characteristics. Some of the most popular types are Pale Ale, India Pale Ale (IPA), Belgian Ale, Stout, or Porter. Each of the mentioned styles has its own and unique characteristics than let them be easily distinguished form the rest in terms of appearance, flavour, and aroma.

In general ales are known for having a higher alcohol content than lager beers. This is explained by the type of yeast used: top-fermenting yeast is able to work at higher temperatures, which ferment quicker and produces a higher amount of alcohol. In addition, ales usually employ some ingredients, such as malted barley, which contain more fermentable sugar than the typical grains employed in lagers.

In general, ales are known for their rich, aromatic, and intricate taste and aroma. With a diverse range of tastes and styles available, ales are a versatile option that can be enjoyed on their own or paired with an aperitif, providing a unique and satisfying drinking experience to suit a variety of preferences.

Figure 2.3. *Typical appearance of an Ale style beer. Source [6]*

Speciality beers a broad category of beers that encompasses a wide range of unique and innovative styles. Any beer that does not fit into the ale or lager group is included in this category. These beers often feature unusual ingredients (such as fruits, herbs, or species) and brewing techniques that push the boundaries of traditional beer manners.

An aspect that is shared between all beers included in this heterogenous group is their focus on experimentation and innovation. Breweries specialized in these styles are often looking to create something new and exciting, using a wide range of techniques and ingredients that usually do not fit into the typical brewery styles. Typical ingredients used are fruit, spices, coffee, herbs, and chocolate, and the most daring are starting to include unconventional ingredients such as seaweed, oysters or even chilli peppers. By doing so, new flavour profiles can be achieved.

There exist many different types of speciality beers, therefore it is difficult to assign a characteristic profile in terms of alcohol content, flavour, and aroma. The most popular styles among them include sour beers, barrel-aged beers, smoke beers and wild ales.

What beer enthusiasts like the most about these kinds of beers is the sense of creativity and innovation that surrounds them. Brewers are constantly experimenting with new ingredients combinations and techniques, resulting in a never-ending array of unique and exciting beer styles to discover and enjoy.

Overall, speciality beers offer a new and unusual experience for beer lovers who are looking to explore different and creative flavours. They are a testament to the creativity and ingenuity of the craft industry, and for sure will leave nobody indifferent.

These three main groups are a helpful way to classify beers and understand their main characteristics, although within each group there is a huge variety of different styles, flavours and ingredients that make each craft beer unique.

Since KOM beer is a company specialized in a specific type of Ale beers called NEIPAs, which in turn is a type of IPA. Indeed, some of their creations are Stouts, which is also a different style of Ale beer. Therefore, a deeper analysis of these particular beers will be done, to further understand their unusual characteristics in terms of appearance, flavour, aroma, etc.

2.3.1 IPAs

History

To understand what an IPA is, one has to think about the different types of beers explained before in this text. An IPA is a type of Ale beer, meaning that the yeast in the fermenting process remains at the top of the fermenting vessel.

IPA stands out for Indian Pale Ale, and it is a style of beer that appeared for the first time in the 18th century in England. The story behind this beer is that it was originally brewed for the British troops that were stationed in India due to the war.

At that time, beer was the most consumed drinking by the British troops stationed around the world. However, traditional English ales did not get along with long sea travels and warm temperatures, especially those of the tropics. So, it was not a surprise that when the beer arrived at its destination, it was completely spoiled and undrinkable for the troops.

To solve this problem, English brewers started to experiment with new brewing techniques and ingredients. They ended up by adding more hops, which acted as a natural preservative, and also incremented the alcohol content, since the higher the alcohol content is, the less changes of spoilage exist.

It was in 1827 when the first recorded shipment of IPA to India was registered, when a shipment of beer was sent from George Hodgson's Bow Brewery in London to their agent in Calcutta. The shipment was well-received, and it was a complete success since it quickly became a popular style of beer among English troops and expatriates in India.

Over the time, IPAs spread beyond India, and they became one of the most produced British beers. However, in the early 20th century, IPA stopped their huge growth because lighter and less bitter beers became more popular. However, in the 70s IPAs regained popularity as part of the craft beer movement. Nowadays, IPAs are brewed all over the world and come in different variations.

Characteristics

IPA style has considerably evolved since the first brewing in England. It is now produced worldwide, and the characteristics associated with it are well-known for everybody who is passionate about beers world.

One of the most recognizable features of an IPA is its strong hope flavour and aroma. This intense fruity aroma is accompanied by a bitter taste that is usually balanced our by the sweetness of the malt. IPAs are also known for their high alcohol content, which ranges from 5 to 7%, although some double and triple IPAs can reach alcohol levels above 10%.

When it comes to appearance, IPAs usually have a golden to amber colour, although the range can vary, and some IPAs may be darker or hazier. Bitterness is also a key characteristic of IPAs, with large amounts of hops being used in the brewing process. To balance the bitterness of the hops, it is required a medium to high level of malts in the beer.

Finally, IPAs are known for their dry finish, which makes them incredibly refreshing to drink. All of these elements combined make an IPA an excellent choice for those who enjoy a complex and flavourful beer.

Figure 2.4. *Wide range of typical IPAs appearance. Source [8]*

2.3.2 NEIPAs

History

NEIPA stands for New England Indian Pale Ale, which is a style of beer that originated in the northeast of the US in the end of the 1900 century and the early 2000s. Although it is not known with accuracy where did exactly originate, the achievement for such creation is popularly attributed to a small group of craft breweries in Vermont and Massachusetts, that is why this type of beer adopts the letters NE in its name, since both cities belong to New England state.

The birth of the NEIPA style was influenced by different factors, including the rising popularity of IPAs, the availability of new hop varieties and the desire to create beers with a distinctive taste and look. The early pioneers experimented with diverse brewing methods and components, including the use of specialty malts, late hopping, and yeast strains that helped to reach the cloudy appearance and fruity taste of the beer.

The availability of new hop varieties, such as Citra, Amarillo, and Mosaic, was a key factor in the development of the NEIPA style, because they offer a strong aroma and flavour, exactly what breweries were looking for.

With years, the popularity of NEIPAs has increased among beer enthusiast, and today NEIPAs are one of the most consumed type of beers and are brewed all over the world, usually using local ingredients, which makes each of the creations unique and different from the rest.

Characteristics

As its name suggests it is a type of IPA, which is known for its hazy appearance, fruity and juicy flavour, and low bitterness.

This type of beers is typically brewed using a large number of hops that are high in essential oils, making it possible to achieve a hop flavour and aroma instead of making the focus on the bitterness. The hops are used in different stages of the cooking process, including during the fermentation.

NEIPAs are also known for the use of speciality malts, such as wheat or oats, which give them a smooth and creamy texture. The use of these types of malts as well as the yeast strain are probably the main responsible of the hazy appearance of the beer.

The main differences between NEIPAs and a usual type of IPA are mainly two. The alcohol content is higher in NEIPAs, and IPAs are more bitter than NEIPAs. Both can be explained because the type of hops used in NEIPAs is sweeter, which helps to balance out the bitterness of the hops and in turn these hops have a larger sugar content, which ferment into alcohol during the fermentation process and increase the alcohol content of the final beer.

All in all, NEIPAs are a relatively new style of beer that has become popular in recent years. They are known for their fruity and juicy flavours, low bitterness, and unclear appearance, and they are often brewed by craft breweries that specialize in creating unique and flavourful beers, as it is KOM’s case.

2.3.3 Stouts

Stout is a style of beer that originated in United Kingdom in the 18th century when the beer industry gained adepts in England. The history of stouts is closely tied to the history of porter, which is another style of beer that was popular in England during the 1700s.

Porter was a dark, rich beer that was made by blending different types of malted cereals, especially barley, and was favoured by the working-class population in London. As its popularity grew, brewers began to experiment with different versions of porter, including stouts.

Initially, the term stout was used to describe a strong or heavy porter, with a higher alcohol content and a more robust flavour profile than typical porters. Over time, stouts evolved into their own distinct style, with their own unique characteristics.

One of the most famous stouts, which indeed is popularly known as the first ever brewed stout, is Guinness, which was first brewed in Dublin, Ireland in 1759. Guinness' founder, Arthur Guinness, developed a unique brewing process that gave the beer its distinctive dark colour and rich flavour. The beer's popularity grew, and Guinness eventually became one of the most widely recognized beer brands in the world.

Today, there are many different types of stouts, including dry stouts, sweet stouts, oatmeal stouts and imperial stouts. This style of beer is nowadays brewed all over the world and is enjoyed by beer enthusiasts for their complex flavours and rich, full-bodied texture.

Characteristics

Stout is a style of beer characterised by its dark brown to black aspect. It typically has a higher alcohol content than other beers and a creamy and smoothy texture and known for its distinctive roasted malt flavour.

This type of beers is made with an extended variety of malts, including roasted barley, which gives its characteristic flavour. They can often offer notes of chocolate, coffee, and caramel and even in some cases they can taste slightly sweet depending on the specific style.

Stouts are typically carbonated with low levels of carbonation, which helps to enhance their smooth, creamy texture. Some stouts, such as milk stouts, may also contain lactose, which gives them a slightly sweet taste.

There exist different varieties of stouts, including dry stouts, sweet stouts, oatmeal stouts, and imperial stouts. From all variants, dry stouts are the most common type, and they are known for their dry, bitter taste, with less alcohol content than other stouts. Sweet stouts are brewed by adding sugars or other sweeteners, giving them a sweet taste. Since more sugar is added, more sugar ferments and a higher alcohol content is achieved.

Oatmeal stouts are the result of brewing with oats, which give the beer a smoothy texture and a slightly and difficult to appreciate sweet taste. On the other hand, imperial stouts are the strongest and most full-bodied stouts, with a high alcohol content and a rich and complex flavour profile.

All in all, stouts are flavourful and satisfying beers that are easily distinguished from other styles because of its dark appearance, given principally by the roasted malts. Apart from their appearance, the use of this type of malts gives them a flavour making it differential and unique, loved for all those enthusiasts who enjoy living new experiences trying and enjoying new creations every day.

3. KOM's project

To know the best way to proceed and analyse the company it is necessary to understand their history and the goals of the company. Moreover, although in the previous chapter it has been explained the typical process of crafting beer it is necessary to make a deeper study of the process at KOM's factory, since it has been adapted to the current available resources and it is slightly different. This understanding of the process will help understand the implied costs of production, both direct and indirect, to it.

3.1 KOM history

KOM beer is a project that was born in 2019 by a group of three friends, called Aleix, Albert and Adrià. They are passionate about craft beer, specially NEIPA's and decided to start cooking their first beers at home, converting them into homebrewers.

After experimenting with many combinations of hops in whirlpool, dry hop, malts, water profiles, yeasts, fermentation processes, etc. they decided to take the challenge to share their creations with everybody and run their business in a small factory in Manlleu.

Since their creation, more than 15 different beers have been created in their brewery, each of them with a unique flavour and aroma, making it special and different from the others. This is one of the main characteristics of KOM beer: to produce in small quantities making exclusive beer and allowing them to have a greater rotation of beers. In turn, this is key to let them experiment and improve in each cooking until a point in which it is guaranteed the maximum quality and freshness in each of their creations.

Since it has been explained that they have created more than 30 different beers, one could think that they work with all kinds of technics and employing different types of yeasts and hops, but this is not the case since they have specialized in IPAs, specially NEIPAs, although they have also tried to craft special beers, including fruity beers.

3.2 Process at KOM

As mentioned previously, the process of creating craft beer is not simple, indeed one has to be really accurate and follow all the steps precisely to acquire the desired results. And this is what they try to do at KOM.

Previously in this project, it has been explained the general process of the beer crafting industry, but in order to optimize resources and existing machinery, the process at KOM has been slightly modified and in this section, it will be explained in detail.

3.2.1 Malt and milling

The brewing process begins with raw barley, wheat, oats, or rye, that is germinated in a malt house. To do so, the grain is immersed in water at 12 to 15ºC. It is important that, when the grain is collected, it has less than 12% moisture. With higher moisture content, there is a huge exposure to fungal and insect problems. Once the grain is into water, it starts to increase its volume and moisture content. When achieved 125% and 45% of each respectively, it is ready for the next step. It usually takes from 40 to 50 hours.

Right after that, the grain is dried in a kiln, even sometimes it is roasted to achieve different beer profiles. By doing this step, it is easier to crack the husks of the grain, allowing them to have a higher level of exposure of their starches (sugars) during the mashing process.

After killing, the malt is milled, known as grist, for a better efficiency when mixed with water. The objective of this procedure is to retain the husk relatively intact while breaking up the brittle, modified starch into particles.

3.2.2 Mashing

The grist is then transferred to the mash tun. There, it is mixed with water, creating a liquid solution called wort, which will be in constantly recirculating through a closed circuit with the help of an electric motor, for about one or two hours at temperatures between 40 and 80ºC.

By doing so, the idyllic conditions are met for starch, enzymes, and other molecules to break down, converting them into sugars, which will eventually become alcohol. In some cases, temperatures are increased, allowing to activate and develop different enzymes and affect the release of proteins and fermentable sugars.

For heating the wort, steam is used, and temperatures may vary depending on the type of enzymes that are decided to be activated, always considering the final beer profile and characteristics that are wanted to be obtained.

Figure 3.1 & 3.2. *Heating deposit and mash tune with the filtering membrane*

At the bottom of figure 3.1, it can be seen the heating deposit, in which the osmotic water is heated up to temperature close to the heating point, but not reaching it. The deposit has a capacity of 1000 litres, which takes up to 3 to 4 hours to heat up.

The mash tune is the silvered container where the water is mixed with the wort. In figure 3.2, the filtering plate can be observed. In reality, when the process is done, there are four plates, with different hole sizes, each of them in charge of ridding of particles from different sizes.

In both pictures there are seen red hoses which are used to transfer the liquids (water, wort, etc.) from one recipient to another.

3.2.3 Filtration

Once the wort has recirculated for the required time, the mash tun is fitted with a false base containing precisely machined slots small enough through which the husks of the grain cannot pass.

Filtering consists in three principal steps, called mash out, recirculation and sparging. The mash out process consists of a latter increment of the temperature slightly over 80ºC, which stops enzymatic reactions and preserves the fermentable sugar profile of the wort, making it less viscous and easier to work with.

The recirculation process consists of making use of the electric motor to recirculate the wort that is drawn out from the bottom of the mash tun. Each time the wort is filtered more quantity of husk is trapped, thus forming a filter bed that removes the solid of the word as it is drained.

Lastly, sparging is the process of rinsing the used grain with heated water, usually at about 80ºC, to get as much of the sugars as possible, from the remaining grain of the wort. Usually, the solid residue is then thrown away, but in KOM's case, it is given to a local farmer, in exchange for some of his products, such as eggs, milk, vegetables, etc.

Figure 3.3. *Motor used to pump the wort into the recirculation circuit, also seen in the picture*

Figure 3.4. Distribution of the different instruments used in the first stage of the brewing process at KOM factory

3.2.4 Boiling and cooling

Once the filtering process is completed, the wort is transferred to a vessel, called kettle, with the help of the same electric motor. During the boiling process, which typically lasts from one to two hours, the wort is sterilized, and the enzymatic activity is stopped. In addition, undesirables aromas evaporate, and insoluble proteins precipitate.

At the boiling stage things can become different depending on the style of beer being created, as the time when hops are added can vary, leading to different beer profiles. The earlier the addition of hops, the more bitterness the beer is. Latter hops are added to give special flavour and/or aroma to the beer. Indeed, in later stages when boiling has ended, more hops can be added in the whirlpool process.

Whirlpool is the process to separate hop particles and trub, which is the junk formed in the boiling vessel, from the wort before transferring it to the fermenter. The process, as its name indicates, consists of creating a whirlpool in the wort, which in their case is created using the electric motor, by pumping the wort into the vessel at an angle that encourages the wort to spin as if being stirred.

Later, the wort is cooled with the help of a plate heat exchanger, which is an enclosed vessel in which the wort goes through the plates, while in the other direction and in the other side of the plates cold water flows. Once the wort is sufficiently cold, it is transferred to the fermentation vessel.

Figure 3.5 & 3.6. *Kettle where the wort is boiled & entrance of the gas*

3.2.5 Fermentation

In this stage, which is the most important one of the brewing processes, the simple sugars of the wort are converted into alcohol and carbon dioxide, creating what is called the green beer (early stages of the fermentation).

Fermentation of sugars is carried out by yeast, which is added to wort at a rate of 0.3 to 0.4 kilograms of yeast per hectolitre of wort. Once the yeast has been pitched at the proper temperature and the fermentation has started, the beer remains untouched at the fermentation vessel for a period that may vary between two and four weeks.

During all the process, it is significant to consider that the mixture has to remain at a desired temperature, usually around 2ºC. In their factory, KOM employees control the wort temperature by recirculation of cold liquid through a closed circuit, in jackets fitted inside the wall of the vessel. Moreover, during this large stage, it is of huge importance to take periodic reviews to the beer, checking that everything is following the desired path and that it has not spoiled.

Figure 3.7 & 3.8. *Non-adiabatic 1500 litres fermenters (conical on the left and flat on the right)*

3.2.6 Filtering

Once the fermentation process has ended, the beer is transferred to a closed circuit that recirculates it through a filtration medium to remove any remaining particles or yeast that may affect the beer's appearance, flavour, or stability.

In KOM's case, this process consists of pumping the beer from the vessel to a closed circuit consisting of nine plates. The filtration is done through small particles of sand that retain the remaining particles that could still be in the beer.

It is important to do this process at a temperature between 0 to 5ºC to facilitate the filtration process, which will give the beer a clearer appearance and a higher stability over time. This process is typically done with lagers, so in KOM's case the filtering process is only experienced by one of their creations, 'Malhivern', which is the most similar to the mass-produced ones.

Figure 3.9. *Filtering machine used in KOM. Source [9]*

3.2.7 Conditioning

This stage is not done in all of their creations. In KOM's factory, there are two different types of fermenters, adiabatic and non-adiabatic. In the adiabatic fermenters, the fermentation process is done at a higher pressure than the atmospheric one. By doing so, the beer is not in contact with the oxygen at any point, providing fewer risks of the beer being spoiled. Moreover, it allows to carbonate the beer inside the same fermenter, without the need of changing it to another vessel.

On the other hand, the non-adiabatic fermenter does not allow carbonating the beer, since as it is at the same pressure as outside, all the inserted gas would be able to go out of the vessel and therefore the beer would not be carbonated.

For this reason, all beers fermented in a non-adiabatic fermenter are then transferred to a secondary vessel, which allows the beer to be carbonated. Moreover, these few days that the beer rests into it, allows to further develop the flavour and aroma of the beer.

Figure 3.10. *Secondary vessel where beer is carbonated*

3.2.8 Carbonation

It is the latter stage before the bottling. It consists in injecting small bubbles of carbon dioxide until the beer reaches the desired pressure. At this stage, they sometimes add nutrients and clarifiers that help to degrade the small amounts of proteins that could still be in the beer. By doing so, the carbonation process can be reduced.

Although once the carbonation process is finished the beer should be ready to bottle and sell, right before sending to them to their clients, they check that the pressure is at the optimal value by adding or subtracting small quantities of carbon dioxide, which indicates that the beer is at their optimal point to be consumed and enjoyed.

Figure 3.11. *Motor used to transfer wort from one container to another*

Figure 3.12. *Carbonation bottles used to add gas to the beer*

3.2.9 Bottling

Regarding their prevision of sales, once the beer is ready to be bottled, they have three different methods to pack them: bottle, canning, key-kegging. Indeed, only one of their creations is bottled, the rest is only sold canned or in key-kegs.

The process of bottling the beer is doing from the fermenter itself, and it is possible through a plastic cable with a hole in the middle that ends up with a hydraulic pistol. The process is still a little antiquated, and it is for sure the most exhausting and time-consuming of the whole process (from those that request human activity).

Using the previously mentioned technique allows them to package the beer without being in contact with oxygen at any time, which would be highly risky to get spoiled.

Figure 3.13 & 3.14. *Cannular machine to bottle cans*

Figure 3.15. *Bottling machine used to fill and pack bottles*

3.2.10 Labelling

Once the beer is ready to be consumed, filled, and packed in the corresponding container, it is then labelled using stickers that are designed by the own KOM partners. For each different beer produced, a sticker is created.

The machine used is manual, similar to the Cannular machine used to seal the can, in which each product (can or bottle) needs to be labelled one by one.

Moreover, depending on the type of product being labelled, the machine needs to be manually configured in a specified position, making it a really slow process.

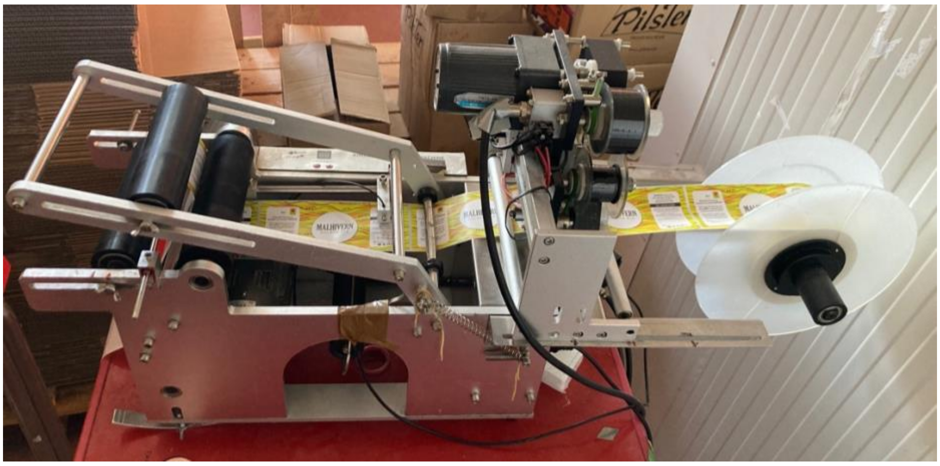


Figure 3.16. *Labelling machine*

Later on, once the final product is ready to be sold, it is kept into a fridge to the desired consuming temperature until the distributor or the client comes to the factory to pick it up for its distribution or consumption.

Figure 3.17. *Fridge where packed beer rests until the distributor picks it up*

3.2.11 Cleaning up

After concluding a brewing process, all the material and machinery involved in it needs to be cleaned up, in order to be ready to use in the next brewing process. Moreover, it is important to use disinfectant liquid, which is mixed with water, to get rid of any contaminant, such as bacteria, yeast, chemical residues, from the production of beer.

Since, as explained throughout the whole document, for artisanal beers it is essential to achieve in the maximum level of precision the desired profile and characteristics, any residue left from previous batches can introduce unwanted elements into the next brew, affecting the flavour, aroma, and overall characteristics of the beer.


Figure 3.18 & 3.19. *Container where the mixture between disinfectant and water is heated up*

4. Cost calculation system

One of the main objectives of this project is to analyse the productive process of creating the craft beer to understand and identify all the costs related with this process. In the previous chapter, an exhaustive study of the beer process has been done.

Regarding the nature of the project, in this section an explanation of all the cost related with the production of the beer will be done, as well as providing a solution to the problem they are facing in KOM's factory: although they have an approximation, they do not know the real price of the beer they produce, and they do not dispose of an intuitive and easy-to-use tool to calculate it.

4.1 Description of the problem

As mentioned in KOM history chapter, the company was born last year, and since then they have produced lots of beer, leaving a bit aside the accounting part of the company. Although they have an approximation, they do not know with precision the real price of the beer they produce.

This fact is explained because the high amount of work that requires to produce and distribute the beer, which does not allow any of the three partners to take care of the economic activity.

For this reason, it is intended to create an intuitive and easy-to-use tool which does not demand highly amount of time for helping them to calculate accurately and considering every single step taken in the craft process to calculate the final price of the beer.

This part of the project has involved going several days to their business to understand the whole process and discuss with them which is the best tool to solve this problem. Foremost, a description of all the costs, since the raw material arrives to the factory until the client gets the product, is done, for a better understanding of the final solution.

4.2 Description of the costs

As explained previously, the process of making beer is neither easy nor fast. Therefore, there are lots of costs that one could even not think of related to the process. Moreover, the fact of creating many different types of beers hinders the task of finding the optimal tool to solve their problem.

For this reason, distributing the costs by their typology helps to understand the dimensions of the problem and reduce the possible tools to solve it.

4.2.1 Production costs

All costs directly related with the production of the beer are included in this section. They count for the majority of the costs and imply the higher percentage in the total cost of the beer. In the list below, all the cost related with the ingredients are shown.

1. Grain

The grain is bought when it is already cracked and milled, being ready to be mixed with water and create the wort. This implies a higher price with respect to the raw grain, but there is no need to have a kiln nor a malt miller.

2. Hops

It is the key ingredient of the process. There exist lots of different types of hops, implying a wide range of prices. So, depending on the type or types of hops used, the price may vary.

3. Osmotic water

It is the water used to produce the beer. Using this type of water, which has suffered a purification process to remove impurities and contaminants from the water coming from the distribution network, allows them to fully control the final profile of the beer.

Although water from the distribution network could be used and would be cheaper, KOM's partners want a level of excellence in all of their products that could not be achieved using this type of water.

4. Yeast

It is the most expensive ingredient from the whole process. There are used different types of yeast depending on the beer. Since it is used in small quantities, it does not imply a huge increment in the final cost of the beer.

5. Additives

Since the water used to craft the beer is as neutral as possible, some additives may be added to the creation, allowing the crafter to fully control all the aspects of the beer.

6. Nutrients & Clarifying

They are added in the last period of the fermentation process and are used to help to remove impurities and haze-forming proteins particles from the beer. In some of their creations, they do not use them.

4.2.2 Indirect costs of production

In this section are encompassed all costs indirectly related with the production, meaning that exist because of the final product but are not visible nor tangible on it. Consequently, this list includes a wide range of activities and their implied costs.

1. Cleaning up

Once one craft process has finished, in order to start the following one, all the vessels used and the material used to transfer the beer from one vessel to another, or to fill the bottles up, etc. has to be properly cleaned with the required products.

2. Packaging

In this subsection all costs related to the packaging, from key-kegs to bottles and cans are included, making a distinction between the different types of packaging options. Moreover, the stickers are also contemplated.

3. Filtering

Although this cost will be just computed for one of their beers, it is also included. This cost relates to the filtering process of the beer when it is already finished to be packed. This process is done through very small particles of sand.

4. Carbonation

Since some fermenting vessels are not adiabatic, the beer needs to be carbonated once it has fermented. For this reason, an average of half a bottle is used every time a beer is produced.

5. Alcohol tax

In Spain, there exist an alcohol tax which is applied to all alcoholic beverages, including beers. Depending on the alcohol content the amount to pay may vary, but for the style of beer produced in KOM's factory the rate is of 0.1€ per litre sold.

6. Labour force

The labour force is one important cost to reflect on the price. Until today there are only three workers in the factory, which are the partners themselves, but regarding their rapidly growth, the workforce will increase very soon.

It is important to make a distinction between the different types of packaging since the time required by the workforce for each of them is completely different. Therefore, the total price of packaging will not be only the mentioned in point 3 of this same section, but also considering the workforce.

4.2.3 Monthly costs

Apart from the mentioned costs, there exists a list of indirect costs related to the production of beer, that are computed monthly or bimonthly. Similar to the indirect costs of production, these types of costs do not vary abruptly from one period to another.

1. Water

It is the cost related to the use of water coming from the network distribution. Basically, the usage of this water comes in the cleaning up process.

2. Electricity

From the monthly costs, it is the most expensive one. Used for lots of activities of the process, such as powering up the motors, lighting the whole factory or maintaining the fridge at the proper temperature for the beer to rest.

3. Gas

The gas in the beer production is used in the boiling process, because when the wort is in the kettle, it is heated up by burning gas.

4. Rent

The KOM factory in Manlleu, in which all of their creations are made is a renting space, therefore it accounts for the monthly expenditures.

5. Stickers design

For all of their creations, a particular sticker is designed. Although the price is not high because a friend of them do it, it should be considered in the final price of the beer.

6. Extra costs

The production of beer is not optimal and therefore some extra costs, which can be different every month, need to be considered. The extra costs could be from machine maintenance to required material for a specific task, such as bridles, wrenches, etc.

All the mentioned costs in this section will be equally distributed to the total number of creations during that period. A period will consist of two natural months since each gas invoice accounts for such a period.

Since all the beers will require from all the mentioned costs, it is extremely difficult to determine the quantity of the cost that can be attributed to each of them. Therefore, it has been established, together with KOM's partners, that all cost would have the same weight to all the beers created in a period.

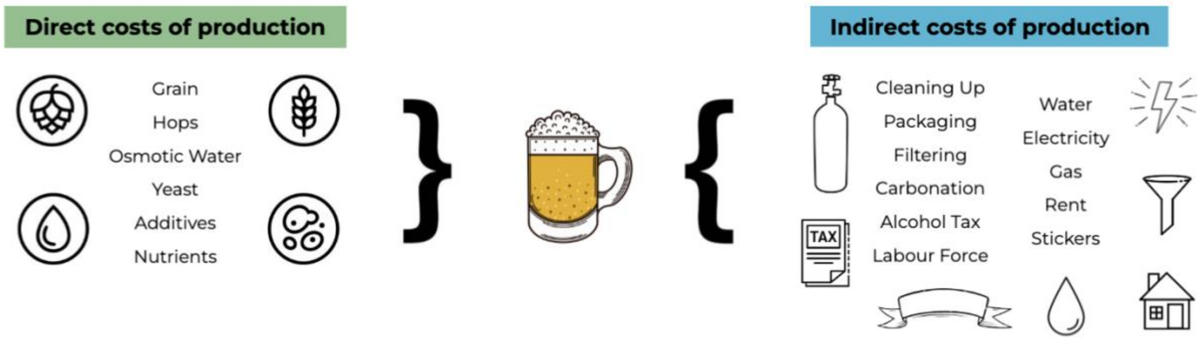


Figure 4.1. *Representation of the different costs related to the production of beer. Source [7]*

4.3 Alternatives for solving the problem

Once a breakdown of costs has been made, it is time to understand and analyse the possible solutions to attack the problem, which was to find the adequate tool such that it allows to accurately calculate the cost of the beer produced.

Alternative 1

The first alternative was to create a template using the Excel Spreadsheet that could be used for any of the beers. This alternative consists of considering all the costs mentioned in the previous section and divide them by the total number of litres produced.

Excel is a program they have used previously which would not imply any requirement for them to use. Moreover, the template is thought to be intuitive and ready to be filled quickly.

Alternative 2

The second alternative consists of using a program specialized for the calculation of costs in the brewing industry, called Probirra, which was created by the former owners of the factory. It is based on introducing the quantities of the row materials used for the brewage process and the final price of the production is calculated.

The problem with this alternative was that it uses a very specific software that it takes time to get used to it. Although it may seem more professional because it is a special program for this particular industry, the initial template only studies the production costs, without considering the indirect costs.

Hence, it would get some time both for me to adapt the existing template and both for KOM's crew to get used to it.

Table 4.1. *Comparison between Alternative 1 & 2 main characteristics*

	Easy-to-use	Intuitive	Quick
Alternative 1			
Alternative 2			

Bearing in mind the aspects mentioned previously, it was decided to adopt the first alternative and create a template using the Excel Spreadsheet, which allowed to finish the first part of the project quickly and continue through the next steps.

In the following section, an explanation of the template will be done, paying deep attention to the calculations behind each of the steps involved in the path to achieve the final price of the beer.

4.4 Solution (Excel Spreadsheet)

The Excel sheet template consists of two sub sheets, one for the costs that are equally distributed to all the beers, which have been named as 'Monthly costs' and the other one for the remaining costs.

The template is thought to be used one for a period of two months, consisting of a total of six sheets in a natural year. This is an adequate way to have the information well-structured and to be able to quickly revise previous registered beers.

The duration of each period is mainly due to the arrival of the gas invoices, each of them taking a period of two natural months.

The other studied alternative, was to create a sheet for every month, computing the gas cost as half of the total cost per each month. This would allow having a better tracking of each creation. However, this would imply having twelve different sheets per year as well as not having the exact price until the invoice arrives, which would be one month later. For this reason, it was decided to stablish a period of two months.

Moreover, the created tool allows not only to check the final price of the beer, but it is also useful as a receipt historical book, since every time a new receipt is introduced in the template, it is required to register all the quantities of raw materials used to properly calculate the final price.

Although the achieved solution is an excellent way to store the most relevant information of each beer, it requires some time and attention for the user part to gather the information that has to be written in the template. This basically implies the receival of the invoices by email.

For internal reasons, the calculation of costs is to be done without taking into consideration the taxes, which in KOM's case is only the VAT (Value Added Tax).

All in all, the created template will help KOM to have a much more structured and organized tool to record all of their secret receipts and also to calculate in detail the final price of each beer.

4.4.1 Common template

In Sheet 1 there is a description of what are called 'Monthly costs'. It is shared among all the beers created in that period, since the costs included in the template affect in equal manner the final cost of all the beers produced in that period of time.

Figure 4.2 shows the appearance of this part of the work, where all the costs mentioned in the 'Monthly costs' section of the previous chapter are included. Apart from a description of the previously mentioned cost, there is a space for the beer production in that period. In there, it will be written the total number of beers produced in each month of that period.

Periode:
Nom cerveses:
Observacions:

Despeses Indirectes							
Aigua		Electricitat		Lloguer		Disseny Etiquetes	
Mes	€	Mes	€	Mes	€	Mes	€
Gener		Gener		Gener		Gener	
Febrer		Febrer		Febrer		Febrer	
Total Aigua	0	Total Electricitat	0	Total Lloguer	0	Total Disseny	0
Gas		Extres		Producció Cervesa		Total	
Mesos	€	Mes	€	Mes	Número	Mesos	Total Extres
Gener & Febrer		Gener		Gener		Gener & Febrer	0
		Febrer		Febrer		# Cerveses Produïdes	0
Total Gas	0						
		Total Extres	0	Total Cerveses	0	Cost extra per cervesa	#DIV/0!

Figure 4.2. *Sheet 1 of the cost calculation template*

To fill Sheet 1 is necessary to collect and review the invoices for the specified costs, which in KOM's case are received by e-mail. Then, the amount in € is written at its corresponding place, in order to calculate the addition of the total monthly costs to each of the produced beers.

Different from the other sub-regions, the one called 'Beer Production' works as an accounting for the number of times that beer has been produced in the mentioned period. It does not refer to the specific litres obtained from a brewing process, nor the number of different beers produced in that period. The section refers to the sum of times that the brewing process explained in previous sections has been repeated through the period.

Lastly, in the bottom-right space, called 'Total' a sum of each of the individual monthly costs computed in their respective sections is done, in order to be able to divide it by the total number of different beers produced that period and to obtain the final cost that should be added to each creation from this ‘Indirect Monthly Costs’ section.

$$Monthly\ cost\ per\ beer = \frac{\sum Individual\ Monthly\ Costs}{\sum Beers\ produced}$$

4.4.2 Individual template

The second sheet of the template is where the receipt is to be written and therefore it could be revisited in any moment, in case of replicating it or revising some ingredients used.

Similar to the previous sheet, it consists of an itemization of the different cost related with the production, both the raw material and the indirect costs of production. It consists of a much heavier paper, considering any possible combination of ingredients and packaging procedure.

In the upper part of the table, there are included three lines to add some relevant data of the cooking process:

1. Exact day of beer production: it allows to have a structured method to organize the information related with the beer production, also allowing to maintain the order of production followed in a period of time.

2. Name of the beer: for all the new creations, KOM’s partners choose a witty name that tries to reference and describe the thoughts the beer remembers of when drinking it. Usually, the given names try to incorporate the beer’s name brand, such as KOMfitura or KOMstel·lació.

3. Observations: to have a track and register all the incidents or relevant information that is not written in the receipt, there is a space to write down characteristics of the beer, problems in the crafting process, if any special step in the process has been added, usage of special and unusual ingredients, etc.

Following the space in which relevant information of the beer is written, there is the template itself, consisting of three main columns that separate the different remaining costs, giving to each of them a different colour to clearly differentiate each of them.

1. Production costs. Costs related to the production of the beer. Inside each of the subgroups composing the column, there are specified different types of the main ingredient. To create different beer profiles and flavours, different ingredients need to be used.

2. Indirect costs of production. As explained previously in this paper, all costs related with the production or post-production of the beer that do not belong to the raw materials, such as cleaning, packaging, are included here.

The subsection ‘Packaging Costs’ shows the four different packaging options, as well as the money invested in each of the options.

3. Work force costs. Before the start of this project, the beers sold from KOM’s factory did not reflect the long journeys spent on the factory by their partners, and this was something they wanted to consider when establishing the price in the future. Therefore, a column regarding this information has been added in the template.

It is important to notice that there has been established a differentiation between packaging and the other functions of the beer production. This is because there is a huge difference in packaging time depending on the product: due to the machinery available, it takes much more time to package the same quantity of beer in cans that packaging in key-kegs or bottles. Therefore, the packaging price of the can has to be higher than the other products.

4. Addition of costs. A final table with the addition of all the costs is added, which shows the sum of the final price per litre, as well as the cost of each of the four available products.

5. Percentages. In this section a description of the weight that each of the products/tasks have to the final price of the beer is computed, helping the user to analyse where further improvements in the production line can be done in order to reduce the final cost of the product, always without sacrificing the excellence of the beer.

Data:
Nom cervesa:
Observacions:

KOM BEER

Cost Producció

Gra

Tipus	Kg	€/Kg	€
Caramalt		1,34	0
Crystal T50		1,34	0
Dextrin Malt		1,31	0
Extra Pale Ale Malt		1,35	0
Flocs de blat		1,33	0
Flocs de civada		1,41	0
Golden Naked Oats		1,62	0
Low Colour Golden		1,41	0
Malta de blat		1,5	0
Malta de civada		1,41	0
Roasted Barley		1,27	0
Total Gra			0

Llúpol

Tipus	Kg	€/Kg	€
Cascade		22,3	0
Centennial		27,7	0
Citra T90		35,24	0
Citra Cryo		71,7	0
HBC 630		31,6	0
Idaho T90		32,3	0
Idaho Cryo		73,7	0
Mosaic T90		34,1	0
Mosaic Cryo		70,5	0
Motueka		42,5	0
Nelson Sauvin		43,7	0
Nugget		20,6	0
Riwaka		59	0
Simcoe T90		33,9	0
Simcoe Cryo		66,2	0
Strata		38,7	0
Zappa		41,4	0
Total Llúpol			0

Aigua (Osmotitzada)

Tipus	Kg	€/Kg	€
Mash		0,0719	0
Sparge		0,0719	0
Total Aigua			0

Llevat

Tipus	Kg	€/Kg	€
AEB New England		94,08	0
Bry 97		146	0
Essential Ale		76	0
Philly Sour		234	0
Verdant		208	0
Verdant New England		208	0
Windsor		154	0
Total Llevat			0

Additius

Tipus	Kg	€/Kg	€
Àcid Fosfòric		7,5	
Bicarbonat de sodi			
Clorur de calci		1,02	
Epsom (Sulfat de magnesi)		2,83	
Gypsum		2,83	
Sal (Supermercat)		1,25	
Total Additius			0

Nutrients & Clarificants

Tipus	g	€/Kg	€
Clarex		168	0
Clarificant Algues		15	0
Total Nutrients			0

Cost Neteja

Tipus	Kg	€/Kg	€
Sosa (Deptal)		3,05	0
Àcid Paracètic		2,97	0
Total Neteja			0

Cost Envasat

Ampolla

Tipus	Units	€/unit	€
Ampolla		0,25	0
Etiquetes		0,12	0
Total Envas Ampolla			0
Preu Unitari Ampolla			0,4

Llauna

Tipus	Units	€/unit	€
Llauna		0,25	0
Etiquetes		0,12	0
Total Envas Llauna			0
Preu Unitari Llauna			0,4

KeyKeg 20L

Tipus	Units	€/unit	€
KK 20		16,29	0
Etiquetes		0,12	0
Total Envas KK20			0
Preu Unitari KK20			16,41

KeyKeg 30L

Tipus	Units	€/unit	€
KK 30		17,5	0
Etiquetes		0,12	0
Total Envas KK30			0
Preu Unitari KK30			17,62
Total Envasat			0

Cost Filtratge

Enoquímia

Tipus	Kg	€/Kg	€
Sorra		1,95	0
Total Filtratge			0

Cost Carbonatació

Tipus	Bombona	€/Bombona	€
CO2		42,83	0
Total Carbonització			0

Impost Alcohol

Litres Produïts	1200
Impost Alcohol	120

Costos Indirectes

Total

Mesos	Total Extres
Gener & Febrer	0
# Cerveses Produïdes	0
Cost extra per cervesa	#DIV/0!

Cost Operaris

Resum Preparació & Producció

Procés	# treballadors	h	€/h	€
Preparació				0
Mash				0
Sparge				0
Boiling				0
Fermentació				0
Filtratge				0
Neteja				0
Revisió CO2				0
Preparació Lots				0
Oficina				0
Total Preparació				0

Resum Envasat

Tipus	# treballadors	h	€/h	€
Ampolla				0
Llauna				0
KK20				0
KK30				0
Total Envasat				0

Cost Total

Resum Costos

Litres Produïts	1200
Cost Ingredients	0
Cost Indirecte Total	#DIV/0!
Cost Total Per Litre	#DIV/0!
Cost Total Ampolla	#DIV/0!
Cost Total Llauna	#DIV/0!
Cost Total KK20	#DIV/0!
Cost Total KK30	#DIV/0!

Percentatges

Producció

Gra	#DIV/0!
Llúpol	#DIV/0!
Aigua Osmotitzada	#DIV/0!
Llevat	#DIV/0!
Additius	#DIV/0!
Nutrients & Clarificants	#DIV/0!

Preu Total Producció (Directe + Indirecte)

Producció	#DIV/0!
Neteja	#DIV/0!
Filtratge	#DIV/0!
Carbonatació	#DIV/0!
Impostos	#DIV/0!
Costs Indirectes Mensuals	#DIV/0!
Operaris Producció	#DIV/0!

Preu Total Producte

Ampolla	
Cost Ampolla Unitari	#DIV/0!
Cervesa	#DIV/0!
Envasament	#DIV/0!
Llauna	
Cost Llauna Unitari	#DIV/0!
Cervesa	#DIV/0!
Envasament	#DIV/0!
KK20	
Cost Llauna Unitari	#DIV/0!
Cervesa	#DIV/0!
Envasament	#DIV/0!

Figure 4.3. *Sheet 2 of the cost calculation template*

4.5 Operability of the solution

The code behind the template follows the same procedure for the different costs. It consists of multiplying the second sub-column (units) by the third (price per unit), and the result is obtained at the fourth column (price).

For each subsection, for example grain or hops, the addition of the specific ingredient/task is added at the last line of the subsection, named ‘Total (name of the ingredient/task)’.

The section called ‘Indirect Costs’ is linked with the addition of indirect costs calculated in Sheet 1, which allows to be added to the final cost of the beer.

When all quantities have been written in the template, an addition is computed in the yellow part of the chart, called ‘Total Costs’. In there, there is an accurate description of the total cost of the produced litre of beer, as well as the cost of each of the products they have in stock: bottle, can, and key kegs of 20 and 30 litres.

The calculation procedure behind the production process is as follows:

$$Cost\ of\ an\ ingredient = Units \cdot \frac{Price}{Unit}$$

$$Production\ Costs = \sum Individual\ Ingredient\ Costs$$

The same procedure applies for the calculation of the remaining costs, in which the units will change accordingly to the nature of the task.

To calculate the final price of each of the packaging options, the following process is followed:

$$Bottle\ cost = Unitary\ bottle\ price(€) + 0.33(L) \cdot \frac{Total\ Price(€)}{Litre(L)} + \frac{Bottling\ price\ (€ \cdot Units)}{Bottles\ packed\ (Units)}$$

$$Can\ cost = Unitary\ can\ price(€) + 0.44(L) \cdot \frac{Total\ Price(€)}{Litre(L)} + \frac{Canning\ price\ (€ \cdot Units)}{Cans\ packed\ (Units)}$$

$$KK20\ cost = Unitary\ KK20\ price(€) + 20(L) \cdot \frac{Total\ Price(€)}{Litre(L)} + \frac{Pack\ KK20\ price\ (€ \cdot Units)}{KK20\ packed\ (Units)}$$

$$KK30\ cost = Unitary\ KK30\ price(€) + 30(L) \cdot \frac{Total\ Price(€)}{Litre(L)} + \frac{Pack\ KK30\ price\ (€ \cdot Units)}{KK30\ packed\ (Units)}$$

Regarding the percentages section, it has been calculated the importance of each of the raw materials used in the production section to the final price of it, as shown in the example.

$$\% = \frac{Hops\ Cost}{\sum Raw\ Material\ Costs} \cdot 100$$

A similar calculation has been done in sections ‘Total Production Price’ and ‘Total Product Price’, making a distinction between each of the selling products.

4.6 Example

Periode: 01/02/2023 - 31/03/2023
Nom cerveses: Relíquia, Deliri, Komstelació, ...
Observacions: Març molt consum electricitat

KOM BEER

Despeses Indirectes

Aigua		Electricitat		Lloguer		Disseny Etiquetes	
Mes	€	Mes	€	Mes	€	Mes	€
Febrer	207,43	Febrer	256,62	Febrer	659,77	Febrer	80
Març	233,58	Març	541,29	Març	659,77	Març	70
Total Aigua	441,01	Total Electricitat	797,91	Total Lloguer	1319,54	Total Disseny	150

Gas		Extres		Producció Cervesa		Total	
Mesos	€	Mes	€	Mes	Número	Mesos	Total Extres
Febrer & Març	62,72	Febrer	30	Febrer	4	Febrer & Març	2846,18
		Març	45	Març	5	# Cerveses Produïdes	9
Total Gas	62,72						
		Total Extres	75	Total Cerveses	9	Cost extra per cervesa	316,25

Data: 27/03/2023
Nom cervesa: Haka
Observacions: DIPA 8% (Llúpol New Zealand)

KOM BEER

Cost Producció

Gra

Tipus	Kg	€/Kg	€
Caramalt		1,34	0
Crystal T50		1,34	0
Dextrin Malt		1,31	0
Extra Pale Ale Malt		1,35	0
Flocs de blat	15	1,33	19,95
Flocs de civada	64	1,41	90,24
Golden Naked Oats		1,62	0
Low Colour Golden	182	1,41	256,62
Malta de blat	30	1,5	45
Malta de civada	10	1,41	14,1
Roasted Barley		1,27	0
Total Gra			425,91

Llúpol

Tipus	Kg	€/Kg	€
Cascade		22,3	0
Centennial	0,9	27,7	24,93
Citra T90		35,24	0
Citra Cryo	0,92	71,7	65,97
HBC 630		31,6	0
Idaho T90		32,3	0
Idaho Cryo		73,7	0
Mosaic T90	4,7	34,1	160,27
Mosaic Cryo	1,48	70,5	104,34
Motueka		42,5	0
Nelson Sauvin	3,6	43,7	157,32
Nugget		20,6	0
Riwaka		59	0
Simcoe T90		33,9	0
Simcoe Cryo	0,9	66,2	59,58
Strata		38,7	0
Zappa		41,4	0
Total Llúpol			572,41

Aigua (Osmotitzada)

Tipus	Kg	€/Kg	€
Mash	844	0,0719	60,69
Sparge	444	0,0719	31,93
Total Aigua			92,62

Llevat

Tipus	Kg	€/Kg	€
AEB New England		94,08	0
Bry 97		146	0
Essential Ale		76	0
Philly Sour		234	0
Verdant	0,5	208	104
Verdant New England		208	0
Windsor		154	0
Total Llevat			104

Additius

Tipus	Kg	€/Kg	€
Àcid Fosfòric	0,6	7,5	4,5
Bicarbonat de sodi		3,5	0
Clorur de calci	0,9	1,02	0,92
Epsom (Sulfat de magnesi)	0,15	2,83	0,43
Gypsum	0,31	2,83	0,88
Sal (Supermercat)		1,25	0
Total Additius			6,73

Nutrients & Clarificants

Tipus	g	€/Kg	€
Clarex		168	0
Clarificant Algues	1,8	15	0,03
Total Nutrients			0,03

Cost Neteja

Tipus	Kg	€/Kg	€
Sosa (Deptal)	3	3,05	9,15
Àcid Paracètic	2	2,97	5,94
Total Neteja			15,09

Cost Envasat

Ampolla

Tipus	Units	€/unit	€
Ampolla		0,25	0
Etiquetes	0	0,12	0
Total Envas Ampolla			0
Preu Unitari Ampolla			0,4

Llauna

Tipus	Units	€/unit	€
Llauna	450	0,25	112,5
Etiquetes	450	0,12	54
Total Envas Llauna			166,5
Preu Unitari Llauna			0,4

KeyKeg 20L

Tipus	Units	€/unit	€
KK 20	10	16,29	162,9
Etiquetes	10	0,12	1,2
Total Envas KK20			164,1
Preu Unitari KK20			16,41

KeyKeg 30L

Tipus	Units	€/unit	€
KK 30	15	17,5	262,5
Etiquetes	15	0,12	1,8
Total Envas KK30			264,3
Preu Unitari KK30			17,62
Total Envasat			594,9

Cost Filtratge

Enoquímia

Tipus	Kg	€/Kg	€
Sorra	0	1,95	0
Total Filtratge			0

Cost Carbonatació

Tipus	Bombona	€/Bombona	€
CO2	0,5	42,83	21,42
Total Carbonització			21,42

Impost Alcohol

Litres Produïts	848
Impost Alcohol	84,8

Costos Indirectes

Total

Mesos	Total Extres
Gener & Febrer	2846,18
# Cerveses Produïdes	9
Cost extra per cervesa	316,25

Cost Operaris

Resum Preparació & Producció

Procés	# treballadors	h	€/h	€
Preparació	2	0,5	15	15
Mash	1	1	15	15
Sparge	1	1	15	15
Boiling	1	1	15	15
Fermentació	2	3	15	90
Filtratge			15	0
Neteja	1	0,75	15	11,25
Revisió CO2	2	0,5	15	15
Preparació Lots	2	0,5	15	15
Oficina	1	0,5	15	7,5
Total Preparació				198,75

Resum Envasat + Etiquetes

Tipus	# treballadors	h	€/h	€
Ampolla			15	0
Llauna	2	4	15	120
KK20	2	1	15	30
KK30	2	1,75	15	52,5
Total Envasat				202,5

Cost Total

Resum Costos

Litres Produïts	848
Cost Ingredients	1201,7
Cost Indirecte Total	636,31
Cost Total Per Litre	2,17
Cost Total Ampolla	#DIV/0!
Cost Total Llauna	1,63
Cost Total KK20	62,81
Cost Total KK30	86,22

Percentatges

Producció

Gra	35,44%
Llúpol	47,63%
Aigua Osmotitzada	7,71%
Llevat	9,38%
Additius	0,56%
Nutrients & Clarificants	0,002%

Preu Total Producció (Directe + Indirecte)

Producció	65,38%
Neteja	0,82%
Filtratge	
Carbonatació	1,17%
Impostos	4,61%
Costs Indirectes Mensuals	17,21%
Operaris Producció	10,81%

Preu Total Producte

Llauna	
Cost Llauna Unitari	24,67%
Cervesa	58,88%
Envasament	16,45%

KK20	
Cost KK20 Unitari	26,13%
Cervesa	69,10%
Envasament	4,78%

KK30	
Cost KK30 Unitari	20,44%
Cervesa	75,50%
Envasament	4,06%

Figure 4.4. *Cost calculation template example*

For a better understanding about the operability of the tool, an example of the workability of the template is provided, as well as an analysis of each section to understand and see how easy and useful its application is.

In the pictures above it is provided a real example of the usage of the Excel Sheet to calculate the price of the beer, as well as to see which stages of the brewing process require more time and energy and which are the most economically demanding, to try to reduce or optimize them to achieve lower final costs of the beer.

As explained previously, the user has to complete the table by filling the table using the monthly invoices for the corresponding sections (Sheet 1) and the receipt for the beer in Sheet 2. Moreover, an accurate estimation about the hours spent in every task need to be done in order to take worker's effort into account in the total price.

To analyse results, a deeper analysis of the percentages section is done, as it indicates which part of the process have more incidence in the final price of each product.

It is important to note that the ingredients (except from the osmotic water) are obtained at cost price, as the company that supplies them is a local company, and the owners are KOM's friends. In addition, all the raw material that is not needed immediately is kept in their own warehouse, so KOM does not have any additional holding cost.

Although the situation with raw materials seems to be idyllic, there are still some changes that could be done to even reduce its costs, as it will be seen later on.

Regarding the 'Total Production' percentage section, production represents more than half of the cost, as it was predictable, but indirect costs of production take relevant importance, indicating almost a fifth part of the total cost.

Finally, a distinction between products is made. It can be seen that the three parts that imply a cost in the final product (packaging, beer, and operator time) follow a similar pattern for the three products, but the operator time takes significant relevance in the can product, as it can be both observed in the template or at the grey column of Figure 4.5.

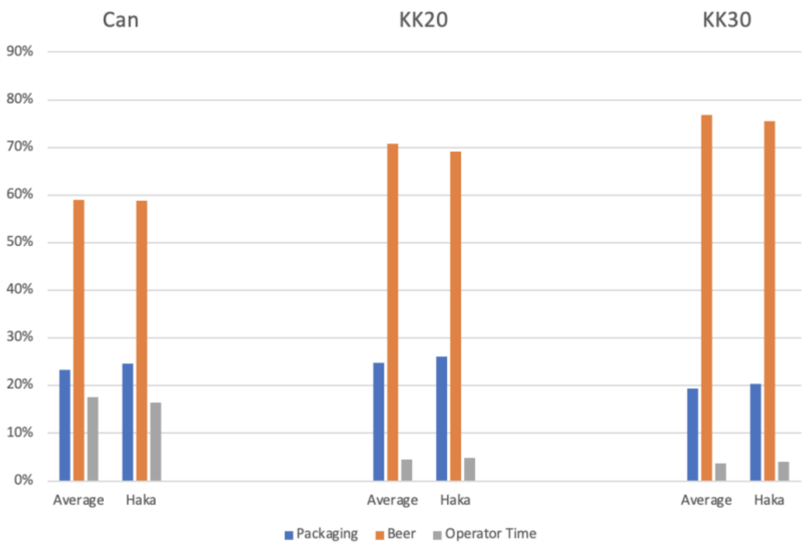


Figure 4.5. *Representation of the weight of each cost*

4.7 Analysis of the results

After a two-month period of implementation of the table in the factory and making the proper adjustments in the template so that the results obtained with previously produced beers are the expected, it was time to analyse the results and to check if some improvements could be done in the factory to reduce the final cost of the beer.

Although the results are quite good, and similar to the expected, there are still some improvements that could be done to reduce the amount of money spent on raw materials and the time required to achieve the beer.

In the example provided in the previous section, it can be seen that the process of canning beer requires highly amount of time from the workforce, which implies that a higher percentage of the beer final price comes from this situation. Indeed, in average, the percentage of the time to can and label the beer supposes around an 18% of the final price of the can, which is 4 times bigger than the other packaging options (around 4.5%). Therefore, later on a proposal will be made to try to reduce the cost of canning the beer.

Moreover, prior to this work, KOM partners were thinking of installing an industrial reverse osmotic plant to directly use the water coming from the distribution network to create the beer. This would allow them to avoid buying the osmotic water from an external company, which implies more than €100 each time that a beer is produced. For this reason, it was decided to continue with this idea and put it into practise.

It has been observed that electricity is repeatedly and by far the cost, of those that are considered indirect, that has the most weight, especially in the summer period. After days of discussion with KOM partners, it was determined that it was probably due to a poor performance of the cooling installation, which was made many years ago and has probably become obsolete.

So, after considering the conclusions from the first part of this work and together with KOM partners, also considering the economical effort of their investments, and for the purpose of this project to be as realistic and useful as possible, although some major and significant changes could be done, it was decided to analyse the following scenarios.

1. Automatic canning machine design: market research and study of the alternatives, viability study and implementation

As mentioned earlier this section, the following steps of the project consisted in doing a deep market research to analyse the alternatives to substitute the problem of time efficiency when canning beers in order to reduce the time spent and cost of the beer.

Clearly the solution comes from substituting the manual canning machine, which is nowadays being used in the factory, for another machine with a higher degree of autonomy, able to can the beer by itself.

2. Reverse osmotic industrial plant: market research, study of the existing alternatives, viability study and implementation

The second proposed improvement consists of installing a reverse osmotic plant to stop buying it from an external provider, saving more than a hundred euros each cooking day.

In this case, the task requires to analyse this market and contact with osmotic plant providers, as well as to follow up the process until the final budget is sent to KOM. Then, an analysis of different alternatives together with a viability study is to be done, to find the best option.

Finally, the installation will be done in the factory.

3. Renovation of the refrigeration equipment

The latter improvement regards the analytical study of the renovation of the refrigeration equipment, since the working ones are quite old and could not accomplish with the current regulations.

The work requires a deep understanding of the current regulations of refrigeration systems in industrial units, as well as a designing distribution for the refrigeration system to reduce electric consumption.

5. Automatic canning machine: market research and study of the alternatives

The canning process is the last step before the beer to be ready to consume and it is extremely important to do it carefully, because a beer that is not properly canned can result into a bad experience for the user.

For this reason, along with all the previous steps, the canning process plays a crucial role in the brewing industry, allowing companies to efficiently package their products while ensuring quality and preservation of the product for their consumers.

After analysing the results of the first task of this project, it can be seen that highly amount of time is invested in canning the beer, averaging a two-man twelve-hour working day each time that a beer is produced. The first person is in charge of filling up the cans one by one and the second one is responsible for canning them, with the help of the manual canning machine that is being used in the factory.

Moreover, in a recent study conducted in the factory it was concluded that from 5 to 10% of the canned beers were not properly canned and therefore they could not be sold. So, apart from the workforce costs, extra costs due to bad packing should be added.

5.1 Current canning process

Nowadays, as explained previously, the canning process is still rudimentary, requiring a high amount of time, effort, and patience to the workers. The canning process in KOM's brewery consists of three repetitive steps that need to be done for every beer.

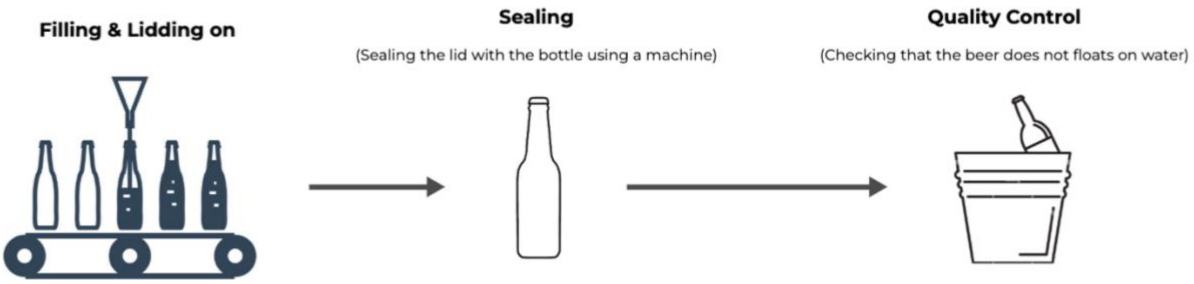


Figure 5.1. *Current canning process scheme. Source [7]*

5.1.1 Filling and lidding on

The filling and seaming process involves accurately dispensing the beer into cans with the help of a hydraulic gun. For this part of the process, it is essential to fully fill the cans so that there is no oxygen left in the container. Once the can is filled up, the lid is put on top, ensuring that there is no oxygen left in the can.

Regarding both tasks, it is important that the beer does not contact anything from the exterior, because it could get spoiled. Therefore, paying attention is key to prevent and reduce the percentage of beers that cannot be sold.

5.1.2 Sealing

The sealing process consists in introducing the can with the lid on the top into the canning machine, which through a semi-automatic process seals the can. Sometimes, even once the can is sealed, there are some leaks, and the sealing process is repeated.

5.1.3 Quality control

Once the beer is sealed, it is introduced into a plastic bucket filled up with water. This latter stage is done to control if there is any oxygen left in the can. If the can floats, it means that there remains enough quantity of oxygen in the can and the beer cannot be sold. On the other hand, if the beer sink onto the water, it means that it is ready to be packed and sold.

5.2 Current canning machine

The current canning machine is a semi-automatic model called Cannular from an Australian company specialized in the brewing industry, called KegLand.

Cannular is easy to use but requires the attention of the worker all the time, since the person is the one in charge of preparing the can and turn on the machine.

Figure 5.2. *Canning machine current model. Source [21]*

5.2.1 Machine description and characteristics

Cannular is a popular canning machine designed specifically for small-scale breweries and homebrewers. It is semi-automatic, as some manual intervention is needed during the process. As it can be seen in figure x, the metallic stem is adjustable, able to accommodate a range of cans, sizing from 330 ml to 500 ml, which allows flexibility for different beer packing requirements.

Its operability is really easy, it just consists in introducing the can full of beer with the tape on top to the slot between the base of the machine and the head, which has 3 different endings depending on the size of the can. Later, some force must be applied by rotating the arm to the left, making the stem to go upwards. By doing so, the beer is fixed.

Finally, a button located on the right side of the exterior case is pushed, and the can starts to turn until it is fixed and sealed with the tape. This procedure is done thanks to a metallic tab that puts pressure on the tape to seal it with the can. The whole process of sealing a can takes about three to five seconds. However, the process of filling up the can, sealing it and proving that the seal has correctly been done is quite larger, allowing to produce about 3 cans per minute.

It is important to mention that although it is a heavy machine, the small size makes it the ideal choice for small breweries with limited space and small production rates. The current price of the machine is €722.

5.3 Study of the alternatives

The main requirement for the machine substituting the current one needs at least to produce at least 10 cans per minute. In order to find the idyllic solution, market research has been done.

By analysing the current market alternatives, it was seen that not many options fitted the requirements, in terms of space, canning rhythm and budget. Moreover, it has to be considered that it is a specific and small market and not many options will be available.

So, after an analysis of the top-leading companies in the canning market, three alternatives were chosen. First, the three alternatives will be presented, pointing out the advantages and drawbacks of each of them, as well as mentioning the characteristics. From this study, the best alternative will be chosen, and a viability study is to be done.

5.3.1 The Mancos – Twin Monkeys

The Mancos is a medium range machine from the American company Twin Monkeys, which are highly specialized in offering innovative and customizable solutions for breweries of various sizes. Their focus on user-friendly interfaces and commitment to customer sets them apart in the market.

Able to fill and seal between 10 and 15 cans per minute, depending on the can size, The Mancos is top one in the market providing a canning system for more different can dimension. No other machine is available for canning such a different number of can size in a single machine.

Furthermore, The Mancos is a compact machine not heavier than 115 kg occupying 1.5 meter of length and 0.9 of width, adjusting perfectly to the dimensions of the factory.

On the other hand, The Mancos is a single machine that does not allow for future expansion, and since it is not fully automatized some manual work is required in the canning process.

The price of this machine is $29.500.

Figure 5.3. *The Mancos canning machine. Source [22]*

5.3.2 Gosling 2.0 – Wild Goose Filling

Able to produce between 10 and 12 cans per minute, Gosling 2.0 is an automated canning system designed for packing and maintaining the quality of small product volumes from tank or keg. The American company is specialized in crating ideal machines for entry-level beverage, as is the case of Gosling 2.0.

The system incorporates a patented seaming and filling technology to deliver a superior consistency typical of higher speed machines. With the ability to accommodate multiple can heights and carbonated or non-carbonated beverages, Gosling 2.0 gives the professional packaging and flexibility needed.

In addition, the machine is a fully automated canning system as a centralized interface allows a comprehensive control and monitoring of the entire canning process thanks to the screen display incorporated in the design. In addition, Gosling 2.0 has a modular design that allows for scalability and future expansion.

Although having a high level of automatization, due to the screen display, it is necessary to introduce the cans in the designed slot for such purpose. So, it requires from manual task to be done.

The price of the Gosling 2.0 is $27.500.

Figure 5.4. *Gosling 2.0 canning machine. Source [23]*

Gosling 2.0 is a machine able to deliver up to 12 cans per minute, which functioning is as simple as introducing the can through the metallic corridor inside the machine, which is filled and sealed in a single line and leaves the machine through the transparent hole of the left hand-site part of the structure.

To make the process less manual, some additions can be added on the right part of the structure, which include a sensor to detect when a can needs to enter to the machine and pushes another one through the corridor. This would be possible by adding a tray at the top of it.

5.3.3 Beverage Compass 25 – Alpha Brewing Operations

Beverage Compass 25 is a machine manufactured by an American company which has the capacity to fill and seal 25 cans per minute. It is specially designed for large production breweries, offering efficient canning for craft beer producers.

The machine is assembled with a patented high technology, precise enough to fill the volumetric amount required without wasting beer. Its compact stainless-steel construction provides durability and hygiene. This machine, similar to other mentioned alternatives, can adjust to different can sizes and configurations, offering a wide range of flexibility.

From the three mentioned alternatives it is the unique having full automatized system, not requiring human attention when it is working.

For all the mentioned characteristics, the price of this machine is $49.900, making it an unreal option for KOM’s possibility. Moreover, the space required for the Compass 25 is bigger than the available at KOM, which would make restructure the factory.

Figure 5.5. *Compass 25 canning machine. Source [24]*

As seen in Figure 5.5, the operability does not require from human activity. The pallet full of cans in placed on top of the metallic structure, then cans go its way down following the line slot until reaching the filling part of the machine.

Using the electronic screen, the machine is programmed to fill a determined quantity, depending on the can size, and once the can is filled, it goes to the sealing section. The entire process, from the begging, in which the can is on top of the metallic structure, until it goes out of the machine, filled and sealed, takes about 12 seconds, with the ability to product 25 cans per minute, since the process is done simultaneously with 3 cans.

5.4 Conclusions

In this section, an analysis of the three alternatives will be done, as well as a choice of the best option between them considering KOM’s current situation and future development.

Although Compass 52 is a really serious alternative to consider in a near future, once the company will be more developed and having a higher production rhythm, which would maybe imply to move to another factory, it is no longer an option for today’s improvements.

Therefore, the two remaining alternatives are The Mancos from Twin Monkeys and Gosling 2.0 from Wild Goose. Regarding price, which is a key factor involved in the choice, both options are quite similar, so the difference between them will not remark a difference in the choice.

Considering other important characteristics and taking into account the high investment that would suppose acquiring either of the two alternatives, a key aspect to consider is the possibility that Gosling 2.0 has in incorporating future expansion to the machine, which is something that The Mancos does not allow.

On the other hand, The Mancos has a wider range of packaging different can size with respect to the other alternative. One has to bear in mind that KOM uses the same can for all of their creation, making this outstanding characteristic to lose importance in their case, since no use to it will be given.

In the comparative table below, the main characteristics of the current and the proposed canning machines alternatives.

Table 5.1. *Comparative table of the canning machines. Sources [17], [18], [19], [20]*

	Price [$]	Speed [cpm]	Dimensions [cm^3]	Future expansion
Cannular	800	3	41x25x54	No
The Mancos	29.500	10	52x32x33	No
Gosling 2.0	27.500	12	44x26x43	Yes
Compass 25	49.900	25	-	Yes

Although in the comparative table major characteristics have been included, for the choice of the proposed canning machine to substitute the current model other important aspects such as versatility to adapt to different canning types or level of automatization of the process.

With the exposed arguments, the findings from this section show that the model who better adjusts to current KOM's needs is Gosling 2.0, thanks to an incredible design that allows for scalability and future expansion, as well as a canning rhythm optimal for their current and near future production.

6. Industrial reverse osmotic plant: market research, study of the alternatives and implementation

The last section of this work consists of analysing the existing alternatives in the market to install the reverse osmotic plant in the factory. For this purpose, more than ten specialized companies have been contacted to get a budget proposal for KOM's case.

But firstly, it is important to know what an osmotic process is, and to understand how these plants work.

6.1 Osmotic water in the brewing industry

Osmotic water, also known as reverse osmotic water, is a highly purified type of water produced by using a reverse osmosis system that is becoming an increasingly popular choice for use in the brewing process. Water is a key ingredient for the beer, and the quality of the water used can have a significant impact on the taste and quality of the final product.

Since osmotic water is highly purified and free from impurities, minerals, and dissolved solids, basically is the most neutral water possible, it makes it the perfect choice for the brewing industry, allowing brewers to have greater control over the quality of their beers.

The removal of impurities and minerals allow brewers to start with a blank slate, adjusting the water profile to match the specific needs of the different style of brewed beers. This means that brewers are able to fine-tune the water chemistry to achieve the desired flavour profile and character of the beer.

Additionally, osmotic water is free from minerals that could potentially cause scaling and corrosion in the brewing equipment, leading to costly repairs and maintenance in the long term. This fact makes it a more cost-effective choice. From the environmental point of view, the use of osmotic water eliminates the requirement of expensive water treatment equipment or chemicals.

While osmotic water is an excellent option for brewing, it is important to note that it may not contain the same minerals and nutrients that are found in natural drinking water. For this reason, some brewers choose to supplement their osmotic water with additional minerals and electrolytes that help to achieve the specific desired flavour profile or balance.

6.2 Reverse osmosis system

Reverse osmosis (RO) is a water purification technology that uses a semipermeable membrane to remove ions, molecules, and larger particles from drinking water. The membrane allows the passage of water molecules while blocking the passage of contaminants, producing clean, high-quality water.

The reverse osmosis process involves several steps. First, the water passes through a sediment filter to remove any large particles and impurities. Then, it moves into the RO membrane, which is designed to allow the passage of water molecules while trapping contaminants. The RO membrane is extremely effective at removing impurities, including dissolved solids, bacteria, and viruses.

As the water passes through the membrane, two streams are created: the permeate (clean water) and the concentrate (wastewater). The permeate is collected and used for drinking, cooking, and other purposes, while the concentrate is discharged as wastewater.

Reverse osmosis systems can be used for a variety of applications, including residential, commercial, and industrial settings. They are commonly used to provide clean drinking water, as well as for food and beverage production, pharmaceuticals, and other industrial processes.

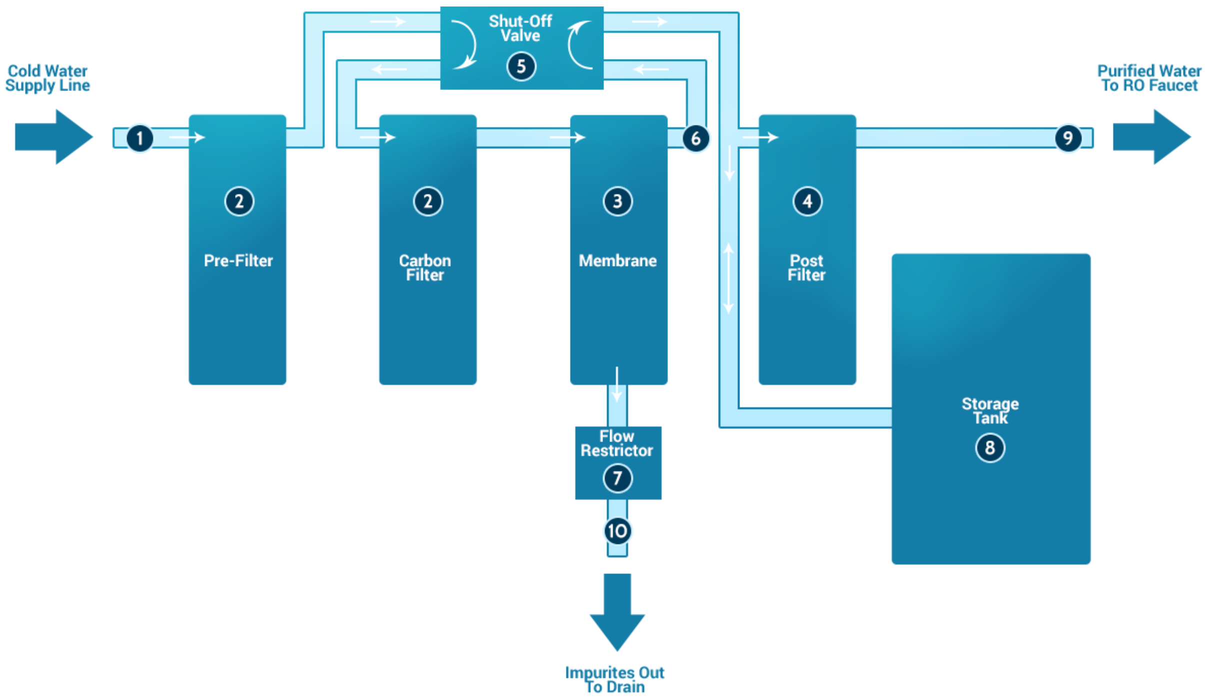


Figure 6.1. *Scheme of a reverse osmosis system process. Source [16]*

6.2.1 Stages of the RO

1. Pre-filtration

The water to be treated first goes into a pre-filtration stage where it passes through a sediment filter. In this process, the filter removes the largest particles, such as sand, clay, and other undesired particles from the water. This stage is of high importance as it helps to protect the RO membrane from clogging and enhances its performance.

2. Carbon pre-filter

The water leaving the sediment filter goes to a carbon filter. This filter contains activated carbon, which has a highly porous structure. Thanks to its structure, the carbon filter effectively absorbs and removes certain chemicals, organic compounds and other unpleasant tastes and odors from the water.

3. Reverse Osmosis Membrane

Once the pre-filter process is finished, water is distributed to the main stage of the process, which involves passing thorough a semipermeable membrane. This membrane has extremely small pores that allow water molecules to go on, but block contaminants like remaining solids, minerals, or bacteria. The RO membrane is crucial in purifying the water.

4. Pressure System

In order to overcome the natural osmotic pressure, water needs to be pressurized before entering the RO membrane. If water was not pressurized, it could not pass through the RO membrane because of the tiny dimension of its holes.

Moreover, water leaving the membrane also needs a pressure boost, since the outflow flux is quite low due to the shock with the membrane.

5. Water Collection

The purified water, known as permeate, passes through the RO membrane, and is collected for its use. This permeate is free from impurities, dissolved solids, and most contaminants, making it perfect for beverage industry allowing brewers to give each beer the desired profile.

6. Concentrate Water Discharge

Water that does not pass through the RO membrane, called concentrate, is the portion of water that carries the concentrated impurities and contaminants that are not allowed to pass through the RO membrane. This water, the concentrate, is discharged as wastewater and in some cases is used for other purposes like irrigation.

6.3 Characteristics of the desired plant

Considering the increasing production volume of the factory, not all kind of reverse osmotic plants fitted the requirements. Keeping in mind that the plant would completely substitute the use of external osmotic water the quantity required is significantly big.

Recently, the production volume of KOM's factory was approximately of one to two creations per week, requiring an average of 1450 litres of osmotic water per produced beer. Since the water needs to be prepared at the beginning of the day, it is required an external deposit to store the osmotic water.

Considering that the working day lasts for 12 hours (the days in which workers go to the factory, not every day), the 1500 litres of water required for the following brewing process might be produced during this 12-hour period. Therefore, it is required at least a **production of 125 litres per hour**.

Referring to the external tank, considering the dimensions of the factory, it is required at least a **1500 litres external deposit**, to store the produced water in the working day.

Lastly, it is important to mention that some reverse osmotic plants cannot continuously work for twelve hours straight, which is an important issue to take into consideration, since the required plant needs to **work for an average of twelve straight hours**.

6.4 Market research

To be sure that the best option was reached, market research was done, paying the attention to the companies specialized in reverse osmosis operating in Spain, more concretely in Catalunya.

A first approach to the leading companies, as well as some small regional companies, was done, to try to reach the higher possible alternatives and choose the best among them.

A first attempt to contact more than ten different companies operating in Spain was done, explaining KOM's situation. A response to six of them was given, but some companies could not solve the problem, as it was out of their range.

From the contacted companies it was decided to keep working and analyse the proposals of four of them, since they were the most interested in finding out a solution for our problem.

6.4.1 IMEDAgua

The first company is called IMEDAgua, located in Alicante, Valencia. Specialized in water treatments, they are one of the leader companies in the sector. Because of geological factors, the whole process, from the first touch until the closing of the final budget proposal has been done on-line.

A first contact with them was done by email, where some information about the request was provided, and an answer was given quickly. Later on, a video was sent to them, explaining where the osmotic plant should be placed, in order to know if any additional component was needed. Finally, a budget was sent to KOM.

6.4.2 Ideagua

The second alternative comes from a company called Ideagua, whose headquarters are located in Valencia, whose main target are particulars, installing small osmotic machines for the domestic usage. However, they have recently started to install industrial osmotic plants.

Similar to the previous mentioned company the whole process was through email, repeating the process of sending a video for them to properly analyse the situation. Moreover, an analysis of the water was sent in order to know the proper filter to be installed.

6.4.3 Blue Planet

Differently to the previous mentioned alternatives, Blue Planet, which is a company that operates only in Catalunya, came to the factory to analyse the situation, and provide the specific equipment to solve our problem.

After analysing the water and the seeing how the factory is structured, as well as analyse the strategic possible solutions for the osmotic plant to be located, a budget was prepared.

6.4.4 Osmosis Girona

The last budget was sent by Osmosis Girona, a small company located in Sant Julià de Ramis, operating mainly in Girona and surroundings. They were especially excited about the project, since they mainly work with particulars and recently worked in a similar project obtaining very good results.

A technician also come to the factory to see the layout of the machinery, as well as to discuss with us the best strategic position for the osmotic plant to fit the needs. Moreover, an analysis of the water was also done.

6.5 Analysis and conclusions

After obtaining the four proposals, one for each of the companies, it was seen that there was slightly difference between them. Since all budgets were quite similar between them, a further analysis of the companies was done, checking for current client's opinions.

Although trying to reach out more information about the companies, the four of them seemed to be reliable and to do a good job in the projects they are involved in. For this reason, any of the possible choices would be good.

All in all, the chosen company was not the principal issue. Thanks to the initial analysis of the beer calculation cost, it has determined that near a €100 would be saved each time that a beer is produced and considering that an average of 4 beers are produced monthly, more than €4500 would be saved annually.

Table 6.2. *Main improvements of installing RO over acquiring from an external company*

	Price [€]	Availability
Buying Osmotic Water	0.0719/L	Distributor dependence
Installing RO plant	~ 7000	Always

Keeping this in mind, a choice needed to be done. After some discussion and advice from their financial manager, KOM partners decided to work with Osmosis Girona, a small company mainly working in the local area.

The choice was mainly done considering that the fact that it is a small company, mainly specialized in domestic installations, making this project a real challenge for them. Although is principal this could sound as a drawback because of the lack of experience, it is also an opportunity for them to reach new potential clients if the work is correctly done.

For this reason, and also regarding the proximity, it is considered that Osmosis Girona would bring not only a good installation but also an excellent day-to-day contact and following of the functioning of the industrial installation.

Although all budgets will be provided in the annexes of this work, an attached screenshot of the provided budget from the chosen company is provided.

Referencia	Descripción de los equipos	PVP (€)	Ud.	TOTAL (€)
306102	HRM PROFESSIONAL 175	3.183,21	1	3.183,21
647001	Declorador 8L	316,79	1	316,79
530000.2	Filtro sedimentos 20 micras	41,87	1	41,87
740003	Depósito compacto 1000L (rectangular)	626,50	1	626,50
750008	Grupo presión	726,80	1	726,80
	Sistema desionizador (2 botellas)	796,01	2	1.592,02
	Instal.lación	550	1	550
TOTAL TOTAL IVA (21%) NO incluido.				7.037,19 €

Figure 6.2. *Budget for the RO plant*

7. Economic study

A feasibility study is conducted to explore the economic impacts of the implementation of the Gosling 2.0 in KOM's factory. It will evaluate the potential financial outcomes, including cost-effectiveness, productivity gains, and overall profitability.

The study aims to provide a comprehensive analysis of the anticipated economic impacts, providing decision-makers the relevant information to determine the viability and feasibility of integrating the new machine to their business.

Finally, once analysed the different views of such an implementation, some advice to decision-makers will be given whether it is a good investment for the company.

7.1 Executive summary

KOM Beer is a rising craft brewery, known for creating top-class beverage with clients all over the Catalan territory. While KOM project started two years ago, sales have grown from the initial moment until reaching a point in which some investment must be done to fulfil demand levels and produce more quantity more efficiently.

Growth rate has been stalled mainly because the impediment of not using the top machines in the market for each of the brewing processes. One key factor for this slowing growth rate is the use of a fully manual canning machine with a really slow production rate, making it to be really time-consuming, not allowing workers to focus on producing more.

The craft beer marketplace is healthy and seems to show a continued growth trajectory in the upcoming years. KOM is in a position to expand their business by leveraging the top existing technologies, which will help them to boost company's growth projection for the foreseeable future.

7.2 Description of products

KOM is considering installing a reverse osmotic industrial plant, as well as replacing the packaging machine for an updated alternative, able to allow a higher production rate. Prior to this section, an exhaustive description of each of the processes and optimal products to substitute current ones has been provided.

Until now, KOM has been purchasing the osmotic water and has packed the cans one by one manually. Working under these conditions, KOM has not been able to increase its production rhythm, as well as not obtaining more profitability of its beer.

By implementing these two improvement proposals, KOM would have the possibility to expand their business by producing more in a more efficient way, allowing them to expand to new markets and find new potential clients, which in turn will report higher profits.

The implementation of the two equipment will significantly modify the working and producing pace, but in no case, it will imply a difference in the product. This means, that the final product will remain the same and any changes in the production line are outside the purpose of this document.

7.3 Organization and staffing

The implementation of the new equipment is not anticipated to significantly affect the organizational structure of the company. Until today, KOM has three owners which are the only people involved in the production and selling of their products. Moreover, a distributor company is contracted to deliver the products to the final consumer.

However, the addition of new and improved equipment will significantly boost the production rate and therefore some additional people will need to be contracted to fulfil the demand. All the positions to be covered will work in the process of production of beer. Specifications about the timing of the incorporations will be specified later on this report.

7.4 Schedule

The implementation of both equipment is expected to take two to three months from budget approval to installation and functioning of the machines. It has to be considered that prior to budget approval, research was done to find the optimal companies.

All in all, the total time from the first touches with the potential equipment providers until their operability takes approximately 4 to 5 months. The following is a high-level schedule of some significant milestones for this initiative:

- 1st April 2023: Initiate project
- 15th April 2023: First contact with the potential
- 1st May 2023: Sending of the required information
- 15th May 2023: Visit to the company
- 20th May 2023: Receival of the budgets
- 1st June 2023: Decision taken
- 15th June 2023: Last date to indicate if budget is accepted

Next steps to be done:

- 1st to 15th July 2023: Installation of the industrial implementations
- 15th to 30th July 2023: Prior steps to prepare the machine for its optimal functioning
- 1st August 2023: Full implementation and functioning

7.5 Financial projections

The financial projections for the addition of the improved equipment for KOM are highlighted in the tables below. These figures account for projected increment of sales as well as implied costs of substituting the existing machinery.

The assumptions of this project are as follows:

- An increment of production and sales of a 10% with respect to previous period is projected once the implementation has been done.
- It is considered that four periods are included in a year.
- All milestones are performed in accordance with the schedule.
- At some point, an extra worker will be needed to fulfil the demand.

Period	0	1	2	3	4	5	6	7	8	9	10	11	12
	Q2 2023	**Q3 2023**	**Q4 2023**	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Q1 2025**	**Q2 2025**	**Q3 2025**	**Q4 2025**	**Q1 2026**	**Q2 2026**
Extra Beer Production	0,0	1,5	1,5	1,5	1,5	3,0	3,0	3,0	3,0	5,0	5,0	5,0	5,0
Income	0,0	6000,0	6000,0	6000,0	6000,0	12000,0	12000,0	12000,0	12000,0	20000,0	20000,0	20000,0	20000,0
Initial Investment	15000,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Monthly Payments	0,0	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6
Additional Workers Cost	0,0	5400,0	5400,0	5400,0	5400,0	6000,0	6000,0	6000,0	6000,0	11400,0	11400,0	11400,0	11400,0
Payments	15000,0	6935,6	6935,6	6935,6	6935,6	7535,6	7535,6	7535,6	7535,6	12935,6	12935,6	12935,6	12935,6
Cash-Flow	-15000,0	-935,6	-935,6	-935,6	-935,6	4464,4	4464,4	4464,4	4464,4	7064,4	7064,4	7064,4	7064,4
Accumulated CF	-15000,0	-15935,6	-16871,2	-17806,8	-18742,4	-14278,0	-9813,6	-5349,2	-884,8	6179,6	13244,0	20308,4	27372,8
NPV	-15000,0	-866,30	-802,13	-742,71	-687,69	3038,40	2813,33	2604,93	2411,98	3533,96	3272,18	3029,80	2805,37
Total NPV	5411,12												
IRR	11,56%												
PBP	8.13 periods	2.03 years											

Figure 7.1. *Machinery implementation viability study*

It is considered that the initial production rate is of 60 produced beers per year, which is the production rate of the previous year (2022), and since at the beginning of this year the implementation of the new equipment was not yet done, until it is implemented and at full production rhythm (Q3 2023 – Period 1) the production for the first two quarters of 2023 is considered to be 60. Therefore, no extra beer production is considered.

From Q4 2023 on, the new equipment has been implemented and a new production rate of 66 beers per year is the goal to achieve, which means to increase production a 10%. This increment of production is possible through the new equipment, but also requires from an additional full-time worker, which would suppose an additional cost of approximately €1800 monthly for the company. This is approximately a net income of €1100 monthly.

Every year the annual production goal is to be increased a 10% with respect to the previous year, as it can be seen at periods 5 and 9. From periods 5 to 9, although the production is increased, there is no need of an additional worker, since the contracted previously is supposed to have more experience and therefore he/she is able to produce at a higher pace. For this reason, an increment in the salary to €1200 is considered.

At period 9 the production is intended to be of 80 produced beers, meaning that 5 extra beers per period must be produced. Reached this situation in which almost a beer is produced every 3 to 4 days, it is necessary an additional worker, which is paid at the entry level scheme, obtaining €1100 as a retribution.

To finance the total investment of the new equipment, which is of €32.062, an initial investment of €15.000 is done. Therefore, there are still €17.062 that are required to be paid in the upcoming 3 years. Considering the company’s situation, the proposed interest rate is of 8% annually, meaning that the total amount to be paid after the initial investment is €18.427, implying a quarter payment of €1535.6.

7.6 Tools used to analyse the viability study

To analyse the viability study financial tools have been used, which are good indicators in all investment analysis and decision-making projects.

Each of these metrics provide valuable insights into the profitability and viability of the investment project. The tools used in this viability analysis are PBP, NPV and IRR. For a deep understanding, a description of each of them is done, as well as the calculation method.

7.6.1 Payback period (PBP)

The payback period is a simple metric that measures the time required to recover the investment in a project. It helps assess the liquidity and risk associated with an investment. To calculate the PBP, it is necessary to calculate the cash flow of each period, as well as the accumulated cash flow.

Cash-flow analysis is a comprehensive examination of the inflows and outflows of cash within an investment project. Although cash-flow can be categorized into different groups, depending on the activity the money is invested in, in this project it has been considered a single cash-flow, giving insights about the liquidity and financial health of the company. It has been calculated following the expression:

$$CF = Income - Payments$$

In the expression above, income refers to the income gained from the extra production due to the new equipment, while payments consider the sum of all payments, including investment, monthly payments, and additional workers cost.

Once known what cash flow is and how it is calculated, it is time to know how to calculate the payback period, to get an idea of when the investment will turn to be profitable.

$$PBP = Period\ at\ which\ Accumulated\ CF = 0$$

7.6.2 Net Present Value (NPV)

The net present value is a discounted cash flow technique that assesses the profitability of an investment by considering the time value of money. It takes into consideration the present value of expected cash flows over the lifetime of a project.

A positive NPV indicates that the investment should be taken since it is expected to generate a return greater than the discount rate, while a negative NPV suggests a potential loss. The formula to calculate the NPV is the following:

$$NPV = \sum_{t=0}^{12} \frac{CF(t)}{(1+i)^t}$$

In the expression above, t represents time period and $CF(t)$ the expected cash flow during period t. The discount factor is considered in i, since it represents the discount rate.

It is important to consider that for the calculation of the NPV, a unique interest rate is taken, representative of the average cost of capital, although it may vary during the project time life. In addition, it is assumed that positive cash flows are reinvested at the specified interest rate, while negative cash flows are financed at the same interest rate.

7.6.3 Internal Rate of Return (IRR)

The internal rate of return is another discounted cash flow technique used to evaluate the profitability of an investment. It is the interest rate that makes the NPV of the project equal to zero, meaning that the investment would neither give profits nor losses.

In other words, the IRR is the expected rate of return that an investment is anticipated to generate. If the annual interest rate is below the IRR, the investment is expected to be profitable. In the other case, a higher interest rate would imply a failure project.

To calculate the IRR, the following formula must be applied:

$$\sum_{t=0}^{12} \frac{CF(t)}{(1+IRR)^t} = 0$$

As it can be seen the formula is the same as for calculating the NPV, therefore, in simple cases, NPV and IRR coincide in accepting or rejecting an investment project.

The mentioned financial tools are essential in any investment analysis as essential insights to decision-makers is provided. They provide valuable information about the payback period, profitability, expected rate of return and financial health of an investment project.

These tools are crucial for assessing the feasibility risk and value of investment opportunities at KOM and should guide to effective decision-making to those involved in the process.

7.7 Sensitivity analysis

In this section a sensitivity analysis of the results obtained from the viability analysis of the previous section. Some hypotheses were done considering current numbers of the company and forecasts for the next years. However, such assumptions may differ from reality and therefore, it is necessary to compute a sensitivity analysis.

In this sensitivity analysis three situations which differ from the ideal studied previously, are analysed to see how economic indicators would differ if some differences from the preferred situation would differ.

The first situation considers a change in the additional production due to the implementation of the proposed equipment. Although the proposed improved production seems quite reasonable, a new viability study for an extra production of 110% in each period has been done.

Because the proposed improved production seems reasonable, it has been considered that in no case production should differ more than 10% to the production goal set.

The second study consists in the number of workers needed to fulfil the requested production. It has been considered that an extra worker is enough until production reaches the 150% of the current production, meaning that reached 2 years from the initial investment, an extra worker would be required.

However, the study also contemplates the incorporation of an additional half-time worker in the second year, when production is increased by 12 units from the current situation.

Finally, the latter study corresponds to the addition of the extra production and the additional workers.

In the following page, the results of the sensitivity analysis can be observed. It is important to pay special attention to the previously explained tools to analysis the viability study (NPV, IRR and PBP).

Period	0	1	2	3	4	5	6	7	8	9	10	11	12
	Q2 2023	**Q3 2023**	**Q4 2023**	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Q1 2025**	**Q2 2025**	**Q3 2025**	**Q4 2025**	**Q1 2026**	**Q2 2026**
Extra Beer Production	0,0	1,5	1,5	1,5	1,5	3,0	3,0	3,0	3,0	5,0	5,0	5,0	5,0
Income	0,0	6000,0	6000,0	6000,0	6000,0	12000,0	12000,0	12000,0	12000,0	20000,0	20000,0	20000,0	20000,0
Initial Investment	15000,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Monthly Payments	0,0	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6
Additional Workers Cost	0,0	5400,0	5400,0	5400,0	5400,0	8700,0	8700,0	8700,0	8700,0	14100,0	14100,0	14100,0	14100,0
Payments	15000,0	6935,6	6935,6	6935,6	6935,6	10235,6	10235,6	10235,6	10235,6	15635,6	15635,6	15635,6	15635,6
Cash-Flow	-15000,0	-935,6	-935,6	-935,6	-935,6	1764,4	1764,4	1764,4	1764,4	4364,4	4364,4	4364,4	4364,4
Accumulated CF	-15000,0	-15935,6	-16871,2	-17806,8	-18742,4	-16978,0	-15213,6	-13449,2	-11684,8	-7320,4	-2956,0	1408,4	5772,8
NPV	-15000,0	-866,30	-802,13	-742,71	-687,69	1200,82	1111,87	1029,51	953,25	2183,29	2021,56	1871,82	1733,16
Total NPV	-5993,54												
IRR	3,10%												
PBP	10.68 periods	2.67 years											

Figure 7.2. *Extra worker viability study*

By adding a part-time worker and maintaining the production as the initially set, the payback period is 2 years and 8 months. However, the NPV indicator shows that the investment should not be made, since it shows a negative value. In order for the NPV to be positive, the IRR should be smaller than the indicated value.

Period	0	1	2	3	4	5	6	7	8	9	10	11	12
	Q2 2023	**Q3 2023**	**Q4 2023**	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Q1 2025**	**Q2 2025**	**Q3 2025**	**Q4 2025**	**Q1 2026**	**Q2 2026**
Extra Beer Production	0,0	1,7	1,7	1,7	1,7	3,3	3,3	3,3	3,3	5,5	5,5	5,5	5,5
Income	0,0	6600,0	6600,0	6600,0	6600,0	13200,0	13200,0	13200,0	13200,0	22000,0	22000,0	22000,0	22000,0
Initial Investment	15000,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Monthly Payments	0,0	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6
Additional Workers Cost	0,0	5400,0	5400,0	5400,0	5400,0	6000,0	6000,0	6000,0	6000,0	11400,0	11400,0	11400,0	11400,0
Payments	15000,0	6935,6	6935,6	6935,6	6935,6	7535,6	7535,6	7535,6	7535,6	12935,6	12935,6	12935,6	12935,6
Cash-Flow	-15000,0	-335,6	-335,6	-335,6	-335,6	5664,4	5664,4	5664,4	5664,4	9064,4	9064,4	9064,4	9064,4
Accumulated CF	-15000,0	-15335,6	-15671,2	-16006,8	-16342,4	-10678,0	-5013,6	650,8	6315,2	15379,6	24444,0	33508,4	42572,8
NPV	-15000,0	-310,74	-287,72	-266,41	-246,68	3855,10	3569,53	3305,12	3060,30	4534,46	4198,57	3887,57	3599,60
Total NPV	13898,69												
IRR	16,49%												
PBP	6.89 periods	1.72 years											

Figure 7.3. *Extra production viability study*

In this case, production is increased by 10% each year, with respect to the previous one. Therefore, since the initial production rate is 60 beers per year, the first year the goal is to produce 66 beers. The following year the goal is 72 and finally, the third year, it is set to 80. The study shows a better NPV than the initial situation, therefore the investment should be taken. Finally, PBP shows that the initial investment is recovered approximately after 1 year and 9 months.

Period	0	1	2	3	4	5	6	7	8	9	10	11	12
	Q2 2023	**Q3 2023**	**Q4 2023**	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Q1 2025**	**Q2 2025**	**Q3 2025**	**Q4 2025**	**Q1 2026**	**Q2 2026**
Extra Beer Production	0,0	1,7	1,7	1,7	1,7	3,3	3,3	3,3	3,3	5,5	5,5	5,5	5,5
Income	0,0	6600,0	6600,0	6600,0	6600,0	13200,0	13200,0	13200,0	13200,0	22000,0	22000,0	22000,0	22000,0
Initial Investment	15000,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Monthly Payments	0,0	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6	1535,6
Additional Workers Cost	0,0	5400,0	5400,0	5400,0	5400,0	8700,0	8700,0	8700,0	8700,0	14100,0	14100,0	14100,0	14100,0
Payments	15000,0	6935,6	6935,6	6935,6	6935,6	10235,6	10235,6	10235,6	10235,6	15635,6	15635,6	15635,6	15635,6
Cash-Flow	-15000,0	-335,6	-335,6	-335,6	-335,6	2964,4	2964,4	2964,4	2964,4	6364,4	6364,4	6364,4	6364,4
Accumulated CF	-15000,0	-15335,6	-15671,2	-16006,8	-16342,4	-13378,0	-10413,6	-7449,2	-4484,8	1879,6	8244,0	14608,4	20972,8
NPV	-15000,0	-310,74	-287,72	-266,41	-246,68	2017,52	1868,07	1729,70	1601,57	3183,78	2947,95	2729,58	2527,39
Total NPV	2494,02												
IRR	9,81%												
PBP	8.7 periods	2.18 years											

Figure 7.4. *Extra worker and extra production viability study*

Finally, the combination of both an increment of the production and an addition worker shows that the investment would still be profitable, since the NPV is positive but not as safe as the initial situation. In this case, the payback period is a bit less than 2 years and 3 months.

7.8 Findings and recommendations

Based on the information presented in this feasibility study, it is recommended that KOM approves the substitution of the specified equipment and begins with the implementation project as planned in this work.

The findings of this study show that this initiative will have a highly beneficial impact to the organization, not only to produce more but to expand their business into new market lines, not only local customers.

Moreover, project viability indications show that if the schedule is followed the project has high probability of success. In detail, key findings are as follows:

Organizational:

- New staffing is required at some stage of the planification in order to fulfil the increasing demand.
- No new facilities are required, although in a near future it is expected to more the company to a higher factory.

Financial:

- Break-even point (PBP) occurs between period 7 and 8, slightly before the second year after the initial investment.
- Three-year projection show production to increase by 50% the current production, implying sales to multiply by 1.5.
- KOM will be in a position to find new distributors and to reach new markets.

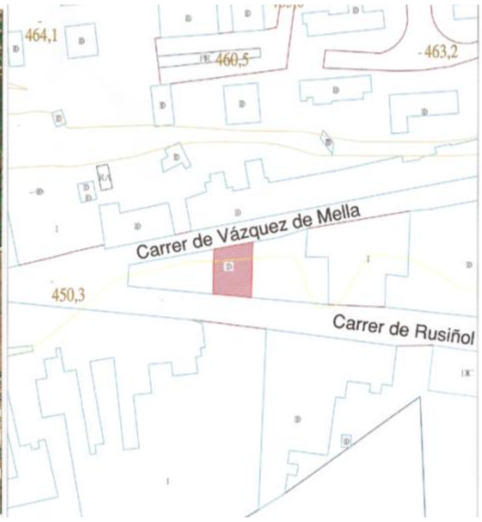
8. Refrigeration equipment study

In this chapter the refrigeration installation of the industrial building will be dimensioned in order to comply with current regulations and to achieve the desired comfort levels, as well as to reduce the energy required for the refrigeration.

First of all, it is important to locate the factory, as well as to know the total surface to be refrigerated and the distribution of the different spaces, related with the beer production, packaging, and resting.

8.1 Location and description of the plant

As mentioned earlier in the text, the factory is located at ‘Carrer d’en Santiago Russinyol, 48’ in Manlleu. It is a building that faces two streets, one entrance faces ‘Carrer d’en Santiago Russinyol’, and the other on ‘Carrer Vázquez de Mella’. The brewery is located in a former car garage which used to be a warehouse.



Figures 8.1 & 8.2. *Location of the factory*

The building has a total surface of $220\ m^2$ and has a maximum height at the midpoint of the crowning of 6.4 meters. The length of the factory is of 15.5 meters and has a width of 14.2 meters. It has to be considered that measurements are approximately done, since no official blueprints about the factory dimensions are still preserved in the factory.

Regarding the mentioned accesses, the building has two entrances with dimensions of 2 metres width and 2.5 metres tall, able for the raw material distributors to easily enter the products inside the factory.

From now on, design plans dated from 2011 will be used, but the current arrangement of the machinery and how the space is being used, has changed since then.

8.1.1 Internal distribution of the factory

The internal distribution of the factory is specified in the following table:

Table 8.1. *Internal distribution of the factory*

Use	Gross floor area $[m^2]$
Office	12.02
Changing room & Bathroom	8.81
Warehouse & labelling machine	15.26
Production	20.00
Fermentation	28.75
Fridge	10.81
Industrial Services	11.08
Raw Material Warehouse	89.50
Entrance	23.87

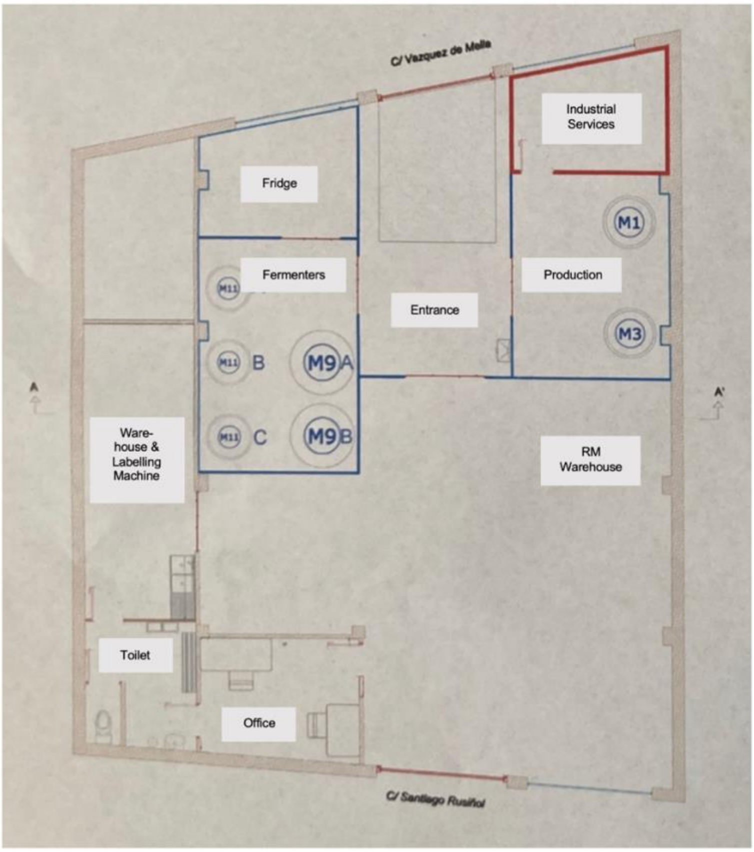


Figure 8.3. *Internal distribution of the factory*

8.2 Climatization

In this section of this chapter, the air conditioning installation of the industrial building will be dimensioned in order to comply with current regulations and to achieve the desired comfort levels.

The rooms that will be considered for the air conditioning study are those that have an established office use, as well as the production and fermentation rooms. Although it is not required the study will also consider the warehouses for raw material, since they have to be at a proper condition for not getting spoiled.

So, all spaces will be considered except the toilet, entrance, and industrial services spaces. In addition, fridge is also not considered since it has its own refrigeration system, as the produced beer requires a special warmer temperature, of around 8ºC.

The premises in which the study will be carried out are summarized in the following table with the corresponding levels of thermal treatment that will be carried out:

Table 8.2. *Summary of rooms to be treated with corresponding heat treatment level*

Space	Thermic Treatment	Humidity	Temperature
Office	Cold	Yes	Yes
Warehouse 1	Cold	Yes	Yes
Warehouse 2	Cold	Yes	Yes
Production	Cold	Yes	Yes
Fermenters	Cold	Yes	Yes

8.2.1 Parameters calculation

For the calculation of the specified air conditioning system and in order to satisfy the conditions of hygiene and comfort according to the specifications of IT1 of the RITE, the parameters explained below have been taken.

8.2.1.1 Exterior temperatures and relative humidity

Outdoor temperatures and relative humidity in summer and winter have been obtained from the meteorological data table of the book "*Guía rápida de necesidades térmicas para calefacción y aire acondicionado*". In the book, it is established that the province of Barcelona belongs to the climate zone C2.

The data obtained from the table mentioned above is collected in the following table.

Figure 8.3. *Exterior temperatures and relative humidity at Barcelona. Source [26]*

Season	Temperature [ºC]	Relative Humidity [%]
Summer	30 (maximum)	72
Winter	2 (minimum)	73

8.2.1.2 Interior temperatures and relative humidity

The interior design conditions for the occupied area are established in the first section of IT 1.1.4.1.2 of the RITE. So, the interior design conditions are as follows:

Figure 8.4. *Interior temperatures and relative humidity at Barcelona.*

Season	Temperature [ºC]	Relative Humidity [%]
Summer	23 to 25	45 to 60
Winter	21 to 23	40 to 55

For all areas where the air conditioning study will be carried out, the indoor temperature will be maintained at 21ºC in winter and 25ºC in summer, as these are the recommended temperatures in order to achieve optimal energy savings.

8.2.1.3 Simplified calculation method for air conditioning

Since the increment in electrical power consumption occurs in summer, in order to propose a required equipment, it is necessary to calculate the required cooling thermal power. To do so, a series of parameters need to be calculated.

The total thermal power is composed by two different types of loads:

- Sensitive: caused by temperature variations
- Latent: caused by humidity variations

The group of sensitive thermal loads includes the heat due to radiation through windows, the heat due to radiation and transmission through walls and ceiling, the heat due to transmission through non-exterior walls and ceilings, the heat due to air infiltration and the sensible heat generated by people, machinery and lighting occupying the space.

In the group of latent thermal loads, it includes the latent heat due to air infiltration, the latent heat generated by people occupying the space, and the latent heat that may be produced by any other cause.

Additionally, to obtain the required cooling power, the effective loads need to be calculated as explained later in this chapter of the report.

Next, the order followed for calculating the different types of both sensitive and latent thermal loads is presented in the calculation sheet created with the EXCEL program.

1. Sensitive thermal loads calculation

- Heat due to radiation through windows

This section considers the energy that reaches the premises that comes from solar radiation that passes through elements transparent to the radiation, which in KOM case are just windows.

It must be taken into consideration that the orientation of the window must be known, and a calculation solar hour and a specific day must be chosen which will be the same for the calculation of the entire thermal load of the project. The chosen solar time will be 3 pm and the day will be July 23.

$$Q_{SR} = S \cdot R \cdot f$$

In the expression above:

- S → addition of window surfaces exposed to solar radiation [m^2]
- R → solar radiation that passes through a simple glass [W/m^2]
- f → product of all the correction factors considered

To know the value of the correction factor considered, usually the applied is a multiplication between a metal frame, as it is KOM's case, which takes the value of 1.17, by the solar factor of the glass, indicated in manufacturer's technical data sheet. In total the f factor takes a value of 0.854.

Regarding the solar radiation, the value for each window orientation, which some of them are NE oriented and some SE is obtained. Considering that the factory is located in Manlleu, which corresponds to the 40º North Latitude, and that the day of study is in July, the corresponding value is either 399 or 393.

Latitud Norte	Mes	Orientación								
		N	NE	E	SE	S	SO	O	NO	Horiz.
		Máximas aportaciones solares R (W / m2)								
30°	Junio	63	437	506	283	66	283	506	437	786
	Julio y Mayo	50	412	515	314	94	314	515	412	774
	Agosto y Abril	34	339	519	405	197	405	519	339	739
	Sept.y Marzo	28	283	496	478	329	478	496	283	666
	Oct. y Febrero	24	122	425	513	456	513	425	122	563
	Nov. y Enero	22	50	364	509	500	509	364	50	456
	Diciembre	19	37	329	509	513	509	329	37	412
40°	Junio	53	418	509	349	169	349	509	418	745
	Julio y Mayo	46	399	515	393	217	393	515	399	732
	Agosto y Abril	34	320	509	458	320	459	509	320	673
	Sept.y Marzo	28	182	469	509	440	509	469	182	575
	Oct. y Febrero	22	109	383	513	509	513	383	109	405
	Nov. y Enero	15	37	314	491	522	491	314	37	324
	Diciembre	15	31	270	465	519	465	270	31	267

Figure 8.4. *Values of the maximum solar contributions through single glass. Source [27]*

- Heat due to radiation and transmission through walls and ceiling

The heat provided by the sun heats up the exterior walls of the industrial facility, and then reverts to the interior. Therefore, the heat of this section is calculated as follows:

$$Q_{SWC} = K \cdot S \cdot DTE$$

In the expression above:

- K → transmission coefficient of considered enclosure (wall, ceiling, or floor) [W/m^2]
- S → surface of the wall, ceiling, or floor [m^2]
- DTE → factor related to the equivalent difference of temperature, and it is a thermal jump corrected to consider the effect of radiation. (For the purpose of this project only the DTE coming from the wall will be calculated, no consideration of external ceiling). The value is to be picked from the following table.

EXPOSURE	WEIGHT OF WALL‡ (lb/sq ft)	SUN TIME																							
		AM							PM													AM				
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Northeast	20	5	15	22	23	24	19	14	13	12	13	14	14	14	12	10	8	6	4	2	0	−2	−3	−4	−2
	60	−1	−2	−2	5	24	22	20	15	10	11	12	13	14	13	12	11	10	8	6	4	2	1	0	−1
	100	4	3	4	4	4	10	16	15	14	12	10	11	12	12	12	11	10	9	8	7	6	6	5	5
	140	5	5	6	6	6	6	6	10	14	16	14	12	10	10	10	10	10	10	10	9	9	8	7	7
East	20	1	17	30	33	36	35	32	20	12	13	14	14	14	12	10	8	6	4	2	0	−1	−2	−3	−3
	60	−1	−1	0	21	30	31	31	19	14	13	12	13	14	13	12	11	10	8	5	4	3	1	1	0
	100	5	5	6	8	14	20	24	25	24	20	18	16	14	14	14	13	12	11	10	9	8	7	7	6
	140	11	10	10	9	8	9	10	15	18	19	18	17	16	14	12	13	14	14	14	13	13	12	12	12
Southeast	20	10	6	13	19	26	27	28	26	24	19	16	15	14	12	10	8	6	4	2	0	−1	−1	−2	−2
	60	1	1	0	13	20	24	28	26	25	21	18	15	14	13	12	11	10	8	6	5	4	3	3	2
	100	7	7	6	6	6	11	16	17	18	19	18	16	14	13	12	11	10	10	10	9	9	8	8	7
	140	9	8	8	8	8	7	6	11	14	15	16	18	16	15	14	13	12	12	12	11	11	10	10	9
South	20	−1	−2	−4	1	4	14	22	27	30	28	26	20	16	12	10	7	6	3	2	1	1	0	0	−1
	60	−1	−3	−4	−3	−2	7	12	20	24	25	26	23	20	15	12	10	8	6	4	2	1	1	0	−1
	100	4	4	2	2	2	3	4	8	12	15	16	18	18	15	14	11	10	9	8	8	7	6	6	5
	140	7	6	6	5	4	4	4	4	4	7	10	13	14	15	16	16	14	12	10	10	9	9	8	7
North (Shade)	20	−3	−3	−4	−3	−2	1	4	8	10	12	14	13	12	10	8	6	4	2	0	0	−1	−1	−2	−2
	60	−3	−3	−4	−3	−2	−1	0	3	6	8	10	11	12	12	12	10	8	6	4	2	1	0	−1	−2
	100	1	1	0	0	0	0	0	1	2	3	4	5	5	5	8	7	6	5	4	3	3	2	2	1
	140	1	1	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	7	6	4	3	2	2	1
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
		AM							PM													AM				
		SUN TIME																							

Figure 8.5. *Corrected temperature differences. Source [27]*

- Heat due to transmission through non-exterior walls and ceilings

Walls and ceilings that are not exterior will be included in this section. It should be noted that glazed surfaces will also be included. For this reason, this section will include interior walls, ground, and interior ceilings.

It is important to mention that doors will not be considered and are included in the surface of wall in question. This heat is calculated as follows:

$$Q_{ST} = K \cdot S \cdot \Delta T$$

In the expression above:

- K → transmission coefficient of considered enclosure (wall, ceiling, or floor) [W/m^2]
- S → surface of the wall or ceiling [m^2]
- ΔT → thermal jump between non-refrigerated premises and the premises where the calculation is being carried out (since if it is a thermal jump between two refrigerated premises it is not considered) [ºC]

- Heat due to air infiltration

The factory to be conditioned is intended to be exempt from hot air inlets coming from the outside. Even so, when the doors or windows are opened it is inevitable that outside air enters the premises. Therefore, the heat due to air infiltration is obtained as follows:

$$Q_{SI} = 0{,}34 \cdot V_i \cdot \Delta T$$

In the expression above:

- V_i → volume of air infiltration [m^3/h]
- ΔT → thermal jump between non-refrigerated premises and the premises where the calculation is being carried out (since if it is a thermal jump between two refrigerated premises it is not considered) [ºC]

- Heat generated by people, machinery and lights present in the building

Firstly, the people who occupy a room generate sensible heat and latent heat. In this section only sensible heat will be considered. It should be noted that when talking about people who occupy the local is the average number of people who occupy it. The sensible heat generated by people is calculated from the following formula:

$$Q_{SP} = n \cdot O_s$$

In the expression above:

- n → average number of people present in the room
- O_s → sensitive heat emitted by people [W] (Value obtained from the table below)

Table 8.5. *Power dissipated as heat from human activity*

Activity	Power [W]		
	Total	Sensible	Latent
Seated at rest	110	60	40
Seated light work	120	65	55
Walking	305	100	205
Heavy work	465	165	300

Secondly, lighting also produces heat and this must be accounted when calculating the thermal loads of the rooms. Due to factory's aging, the lighting is light bulbs, it will be calculated as follows:

$$Q_{SIL} = n \cdot I$$

In the expression above:

- n → average number of light bulbs in the room
- I → electrical power of the lightening [W] (In average, bulbs consume 60 to 80W)

Lastly, it will be considered that the losses of the machinery are completely transformed into sensitive heat:

$$Q_{SM} = P_M \cdot (1 - \eta)$$

In the expression above:

- P_M → electrical power consumed by the machine [W]
- η → machine performance, specified in the data sheet of each specific machine

- Total sensitive thermal load

Once the calculation of each of the sensitive thermal loads have been done, the total sensitive thermal load of the building is the addition of each of them, which takes the value of the following expression:

$$Q_S = Q_{SR} + Q_{SWC} + Q_{ST} + Q_{SI} + Q_{SP} + Q_{SIL} + Q_{SM}$$

2. Latent thermal loads calculation

- Heat due to air infiltration

With the same infiltration rate, V_i, used in the sensible heat infiltration due to air section, the following formula will be applied:

$$Q_{LI} = 0.63 \cdot V_i \cdot \Delta W$$

In the expression above:

- V_i → volume of air infiltration [m^3/h]
- ΔW → difference between the absolute humidity of the air outside the room and inside the it

- Heat generated by the people

This section is very similar to the section of heat produced by people of sensitive thermal loads. In this case, the latent heat generated by the people occupying the premises will be calculated as follows:

$$Q_{LP} = n \cdot O_L$$

In the expression above:

- n → average number of people present in the room
- O_L → latent heat emitted by people [W]. Value obtained from the table x, shown in the previous section

- Total latent thermal load

Similar to the sensitive thermal loads, the total latent thermal load of the building is the addition of each of the different latent loads present in the building.

$$Q_L = Q_{LI} + Q_{LP}$$

3. Calculation of the effective thermal load

To calculate the refrigeration power for the equipment to be installed it is also required to perform the calculation of the effective thermal load of both the sensitive and the latent loads.

The partial effective sensitive thermal load is calculated as follows:

$$Q_{SEP} = Q_S + 0,34 \cdot f \cdot V_v \cdot \Delta T$$

In the expression above:

- Q_S → total sensitive thermal load [W]
- f → coefficient of the cooling battery. It will be considered 0.2 since it is the standard value of a conventional battery
- V_v → volumetric flow rate of ventilation [m^3/h]
- ΔT → thermal jump between non-refrigerated premises and the premises where the calculation is being carried out

To calculate the partial effective latent thermal load, the following expression must be applied:

$$Q_{LEP} = Q_L + 0,63 \cdot f \cdot V_v \cdot \Delta W$$

In the expression above:

- Q_L → total latent thermal load [W]
- f → coefficient of the cooling battery. It will be considered 0.2 since it is the standard value of a conventional battery
- V_v → volumetric flow rate of ventilation [m^3/h]
- ΔW → difference between the absolute humidity of the air outside the room and inside the it

The total effective loads (Q_{SE} and Q_{LE}) will be the partial loads increased by some percentage of safety. It should be noted that, normally, a value between 5% and 10% is taken. In this project, in order to guarantee that all devices fulfil the required energy to be delivered, a percentage of 10% is to be considered.

$$Q_{SE} = 1.1 \cdot Q_{SEP}$$

$$Q_{LE} = 1.1 \cdot Q_{LEP}$$

Finally, to calculate the total effective thermal load, the addition of both loads is computed:

$$Q_L = Q_{LI} + Q_{LP}$$

4. Calculation of the total thermal load (or refrigeration load)

This load refers to the power of refrigeration that is required for the equipment in order to condition the different spaces for the mentioned thermal configuration. From now on, this load is called Q_T and, similar to previous sections, will be divided into two main groups, sensitive and latent.

$$Q_{ST} = Q_{SE} + 0{,}34 \cdot (1 - f) \cdot V_v \cdot \Delta T$$

$$Q_{LT} = Q_{LE} + 0{,}63 \cdot (1 - f) \cdot V_v \cdot \Delta W$$

The nomenclature used in the expressions above has been previously defined in other sections of this part of the work.

The ultimate thermal load, or refrigeration load, takes the value obtained from the calculation of the following expression:

$$Q_T = Q_{ST} + Q_{LT}$$

8.2.2 Results

To calculate the thermal loads, as well as each of the sub-sections mentioned in this section of the report, a table using the EXCEL Sheet program has been created. The results obtained with that Sheet are shown in the following table.

Table 8.6. *Results obtained from the calculation of the thermal refrigeration loads*

Space	Total thermal heat of refrigeration [kW]
Office	5.031
Warehouse 1	8.621
Warehouse 2	16.686
Production	16.803
Fermenters	8.390

8.3 Conclusions and further recommendations

After an exhaustive study of the different thermal loads that are present in the factory, it is now time to substitute the current refrigerating devices by updated ones, having a better performance and able to provide the power specified in earlier sections.

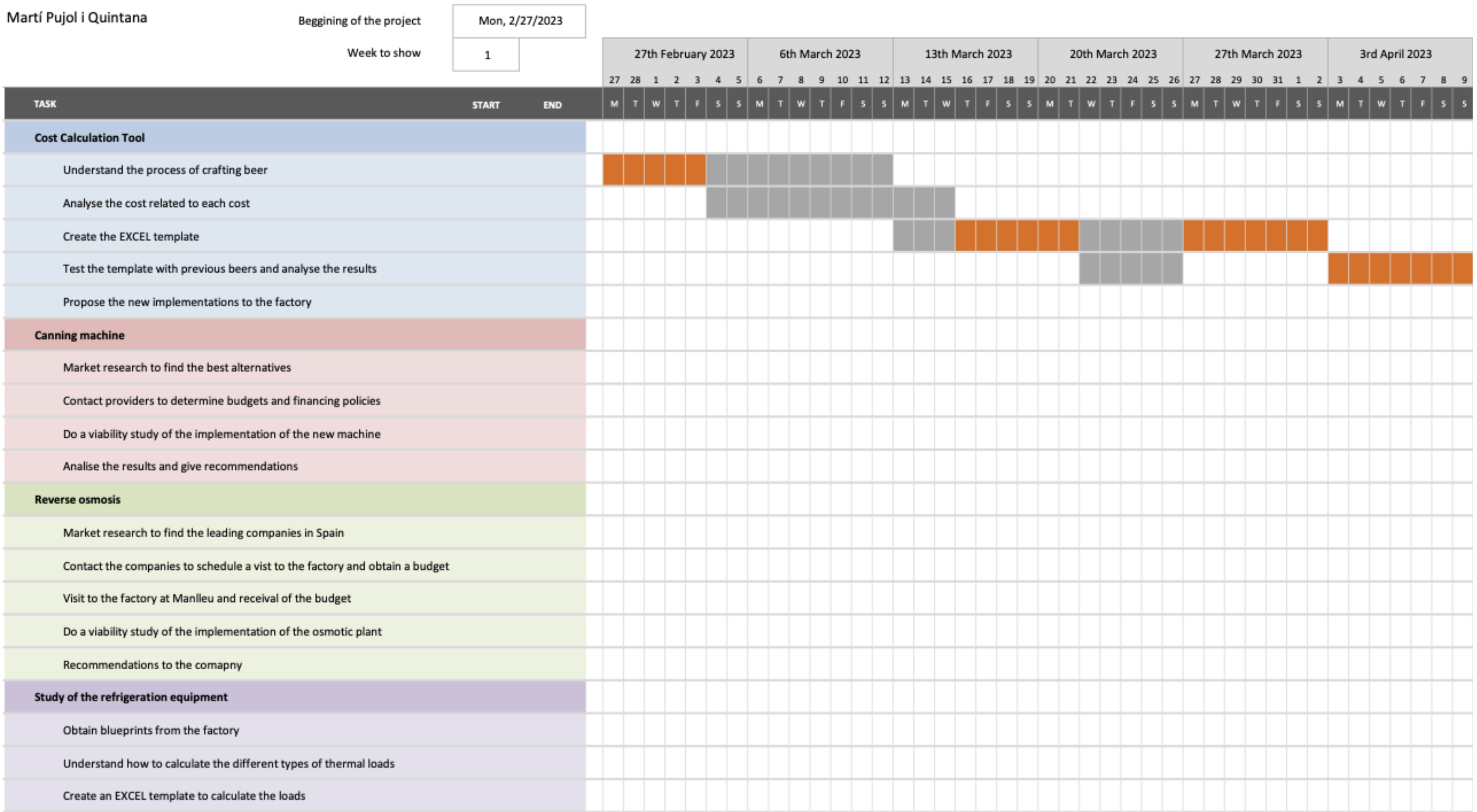
By acquiring the necessary updated refrigerating machinery, the factory would be much more efficient in electricity consumption terms and a higher level of comfort would be achieved.

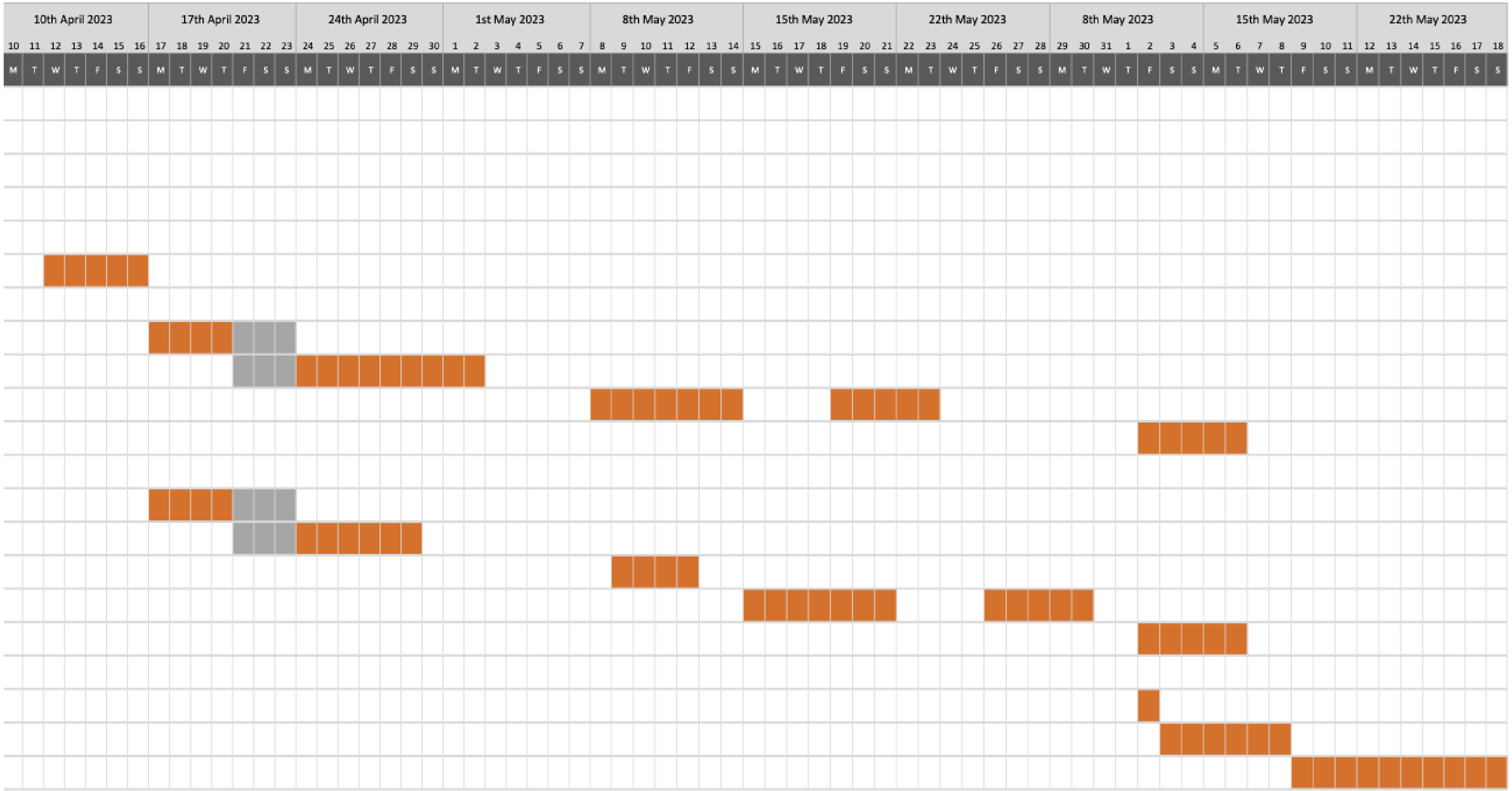
It has to be considered that actual value can differ from the results obtained since the calculations have been done with approximate dimensions of the factory, since no official and up-to-date blueprints are in KOM partner’s hands.

For this reason, if this improvement is one day to be implemented, for safety and monetary reasons, it would be appropriate to update the parameters of the table used to calculate the thermal powers in order to acquire the refrigerating machines that fit best to KOM’s situation.

9. Planning

In this chapter a Gantt chart is presented. In the chart it can be seen how the project has evolved during the fourth month it has lasted, since March to June 2023.




10th April 2023
17th April 2023
24th April 2023
1st May 2023
8th May 2023
15th May 2023
22th May 2023
8th May 2023
15th May 2023
22th May 2023

10. Economic assessment

This section of the project considers the economic assessment of the whole project. It has been considered the hours worked by the student and the professor, as well and the tools used to develop the project.

Moreover, the resources used the days of visiting the facilities have also been included in the economic assessment.

Expenses	Quantity	Price/Unit [€/unit]	Amount [€]
Microsoft Licence	1 unit	69.00	69.00
Computer Depreciation	-	-	60.00
Fuel	30 litres	1.55	46.50
Public Transport	1 card	10.00	10.00
Student Costs	350 hours	15	5,250.00
Engineer Costs	5 hours	60	300.00
Utilities	-	-	50.00
Total			**5785.5**

The total cost of this project is €5785.5, which is the corresponding fees are applied, mainly consisting in the 21% of the IVA, it results into €7000.46.

Considering the magnitude of the project, in my opinion the budget obtained is relatively low compared with the prices that are currently being paid for projects of this magnitude. This project encompasses three major improvements to be done in the factory which in the long term will suppose large savings.

Therefore, if the project were invoiced, it would be a great strategic movement for the company, since although the investment can seem a large quantity, the information delivered in the project would imply larger benefits.

11. Environmental assessment

This project consisted in a theoretical study of a crafting beer company. Since no implementation has yet been done, the environmental impact of this project is relatively low, but not insignificant.

For the development of the present project, it has been used a laptop. Moreover, during the course of it, some visits were done to the factory located in Manlleu. Although it was prioritized to use the public transport, sometimes the particular vehicle, a familiar car, was used.

The continuous use of the computer for conducting the study implies a consumption of electrical energy, which, on average, is estimated to consume around 60 watts of power when being in use. This means that, considering the several hours that the study required, highly amount of electricity has been consumed.

It is important to mention that the source of this electricity is from the public electric network, which should become from renewable source in its majority. Indeed, the European Union has a plan to develop for 2030 that establishes that at least 32% of the energy consumption should be provided by renewable energies.

On the other hand, as previously specified, some of the travels to the factory were done in car with an average consumption of 7 litres per 100 kilometres, specifically 2 times. Considering that the distance travelled is 110 kilometres approximately, meaning a total distance of 220 per journey, the approximate fuel consumption was about 30 litres, resulting in almost 70 kilograms of CO_2 emitted.

In summary, although it is a theoretical study, the usage of the computer and the transportation to visit the factory, makes it not to be entirely free from environmental impacts. Therefore, it is essential to implement sustainable practices to reduce the ecological footprint, such as the usage of public transport or the reduction of the computer electric consumption.

12. Social and gender equality assessment

In this chapter, it will be analysed the current gender trend in the craft beer. Moreover, KOM's case will be discussed and compared to the current situation.

Gender inequality in the craft beer industry is persistent over time. Despite its growing popularity, crafting beer seems to, at least in the current days, be an activity thought and developed by men. And this is not my opinion: a recent study conducted by the Brewers Association, revealed that only 22.6% of the craft brewery owners are women.

Craft beer brewing has long been perceived as a male-dominated field, perpetuating the notion that it is a task for men. Not only this, but it has traditionally been seen that beer is a product consumed by men. Women have to fight for recognition and respect as competent professionals in the sector. Moreover, opportunities for learning and growth for women are limited, often lacking support networks and female mentors.

Nevertheless, as time and society advances, more women are breaking these barriers and making significant contributions to the industry. Safe and inclusive spaces are being created to promote gender equality and amplify the voices of women in the industry.

It is crucial to continue working toward eliminating gender biases and building a more equitable future, not only in the brewing industry, but in all the existing and upcoming working fields.

The mentioned arguments can also be applied in the engineering field. For example, in this engineering project, 5 people were involved, in which the fifth of them were males. However, changes in this field started earlier before the crafting industry and are starting to be visible today, where for example almost half of my university classmates are women.

13. Conclusions

In this section, the objectives presented at the beginning of the memory of this project are recalled to check it they have been completed in the course of the project.

First of all, the main objective of the project, which was to provide KOM with a fast and intuitive tool to calculate the final cost of the beer has been completed. Indeed, the proposed resource is being used nowadays to calculate the cost of their beers.

This project has been constantly changing since latter objectives appeared in the analysis of the solution to the first goal. The analysis conducted finished with a new goal: to reduce the final cost of the beer while an increment of the production is supposed to occur.

In order to fulfil the new objective, three different tasks were set, all of them consisting in improvements to optimize the existing resources at the current factory and to replace obsoleted models for new ones.

At the end of the project, it can be concluded that the three studies of improvements were concluded and in all of them a conclusion was reached. However, because of the length of the project, none of the studies could be implemented in the factory and results cannot be compared with real data.

Apart from technical knowledge, the challenging task of the project was to conduct different studies at the same time, which most of the time was the first time conducting such analysis.

All in all, the project allowed not only to consolidate part of the knowledge acquired throughout the undergraduate studies, but also to work on different fields and to find ways to overcome daily problems, which is for me, the biggest acquisition from the engineering.

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Annexes

Annex I: Cost Calculation Template. This annex consists of an Excel Spreadsheet used to calculate the total cost of the beer. This annex is found in a separate document from the written memory of the project, called Annex I: Cost Calculation Template.

Annex II: Thermal Loads Calculation. This annex consists of an Excel Spreadsheet used to calculate and justify the results given in the refrigeration equipment study. This annex is found in a separate document from the written memory of the project, called Annex II: Thermal Loads Calculation.

Annex III. Reverse Osmosis Budgets. This annex consists of the budgets obtained from the different proposed companies to install the reverse osmotic plant to the factory. The annex is a PDF found separate from the written memory of the project.