A DETERMINATION OF THE CARBON FOOTPRINT OF AN ARTISANAL ICE-CREAM PARLOUR

RESEARCH QUESTION:
WHAT IS THE REDUCTION IN THE CARBON FOOTPRINT OF A SMALL ICE-CREAM PRODUCER, AND HOW MUCH MONEY IS SAVED IF SUSTAINABLE MEASURES ARE INTRODUCED?

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Joseph Schembri

Declaration of Authenticity

Name & Surname: Joseph Schembri

Programme: Bachelor in Culinary Arts

Title of Research:

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Declaration:

I hereby declare that this research study is based on the outcome of self-made research. I, as the authentic author, declare that this research study is my own composition and has not been previously produced for any other qualification.

The research study was conducted under the supervision of Mr. David Pace.

Date

Signature

Abstract

This research project aims to raise awareness of how businesses can adopt sustainable practices that can transform a business into an environmentally friendly operation while generating a return on the savings generated by the mentioned practices. Sustainability measures need to be taken seriously. Our planet is suffering from the past mistakes that industry has made. It left a massive carbon footprint in the atmosphere due to greenhouse gases that have caused catastrophic weather changes in many countries around the world and negatively affected the nature of our planet in many ways.

Sustainability is becoming increasingly crucial for all types of businesses across all industries. A study shows that 62% of corporate investors believe that a sustainable strategy is essential for a company's success, while 22% believe that sustainable business will be a must soon (Haanaes et al.,2022). Sustainability is becoming an essential strategy for a business to create long-term value that considers how a company acts towards the environment. The perception of sustainability states that implementing such measures increases the success of a business, as expectations of corporate responsibility need to be raised. Businesses need to recognise the necessity to act on sustainable measures. This project has shown that a simple bulb change from Compact Fluorescent Lamps (CFLs) to Light-Emitting Diode (LEDs) can significantly save money from bills, reduce carbon footprint and have a return on investment in a very convenient time frame.

A mixed methodology has been used to collect data on the operation of a small ice-cream parlour. Various data were collected to determine how much carbon footprint the operation of the gelateria consumes in a year, considering the three major areas that consume the most carbon footprint during operation. These are electricity consumption, water used for daily operations, waste, and a bulb change exercise.

The research concluded that a €21,755 investment could transform a business into a more sustainable operator, saving 43,465.57 kilogrammes of carbon footprint per year. Hence, an investment made saves the business €5,657.36 per year, resulting from a return on investment within an average of four years.

The research has shown that sustainable measures will help businesses become more successful and will encourage other business operators not to hold back on

taking significant actions to invest in modern technology that will reduce the carbon footprint. Satisfactory results have been obtained, and it is possible to learn the importance of using alternative resources, such as well and photovoltaic panels (PVC) and sustainable waste management practices.

The results obtained vary according to different elements. For example, solar panels generate electricity depending on the weather, as does the rainwater reservoir. The waste amount changes with the customers' demand and compost generation also depend on the season, which affects ice-cream demand.

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Research question:

What is the reduction in the carbon footprint of a small ice-cream producer, and how much money is saved?

Chapter 1: Introduction

Within the sphere of the environment, a new megatrend is forming. It is known as sustainability. It is critical for long-term sustainability to protect our planet and its resources. As a result, the carbon footprint assesses the environmental effect of our everyday life. By minimising the quantity of greenhouse gases created by our lifestyle, we can minimise our carbon footprint and help delay climate change. Involvement in artisanal ice-cream parlour sparked an interest in understanding how to calculate the carbon footprint of an ice-cream parlour and how to analyse it and develop a strategy to reduce it. In reviewing literature recourses in this field, it was found a dearth of research. The purpose of this research is to determine the carbon footprint, the cost of investment to reduce carbon emissions by converting to greener alternatives, the amount of savings and the time it takes to recoup the investment through savings.

1.1The quantity of carbon footprint created by ice-cream parlours has been poorly investigated

Considering that ice-cream is one of the most popular desserts, the carbon footprint caused by this sector has been insufficiently studied. According to Scottish Government studies, one kilogramme of ice-cream produces four kilogrammes of Carbon Dioxide equivalent (CO_2e) (Konstantas et al.,2018). In comparison, Ben & Jerry's ice-cream production generates around 336 kilogrammes of CO_2e for the same weight of ice-cream (Konstantas et al.,2018). None of these researchers have specified the type of ice-cream, other than simply stating that it was a typical regular milk-based ice-cream. Due to a lack of information, it could not be determined whether the ice-cream was commercial or artisanal. In addition, preservation, storage and temperatures such as aeration, maturation, freezing and storage were not taken into account, contributing to the increase in CO_2e of the final estimate (Rolon et al., 2022).

The production of ice-cream consumes both carbon and water footprints. One scoop of ice-cream from the farm to the buyer across the food chain requires 160 gallons of water (Marie, 2022).

1.2 The difference in carbon footprint between various milk and milk substitutes

However, when comparing soy milk to cow's milk, the difference is enormous: 34 litres of water is required to create a 250 millilitres (ml) glass of soy milk, whereas 113 litres of water is required to make the same quantity of cow's milk (Park, 2021). When calculating the carbon footprint of a product, several factors must be taken into account, from the production of the raw material to the journey taken to the customer and, in addition, the waste produced (Healabel, 2021).

1.3 Artesian ice-cream is produced with high-quality ingredients

Artisan ice-cream is often produced with the highest-quality ingredients, and each ingredient has its environmental impact. Different milk varieties, such as fresh milk, UHT milk, whole milk powder, skimmed milk powder, whey powder, and condensed milk, are used to make milk-based ice-cream. Diverse forms of sugar, such as sucrose, dextrose, glucose, fructose, lactose, and inverted sugar (Ruben, 2017), and different types of fat, primarily animal fats and vegetable fats, such as coconut oil, palm oil, and soybean oil (IFST, 2017) also, form an integral part of the production process. Other essential ingredients are emulsifiers, including natural emulsifiers such as egg yolk and sweet cream from the buttermilk. However, in today's industry, all the following should be included: synthetic substances such as glycerol monooleate, polysorbate 80, diglycerides (Ruben, 2019), and stabilisers such as cellulose gum, locust bean gum or guar gum (Tharp, 2013).

Ingredients in gelato bases, which generally fall into different categories, include gelato with no added sugar, dairy-free gelato, fruit sorbets with no fat, sherbets, and granitas, an unlimited range of flavours, all of which have environmental implications. This case study looks at the three main factors contributing to the most significant carbon footprint: electricity and water used during operation and waste.

Chapter 2: Literature Review

One of the most important contributors to climate change is food production. Various stages of the food chain impact the carbon footprint, starting from animal husbandry to food production and distribution.

Milk is one of the staple foods consumed worldwide and one of the main ingredients used in ice-cream production. The intestinal flora of cattle that causes fermentation produces gaseous emissions that are important sources of greenhouse gases such as N_2O (nitrous oxide) produced from the soil organisms and CH_4 (methane) and CO_2 (carbon dioxide) produced by digestive processes (Kebreab et al., 2006).

2.1 Palm oil production leads to deforestation

Some ice-cream products lead to deforestation, most notably palm trees since they are essential in palm oil production and fats used in the ice-cream industry (Gatti, 2019). The conversion of vast tracts of rainforest land into palm plantations causes primary carbon emissions by reducing the area's biodiversity, changing soil flora and fauna, and decreasing habitats for various insects and animals. One hectare of converted rainforest results in a loss of 174 tonnes of carbon, most of which enters the atmosphere as CO_2 (carbon dioxide). The amount of carbon released when palm trees clear one hectare of forest is almost equal to the amount of carbon released by 530 people travelling on a plane from Malta to Canada (Lausanne, 2018).

2.2 Ice-cream manufacturing produces much waste

Emissions come from food production, food waste, product packaging and distribution. Companies conducting research are working hard to test new strategies to reduce carbon emissions. Every food manufacturer must consider the impact of its products on the environment, including the way food is produced and processed. Food processing (transforming raw materials into finished products), transportation, packaging and retailing consume lots of energy and resources. Many people believe that eating local produce is the key to a low-carbon diet (Ritchie, 2019). However, transport emissions only account for about 6% of global food emissions. Although supply chain emissions seem high, they are essential for reducing emissions as they account for 18% of total emissions and prevent food waste. Food waste causes significant CO_2 emissions, in that, a quarter of all CO_2 emissions from food production

(3.3 billion tonnes CO_2eq) are squandered through losses in the supply chain or consumers. Durable packaging, refrigeration, and food processing can help prevent food waste. Processed fruit and vegetables, for example, produce 14% less waste than fresh produce (Ritchie, 2019).

Climate change is becoming more and more evident due to the intense weather fluctuations in different countries. Businesses and consumers should cooperate to become more environmentally aware and implement sustainable measures. In the production of ice-cream, which is the focus of this study, manufacturers need to incorporate sustainable measures into their production practices and methods.

2.3 Ice-cream production consumes copious electricity

Ice-cream parlours use a considerable amount of energy for various reasons, including the power of specific machines, storage at consistent temperatures, and the maintenance of sanitary conditions of the equipment. Modern machines are designed to consume less energy, as determined by an Energy Star rating (Denkena et al.,2020). Savings on energy bills help ice-cream parlour owners to reduce electricity consumption, resulting in lower energy bills while ensuring high machine production. Lower electricity consumption reduces the carbon footprint and helps businesses save money by investing in more energy-efficient equipment (De Souza et al., 2019).

Many simple changes lead to a significant reduction in energy consumption. A simple example is lighting (De Souza et al., 2019). LED bulbs are the most energy-efficient, and researchers report that LEDs are very environmentally friendly with long lifespans, high energy efficiency and the ability to operate at low-temperature conditions (Uddin et al.,2013).

On the other hand, compact fluorescent bulbs (CFLs) pollute and damage the environment during their operation, production, transport, and even disposal in landfills (De Souza et al., 2019). Compact fluorescent lamps generate heat when they are switched on. These lamps heat the room, and more energy is needed to cool it with air conditioning. The lamps are also hazardous because they are made of aluminium (Ratsep, 2021).

When exposed to air, aluminium gets reactive and it oxidises. The interaction of sulphuric acid with the metal creates a hard oxide layer that protects it from further corrosion. Fluorescent tubes should never be thrown in a regular waste bin (De Souza et al., 2019). Fluorescent tubes must be transported to a recycling centre. Still they are considered as hazardous waste (unless there is information stating the contrary) since they may contain very toxic mercury (UNC, 2022). LEDs are significantly less hazardous to the environment than incandescent bulbs (Ratsep, 2021).

2.4 Regular maintenance is essential to minimise access waste of energy

Refrigerators, freezers and air conditioner condensers need to be kept clean to use less energy for cooling and reduce the risk of motors' overheating and leaking gas (Whitlock, 2019). Solar panels have reduced emissions from power plants using heavy fuel oil or coal-fired electricity (Fossil fuel) by 20 times (Basu et al.,2011).

Reducing carbon emissions from manufacturing, construction, and transportation is critical. Energy usage must be reduced, and alternate energy sources must be developed. By implementing such solutions, energy consumption will be reduced, resulting in decreased CO_2e emissions in the atmosphere (Clark, 2012). Regardless of one's stance on climate change, action must be made to address the issues so that one will be part of the solution rather than the problem. (Hoffman, 2011).

A debate may arise as to whether the carbon footprint of the production and consumption of ice-cream is significant or small. This case study examines the carbon footprint of ice-cream and how it can be reduced in particular areas. According to certain studies, ice-cream has a low carbon footprint compared to other food production cycles (Marie, 2022).

Chapter 3: Method of ice-cream

3.1 The procedure of ice-cream making

Ice-cream is an emulsion, a mixture of two liquids that do not normally combine. One of the liquids will separate from the other. In the case of ice-cream, fat globules are liquid dispersed with air bubbles in a mixture of water, sugar and ice (Rohrig, 2014). As mentioned earlier, the main ingredients used to make ice-cream are milk, various types of sugar, fats, emulsifiers, and stabilisers. A key ingredient that may be overlooked is the air in the form of bubbles in the ice-cream. In artisanal ice-cream, the air content is around 25%, while in industrial ice-cream, it can be as high as 90% and even more (Rogers, 2013).

Recipe formulation, pasteurisation, homogenisation, blending and maturation of ice-cream are the first steps, followed by aeration, maturation, freezing and storage, as shown Fig.1

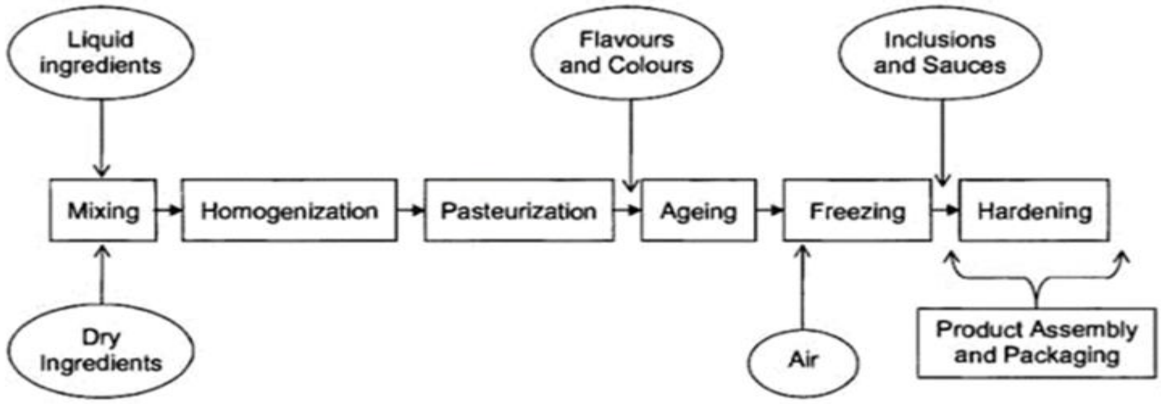


Figure 1: Diagram illustrating a flow chart of the ice-cream manufacturing process (Ruben, 2019)

About 50% of the volume of aeration and freezing (also known as dynamic freezing) involves air, as shown in Fig.2 (Goff et al., 2013).

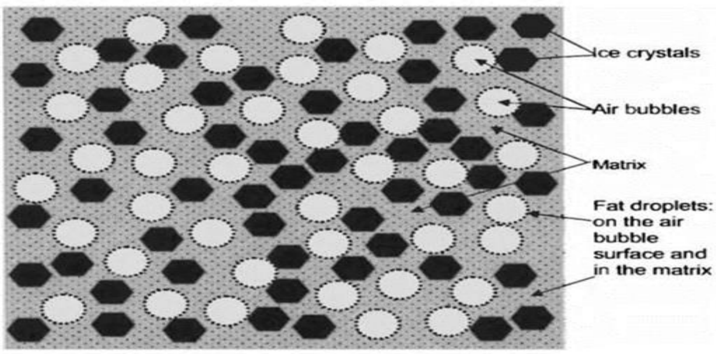
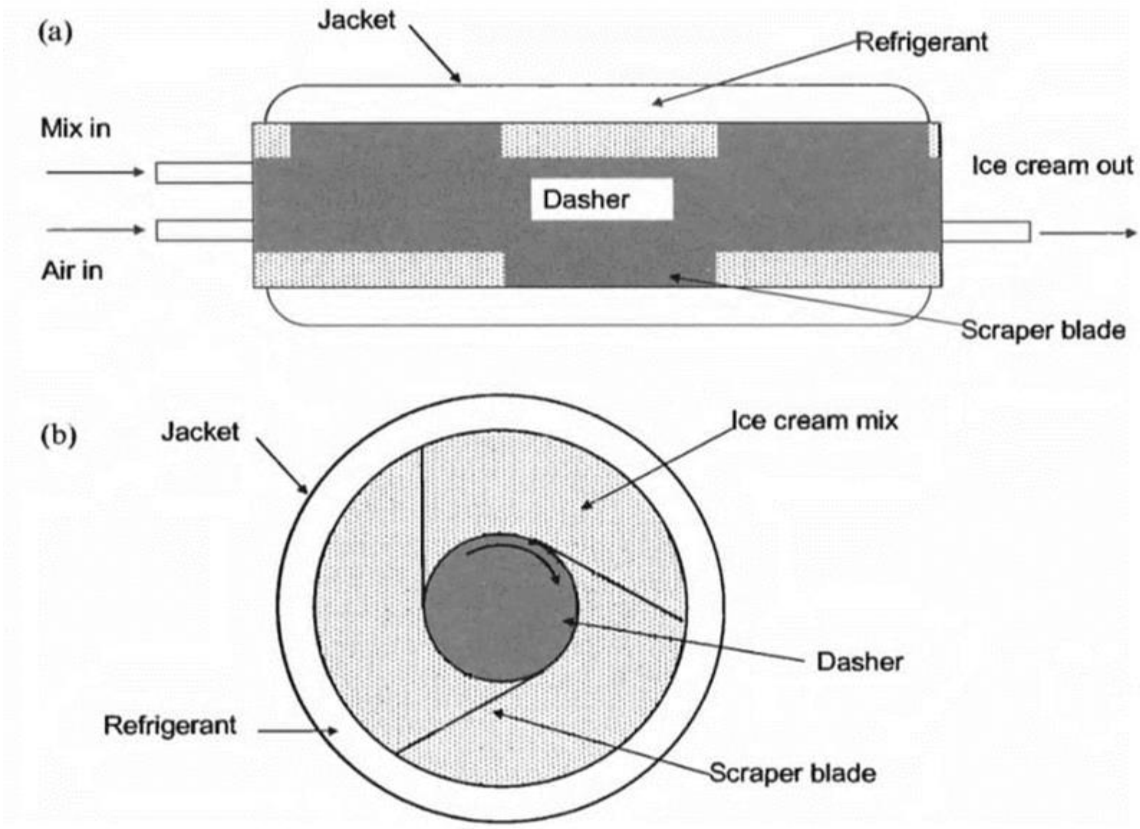


Figure 2: Diagram illustrating the scientific process of the ice-cream (Ruben, 2019).

The machine (batch freezer), which includes the rotating dasher and scraper blades enclosed in a stainless steel cylinder (as shown in Fig. 3), folds and combines the ice-cream texture from liquid to complex. The hardness is achieved by the water in the mixture being converted into ice by the freezing process, known as the freezing whipping process, which will trap air in the ice-cream. The volume is also known as the overrun. The distribution of the air bubbles is essential for the quality and texture of the ice-cream.

The overrun is the percentage expansion that makes up the volume of the ice-cream. The amount of air introduced into the mixture during churning helps increase the volume. Therefore, when calculating the overrun of ice-cream, one must also consider trapped air as an ingredient. Like all other ingredients, the trapped air in the ice-cream contributes to creating a carbon footprint (Rubin, 2012).



(c)

Figure 3: A schematic view of the internal attachments in the batch freezer machine's cylinder that whips the ice-cream (Ruben, 2019).

3.2 The quality of the ingredients determines the texture of the ice-cream

Ice-cream makers use various dairy products: Cream, whole milk, condensed milk, and instant skimmed milk powder. Most Italian ice-cream makers use of full-fat cream (32-35% fat), single cream (18% fat) and whole milk. The fat provides richness, smoothness, and flavour. Skimmed milk powder is used to increase the solids content of the ice-cream and give it more richness, also an essential source of protein. The ice-cream's nutritional value increases if one uses a good quality milk powder to prevent it from having a stale taste (Bryant, 2021).

3.3 The difference between milk and alternative products

Conventional cow's milk produces considerable methane emissions. A significant fraction of 41% of the total climate impact comes from dairy products (Schlesinger, 2019). On a global average, 1.39 kilogrammes(kg) of CO_2 equivalents (CO_2e) are emitted for every litre of milk produced. The CO_2 equivalent emissions are 0.42 kg/litre for almond milk and 0.88 kg/litre for soy milk. The emissions of yellow pea milk are even lower. To reduce the impact on the climate, alternatives to whole milk exist, and ice-cream manufacturers are starting to consider the importance of alternatives in their recipes to become more sustainable (Schlesinger, 2019).

For example, the emissions of almond milk (0.92 kg CO_2 per gram (g) protein) per kilogramme of protein consumed are much higher than those of soy milk (0.12 kg/g protein) and cow's milk (0.07 kg/g protein) (Schlesinger, 2019). Almond milk does not contain much protein. However, if one needs to minimise the impact on the atmosphere while maintaining the same nutrient content, then one should go for cow's milk. Almond milk also looks bad in terms of water footprint as it requires almost 100 times more water than cow's milk for every litre (Schlesinger, 2019).

Another study has shown that it takes 650 meters square (m^2) of land to produce one glass of milk per day for a year, equivalent to the area of two tennis courts and is even more than ten times greater than the production of the same amount of oat milk. More water is needed to produce almond milk than soy or oat milk. A single glass requires 74 litres (19.5 gallons of water) - more than a typical shower. Rice milk is also comparatively voracious to water intake, requiring 54 litres of water per glass of rice milk. However, it is worth noting that both almond and rice milk still require more water to produce than a typical glass of cows' milk (Schlesinger, 2019).

3.4 The amount of carbon dioxide emanated during the manufacturing of raw sugar

A study conducted in Brazil found that 241 kilograms (kg) of CO_2e is released into the atmosphere per tonne of sugar produced (2,406 kg of carbon dioxide equivalent per hectare of cultivated land and 26.5 kg of carbon dioxide equivalent per tonne of sugar cane processed). Most of the total emissions (44%) come from residue burning, about 20% from synthetic fertilisers and about 18% from fossil fuel combustion (Figueiredo et al., 2019).

The study's conclusions recommend that the most essential measure to reduce greenhouse gas emissions from sugar cane could be to convert the cultivated area to a green harvesting system, that is, harvesting without combustion. Sixty per cent (60%) of the cultivated area is harvested by burning, and emissions from fertilisers, herbicides and pesticides are included in this amount (Figueiredo et al., 2019). In contrast, only emissions from the company's marginal areas in Brazil were considered in this framework. Other researchers also consider emissions from the production and distribution of agricultural inputs used for Brazilian sugarcane production and report the net contribution of sugarcane agriculture to the atmosphere as 3,120 kg of carbon footprint per hectare of land (Figueiredo et al., 2019).

Carbon dioxide (CO_2) from sugar cane is released during combustion and during ethanol fermentation. Sugar cane absorbs CO_2 from the air, reducing its carbon footprint. CO_2 emissions from biogenic carbon sources are not included in the calculation of Green House Gases emissions (GHG) from the life cycle of products unless the CO_2 arises from direct land-use change (Figueiredo et al., 2019).

Methane (CH_4) and nitrous oxide (N_2O) from bagasse (fibrous material leftover from the production of sugar cane, sorghum or agave - bio-waste) must be included in GHG emissions. Methane and Nitrous Oxide have a global warming potential that is 298 times respectively than that of CO_2 (Figueiredo et al., 2019). Global warming potential is determined by how efficiently the gas traps heat in the atmosphere and how long it remains before it is broken down. Methane (CH_4), for example, breaks down quickly; the typical methane molecule stays in the atmosphere for about 12 years. However, Methane stores heat more effectively than CO_2, which has a much longer lifetime (Figueiredo et al., 2019).

These gases are added to the CO_2 produced and expressed as CO_2 equivalent (CO_2e). Therefore, even small amounts of methane and nitrous oxide must be considered when estimating greenhouse gas emissions. The carbon footprint of sugar and ethanol is minimal compared to other foods and fuels. Depending on the situation, the carbon footprint of raw sugar is probably 200 to 500 kg CO_2e per tonne of sugar (Figueiredo et al., 2019).

The results show that in the first 20 centimetres (cm) of soil, a layer of bagasse about 40 cm thick accumulates each year, accounting on average for up to 1,950 kg carbon footprint per hectare of land per year, equivalent to 7,150 kg CO_2e per hectare per year. A dramatic difference occurs with an average carbon footprint of 320 kg per hectare of land per year when green harvesting is used instead of burning (Figueiredo et al., 2019). On the other hand, this could effectively be considered as sequestering CO_2e from the atmosphere by converting burnt crop residues into green crop residues, which can reduce the overall GHG emissions of the sector despite all the ambiguities (Figueiredo et al., 2019).

Ice-cream manufacturers need to consider all these issues when buying sugar. One should always ask for the product specification, as this will help reduce the carbon footprint of production by choosing green harvest sugar.

Chapter 4: Analysis of the carbon footprint of palm oil and coconut oil

4.1 The optimal combination of two different oils best suited for ice-cream production

In Southeast Asia, forests are being mercilessly cut down for palm oil production, and the rainforest's native orangutans have been almost wiped out in the last 20 years (Choo et al., 2010). Palm cultivation also reduces the area to a monoculture, which less effective in sequestering CO_2 from the atmosphere.

Coconut oil remains one of the best oils for ice-cream making (Persson, 2009) since it is much less harmful to the environment (Kumar et al.,2020), so ice-cream makers have more confidence in its use. Farming in the modern world is not easy. Moreover, regardless of the product, the environmental impact is unavoidable and can only be mitigated through responsible sourcing (Webb et al., 2001). When grown properly, coconuts are resilient and do not require pesticides, fungicides or fertilisers. Coconuts are usually grown by small holders along with other crops such as coffee, cocoa and bananas (Coca, 2020). A single bush can bear fruit for up to 60 years. Although coconut oil has numerous environmental benefits, most consumers seek an environmentally friendly alternative to palm oil, which has a bad reputation due to human rights abuses and forest fires.

Polycultures help keep the land fresh and nutrient-rich by harvesting the coconuts by hand, as they have to be picked from the trees and rarely use heavy machinery. All parts of the coconut are refined - the oil can be used to make environmentally friendly detergents and off course ice-cream, the juice is used to make sugar, the husks are used to make ropes, mattresses and car seats, the coconut milk can be used as a substitute for dairy products that can be used also for making dairy free ice-cream, the copra is edible (the dry white pulp inside the coconut) and the wood can be used to construct buildings (Coca, 2020).

4.2 The majority of the components used in ice-cream production are imported from far countries

The best way to lower carbon emissions is to buy locally. As mentioned earlier, coconut oil is often imported from Southeast Asia, which means that coconut oil is only available locally after a long journey and the associated carbon emissions. Although the demand for coconut oil is growing by 10%, the supply is only growing by 2% (Hester, 2020).

Governments in the Asia Pacific are beginning to clear additional land for coconut oil cultivation to meet the demand. In this regard, palm cultivation is less sustainable than coconut cultivation. Unlike coconut trees, the palm tree is cultivated in industrial monocultures. Coconuts and their trees can be used in various ways, but palm trees only provide oil. Palm cultivation takes up 18.9 million hectares of land, while coconut production takes up 12.3 million hectares (Coca, 2020). Water footprint: moderate 4,490 litres of water to produce 1 kilogramme of refined coconut oil, compared to moderate 4,971 litres of water to produce 1 kilogramme of refined palm oil. Carbon footprint: moderate 2.1 kg CO_2e to produce 1 kilogramme of coconut oil, compared to palm oil, which has a high carbon footprint, 3.3 kg CO_2e for the production of 1 kilogramme (Healabel, 2021).

4.3 The environmental impact of various egg products during processing and transportation

A carbon footprint label for food should become mandatory. The InterOVO Egg Group has carried out a carbon footprint assessment of the processing and transportation of various egg products (Mao, 2021).

The company determined the carbon footprint of the plants in Waalwijk, Nunspeet and Ochten in the Netherlands of free-range egg, egg yolk, liquid whole egg, whole egg powder and egg white powder; (Mao, 2021). Egg yolk is not used as much in ice-cream production nowadays, as other safe substances can be used to emulsify the fats with water. Egg yolk, which contains fat floating in the water, is an emulsion and a very efficient stiffening agent due to its high lecithin content and many different proteins. For this reason, egg yolk is used in traditional recipes for ice-cream, sometimes called frozen custard. Stability is enhanced by converting the egg yolk's phospholipids into lysophospholipids with the help of lipases (Rubin, 2012).

Egg yolk consists of 16% protein, 32% lipids and 50% water. Phospholipids, especially phosphatidylcholine, make up about a third of the lipids (about 80%). These carbon footprint calculations are for egg white powder (from 33,363 g/kg to 40,524 g/kg), whole egg powder (from 13,607 g/kg to 16,226 g/kg), egg yolk liquid (from 6,587 g/kg to 8,050 g/kg) and whole egg liquid (from 2,830 g/kg to 3,433 g/kg), while the lowest values were found for free-range eggs (from 2,334 g/kg to 2,846 g/kg).

The study shows that the higher the economic value-added, the greater the CO_2 emissions. The egg production system was responsible for most of the CO_2 emissions from egg products (from 68.3% to 79.4%). GHG emissions from egg processing were primarily due to energy use for all egg products (ranging from 78.7% to 93.6%), except for free-range eggs, primarily due to the factory's energy use. Here the most critical factor was the production of packaging material (51.5% overall). Ochten produced the most environmentally friendly liquid product (CO_2 emissions of 149g/kg liquid egg yolk and 149g/kg liquid whole egg), while Waalwijk produced the most environmentally friendly egg white powder (CO_2 emissions of 1,961 g/kg). InterOVO Egg Group can use these findings to minimise GHG emissions in the future.

The environmental impact of the life cycles of these commodities was assessed using a life cycle assessment, with particular attention to processing and transport. The entire life cycle is covered from the means of production, feed and fertiliser to the actual egg production on the farm, to the processing of the egg products and delivery to the consumer. Global warming has received more attention in recent years as its impact on the environment has become more apparent. Large amounts of energy are required to produce, process and transport egg products, and the resulting carbon dioxide (CO_2) emissions contribute to global warming (Mao, 2021). The conclusion of this review is a clear message that the use of synthetic stabilisers and emulsifiers helps reduce the carbon footprint of ice-cream production.

4.4 The environmental impact of the most popular ice-cream flavours

Vanilla ice-cream is the most popular flavour among ice-cream lovers. An independent study concluded that 84 per cent of United Kingdom ice-cream shops ranked vanilla as the most popular flavour (Jenkins, 2021). Vanilla's innate simplicity and versatility fuel demand and ensure that market opportunities for the traditional flavour remain robust. Despite supply difficulties, vanilla remains the "queen of flavours", with synthetic and natural forms used in the industry. No wonder why vanilla ice-cream is so popular. The premiumisation of vanilla offers several opportunities for companies looking to highlight its provenance and sophistication. In 2019, Nielsen-Massey, primarily focused on vanilla products, launched a pure vanilla extract from Uganda and Indonesia to capture consumer interest in global flavours (Fields & Fields, 2021).

The company produces the pure vanilla paste from Madagascar and has developed this essential product, especially for gourmet chefs, bakers and ice-cream makers. Making vanilla in paste form is easier to handle and more practical for standardised recipes. Apart from chocolate, which was voted the second most popular ice-cream flavour by 20% of ice-cream shops in the United Kingdom (Ice-Cream Parlour Survey), strawberry was declared the third most popular flavour by 14% of ice-cream shops (Green, 2020). In Malta, these three particular ice-cream flavours are also very popular.

Vanilla has a considerable water footprint: 1 kilogramme of vanilla beans requires 126,505 litres of water. Vanilla production is relatively destructive, resulting in deforestation, soil erosion, wildlife endangerment, and GHG emissions. Vanilla requires the shade of trees to cultivate and requires a long ripening process; each flower must be pollinated by hand in the morning in all countries except Mexico, where native Melipona bees pollinate. The carbon footprint is possibly low, with 2.0 kg CO_2e to harvest 1 kg of vanilla pods (Healable, 2021).

The usage of cocoa produces one of the most popular sweet treats such as various chocolate flavoured ice-cream. It is also a very valuable commodity in the tropics. It is therefore critical to assess carbon emissions in cocoa-growing areas. The main objective was to calculate the carbon footprint per kilogramme of Colombian cocoa beans produced using the techniques of PAS 2050 for conventional and agroforestry management. The study results were compared with those of other researchers around the world to provide an overview of current research limitations and challenges related to carbon footprints. All calculated environmental impacts were lower (Fields & Fields, 2021).

Composting cocoa pod husks produced about 3.4 kg of methane and 2.55 kg of nitrous oxide emissions per kilogramme of cocoa grain produced under the agroforestry technique. As a result of this approach, Carbon footprint (C.F.) can be reduced by 6 kg CO_2e per 1 kg cocoa powder, which is significant. Due to the anaerobic disintegration of organic material, which accounts for more than 85% of the emissions, these cocoa residues remaining on the soil significantly impact the two farming systems studied (Rodriguez et al.,2016).

REWE Group (2009) studied the entire life cycle of strawberry cultivation in Spain. All stages of production, distribution, purchasing, product consumption and waste disposal result in total emissions of 0.88 kg CO_2 eq./kg strawberry basket (Manuela et al.,2009).

4.5 Waste Management in an artisanal ice-cream parlour

Ice-cream parlours generate much waste, including a high amount of water waste used to clean and manufacture ice-cream. Serving utensils such as cups, spoons, napkins and straws generates much waste. It is essential to be committed to recycling the waste and using local recycling facilities to the maximum. One should inquire about efforts and programmes to separate plastic, paper, metal and glass waste and then look for opportunities to repurpose or recycle non-recyclable waste. Also, one should consider whether one needs to buy these non-recyclable items in the future.

The European Union has agreed to start limiting plastic use. It included a law implemented in the year 2021 to ban single-use plastic (wedzinga, 2019). According to United Nations, by 2050, there will be more plastic in the oceans than fish. In today's world, plastic goods and packaging are no longer sustainable. One needs to consider using paper cups, biodegradable and compost material, metal straws and plastic alternatives.

There are several methods to reduce food waste. Food waste thrown in the rubbish often ends up in landfills where it decomposes and releases large amounts of methane. Reducing food waste as much as possible should be a prime target. Methane is a greenhouse gas that impacts the warming of the planet. One should start using environmentally friendly detergents, including machine and dishwashing detergents. Products with low phosphate content are preferable as they are better for water systems. Phosphates promote algae development and lower oxygen levels, which are harmful to fish and other aquatic life. Many companies have started to offer environmentally friendly cleaning solutions (Konstantas et al.,2019).

4.6 Conclusion

Mitigating climate change will always be a difficult task. All must be on deck, and all countries, especially those with the most pollution, must unite to create alternatives. The impact of climate change on the economic sectors of society and the carbon emissions of the food industry cannot be ignored. This must be seriously addressed to minimise the impact on the countries' economies. Adjustments must be made quickly but sensibly. Serious action must be taken quickly because one of the most alarming aspects of climate disorder could have been avoided if action had been taken earlier. Nevertheless, the global environmental problem will get worse every year if we all remain inactive. Carbon reduction is the only way to keep global warming under control.

Ice-cream parlours can help find solutions by reducing the carbon footprint of the components used to make ice-cream and other commodities. Reducing methane emissions can therefore have a very positive impact on the environment. Most ice-cream parlours rely heavily on dairy products in their recipes. Alternative substances must be utilised to decrease methane emissions.

Reduction of carbon footprint equivalent can be accomplished by expanding the usage of dairy alternatives. As demonstrated in the literature review, the carbon footprint of ice-cream manufacturers may be reduced at each stage and should be addressed with great responsibility. Ice-cream parlours generate much garbage with the disposable containers used in serving ice-cream. The literature review identified many areas that need to be monitored to reduce the amount of carbon in the atmosphere. This research will reveal how much energy is utilised in the gelateria, as well as what components are used, how much water is required, and how much waste is generated. For minimization of pollution, new alternatives must be created.

Chapter 5: Methodology for the Gelateria

5.1 Research based on a mixed methodology

Estimating the carbon footprint of the chosen gelateria is significant for assessing the influence on global warming and identifying mitigation methods. Furthermore, consumers are becoming more concerned about the environmental impact of the businesses they buy from and their products and use. Therefore, going green also makes economic sense as customers may prefer to buy products from shops that advertise a more sustainable form of business (Loughlan, 2017).

This case study will use a mixed methodology of quantitative and qualitative data. Quantitative data refers to quantities since the auditor will calculate the numerical data needed to make the gelateria more environmentally sustainable. In addition, qualitative data will be used to understand outcomes by providing descriptive information and referring to activities that can be seen but not measured. Qualitative data provides the auditor with a multi-method tool by considering an interpretive, logical approach. The auditor will also use qualitative research to examine items in their natural setting and evaluate the information relevant to the current situation.

The research method will begin by determining the level of the carbon footprint in the first phase of the case study. This will lead to developing a framework that provides comprehensive characteristics of all the operations within the ice-cream parlour that contribute to its carbon footprint. When the components are fully represented, the size of the carbon footprint generated in this operation will help the auditor investigate the footprint in the operation of the gelateria and how the implementation of solutions can help reduce it.

5.2 Which tools will be used to calculate the carbon footprint?

The auditor will categorise the emissions produced by the business' operations. To categorise the emissions, environmentally friendly criteria must be devised - standards that are typically classified into distinct categories as follows:

- The direct control category, which includes all carbon emissions produced by machinery and subsequent maintenance. Leaking gases from refrigerators and air conditioners and inefficient condensers that take longer to cool due to lack of maintenance are examples of direct on-site emissions. This inefficiency results in energy prices. This category also includes transportation and commuting using gasoline and diesel.

- Indirect emissions are caused by purchased electricity. These emissions do not occur on-site but instead occur at the power plant during manufacturing, which results from the machinery's energy.
- Business activities that do not own or control, such as shop delivery, procurement and waste and water emissions. These contribute to additional secondary emissions which are often responsible for most of the carbon footprint.

Although the auditor will separate the ice-cream parlour's operational footprint estimations into these categories, the calculation must consider all the business's essential and relevant emission sources. The case study used carbon estimates, power and water use calculations, inventory management plans, and target proposal frameworks to analyse and categorise food waste. Thresholds are used to appropriately represent the carbon footprint components and analyse the carbon footprint caused by the ice-cream parlour's activity.

5.3 Blueprint of the ice-cream parlour

The auditor used the services of a draughtsman to design a blueprint of the ice-cream parlour used for the case study. The draughtsman visited the site and took all the required measurements. A study is being conducted to see how energy may be saved by changing the bulbs, refrigerators, and air-condition compressors placed in the shaft to achieve better air circulation and lower temperatures. The area is constantly under a shadow.

The auditor will work with a technical specialist to track all the ice-cream parlour machinery's energy use. Each piece of equipment that utilises electricity will have its amperage monitored so that calculations can be performed to see which machines are efficient and which are not and how much power is consumed each time they run. Some machines operate 24 hours a day, seven days a week, while others are only activated while certain things are being made.

A yearly electricity bill and kilo watt per hour (kwh) consumption consumed during the operation of the ice-cream parlour were gathered for this project, as shown in Table 2. The annual amount of carbon emissions produced by the ice-cream parlour's operation may be calculated by analysing the data. Having a roof space of about 70 square meters in availability, an engineer will determine the number of solar panels needed to provide a certain amount of power.

The auditor will estimate water consumption if the business will use water from the well. The auditor will record the amount of water used for cleaning machines, tools and floors and the water used by the scooper washers, through which freshwater constantly flows so that the scoopers are rinsed with clean water every time to minimise flavour allergies contamination.

5.4 The premises underpinning the case study's analysis

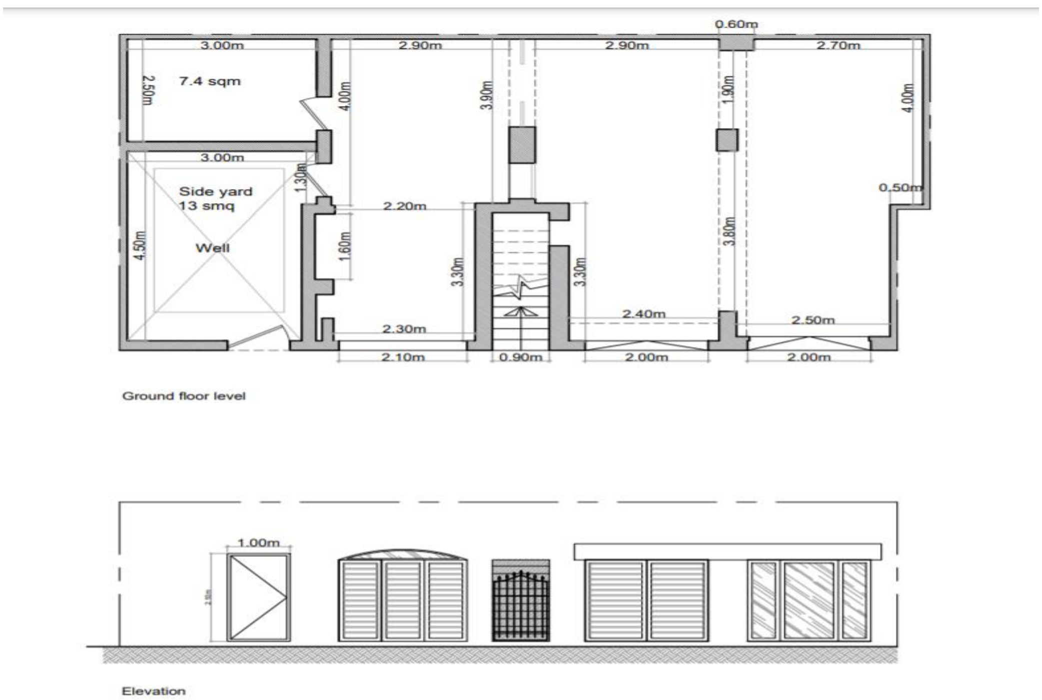


Figure 4: Blueprint plan of the gelateria

The shop is situated in the south of Malta. It can be said that the shop used for this research was opened 30 years ago. The building is not very large, as shown in the draughtsman's plan provided in Fig. 4. The business has 55 years of experience in the ice-cream sector and observed how the industry has changed drastically over these years.

The ice-cream parlour, or gelateria as the proprietor calls it, is separated into three sections. There is one section where the production takes place, another where the ice-cream is served, and the third section is the consumers' area.

All essential equipment for making ice-cream, pastries, and other artesian frozen and chilled treats may be found in the manufacturing area. The sheer quantity of machines and the order in which they are grouped first strikes the visitor. The production area includes a batch freezer that freezes and whips the ice-cream, a pasteuriser that cooks and pasteurises the ice-cream base, and an ageing vat that allows the ice-cream base mixture to mature for 24 hours, a blast freezer, a microwave, and two ovens, one static and one convection, as well as a walk-in freezer that keeps the ice-cream at a temperature of 24^{o}c below 0. There is also a shelf for ingredients on one wall.

One may consider investing in an energy backup. Whenever there is a power cut, especially during peak summer hours, the shop will have to close until the electricity is restored. If this power cut takes a long time, the business will lose thousands of euros because the frozen stock will melt and must be disposed of. Instead of purchasing a generator that generates a high amount of CO_2e, solar panels may be the best solution to be installed on the property's roof. The auditor requested the assistance of a technical expert to compile a list of all machines' total energy usage as shown in Table 1.

According to the auditor, installing solar panels saves energy costs as well as reduces food waste. For example, in the summer season, sometimes power outages occur rather frequently. When the power goes out for a long period of time and of course this would cause all the frozen products to melt, these will have to be thrown away unless solar panels are installed. In addition, because the solar panels provide power, there is no loss of business during a power outage. Installing the panels reduces the carbon footprint of running the ice-cream parlour by reducing the electricity consumption purchased from the power company. Considering how much water is needed to clean all the utensils after discarding the melted ice-cream to clean all the ice-cream containers, including the displays and freezers, the operation results in increased water waste, which also increases the water footprint.

5.5 Electrical power measure for every piece of equipment found in the gelateria

Table 1 shows a list of the equipment used in the gelateria for the operation and production of ice-cream. Even though the gelateria is small, many appliances are needed for operation and the auditor has asked to find out for each appliance how much electricity they generate per hour and an average time of use for each appliance so that one has an idea of how much electricity each appliance generates during operation. The report can be seen in appendix 4. One can also get an idea of how much carbon footprint each appliance generates. It is important to replace the appliances that consume the most CO_2 with modern appliances that produce less CO_2. According to Statista Malta energy consumes 401 grams of CO_2 kilowatt/hour (Tiseo, 2022).

Gelateria							
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Opening Times	Closed	10:00-22:00	10:00-22:00	10:00-22:00	10:00-23:00	10:00-00:00	10:00-22:00
		12 Hours	12 Hours	12 Hours	13 Hours	14 Hours	12 Hours
Description	**Power in watts**	**Phase**	**Used/hour**	**Watt/hour**	**Kilowatts**	**Cost/hour**	
						1000kw/€0.16	
						€0.16	
Laboratory							
Air Condition Lab	4800	3	12	57600	57.6	€9.22	
Walk in freezer	3000	3	24	72000	72	€11.52	
Batch freezer	2000	3	4	8000	8	€1.28	
Ageing Vet	8000	3	24	192000	192	€30.72	
Pasteurizer	1500	3	1	1500	1.5	€0.24	
Blast freezer	1200	1	4	4800	4.8	€0.77	
Microwave	2000	1	1	2000	2	€0.32	
Upright Fridge	260	1	24	6240	6.24	€1.00	
Planetaria mixer small	570	1	2	1140	1.14	€0.18	
Planetaria mixer large	875	1	1	875	0.875	€0.14	
Convection oven 5 shelves	2150	1	3	6450	6.45	€1.03	
Service area							
Soft ice cream machine	1700	3	24	40800	40.8	€6.53	
Slush machine	1600	1	12	19200	19.2	€3.07	
Ice-cream display Freezer	4000	3	12	48000	48	€7.68	
Panna Machine	550	1	24	13200	13.2	€2.11	
Microwave	1800	1	2	3600	3.6	€0.58	
Double door bench fridge + drawer	900	1	24	21600	21.6	€3.46	
Crepe area / Coffee bar							
Air condition	550	3	12	6600	6.6	€1.06	
Blenders x 4	800	1	3	2400	2.4	€0.38	
Coffee machine	3400	1	12	40800	40.8	€6.53	
Waffle burner	1800	1	6	10800	10.8	€1.73	
Bubble waffle burner	1750	1	5	8750	8.75	€1.40	
Double door bench fridge	900	1	24	21600	21.6	€3.46	
Countertop Prep Fridge	1000	1	24	24000	24	€3.84	
Customer Area							
Air condition	550	3	24	13200	13.2	€2.11	
Double door soft drink fridge display	900	1	24	21600	21.6	€3.46	
Glass upright freezer 1	900	1	24	21600	21.6	€3.46	
Glass upright freezer 2	900	1	24	21600	21.6	€3.46	
Display pastry rotator fridge	780	1	12	9360	9.36	€1.50	
Whole Area ceiling lights	1500	1	12	18000	18	€2.88	
Security/Point of sales/internet/tv	1000	1	24	24000	24	€3.84	
Menu monitors x 4	40	1	12	480	0.48	€0.08	
Digital Menu	60	1	12	720	0.72	€0.12	
Total			**452**	**744515**	**744.515**	**€119.12**	

Table 1: Technician report of all equipment.

5.6 Electricity consumption for the year January 2019 – January 2020

Bill number	Consumption / KWh	Bill Amount
1	14502	€2,366.19
2	7608	€1,482.94
3	12819	€2,416.38
4	10676	€1,961.53
5	2392	€2,651.64
6	8227	€1,358.43
7	3907	€1,192.95
8	5171	€848.07
Totals	**65302**	**€14,278.13**

Table 2: Collection of annual bills and consumption.

One had to analyse the energy consumed. To do this, a collection of annual bills from January 2019 to January 2020 had to be calculated. The total bills summed to €14,278.13, for a total amount of energy consumed of 65,302 kWh for that year, approximately 180 kWh per day on average. The auditor presented these figures to the engineer to calculate the number of solar panels needed if investing in the panels was the best option. The construction plan of the roof was also calculated so that the engineer had a clear picture of the situation and could determine if there was enough space to install the required solar panels.

5.7 Engineer's report about the solar panels

The engineer indicated to the auditor that the Photovoltaic (P.V.C.) 11 generates 1600 kWh / kWp (kilowatt peak). In the case stated by the auditor, the engineer determined that around 40 kWp of panels would be necessary to produce the quantity of 65,302 kWh.

According to the engineer, if the business invests in 30 panels, the total power generated is 460 watts (13.8kWp), which generates approximately 60 kWh and saves 8,278 kg CO_2 per year, or 38% of current use (Camilleri, 2021).

The engineer suggested that an area of circa 70 square metres is needed to install 30 panels. According to the measurements of the building plan, this area is available, and the investment can be made depending on the availability of the area. From the documents provided, the total electricity consumption per year is 65,302 kWh, including taxes and rental costs amounting to an annual bill of €14,278. The investment for the installation of the 30 panels is €19,000, excluding government subsidies.

According to the engineer's report, each panel provides 460 watts (13.8 kWp), so the 30 panels provide 13,800 watts in total. If you convert this amount to kWh, you get 13.8 kWh, as stated in the report. The report says that the company will save €4,788 each year by installing the panels, which means that the electricity bill will be reduced to €9,490. An investment of €19,000 without considering government subsidies and a saving of €4,788 means that the investment will pay for itself in less than 4 years (Camilleri, 2021). The engineer's report can be seen in appendix 1.

The engineer stated that, 'According to the local service provider (Enemalta) data, that may be obtained publicly from,

(https://www.enemalta.com.mt/environment/fuel_mix_for_energy_distribution/), generated electricity comes at a carbon cost of 378 gCO_2/kWh.' (Camilleri, 2021). The gelateria produces 24,684 kg of CO_2e only from power use. The gelateria will save 8,346 kg of CO_2e per year by adding solar panels, lowering its carbon footprint by 34%. This is the calculation: Alternative Energy (22,080 kWh) / Energy Consumed (65,302 kWh) x 100 = Carbon Footprint Reduction percentage (34%). Please refer to Table 3.

Energy expenditure	**Energy consumed**	**Space available**	**Number of panels**	**Alternative energy generated**	**Energy saved**	**Carbon unites reduced**	**Carbon footprint reduction**
Euros	KWh	M^2		KWh	%	KG CO_2 / year	%
14,278	65,302	70	30	22,080	38	8,346	34

Table 3: Table showing the engineer's figures report.

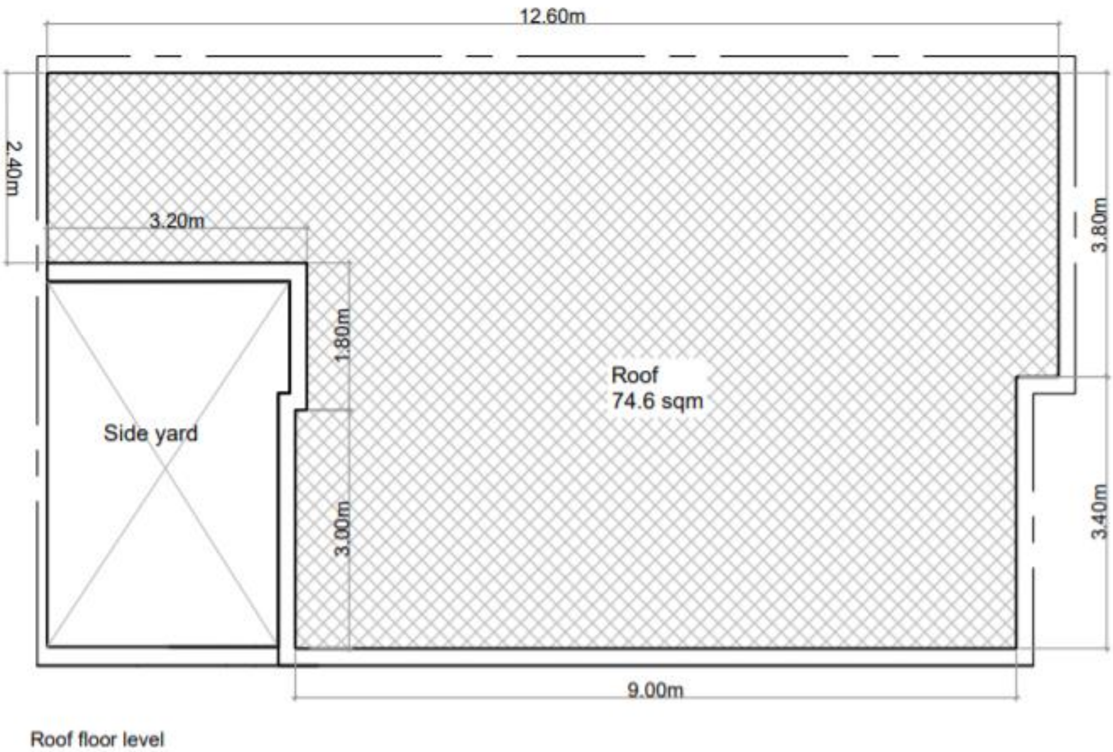


Figure 5: Blueprint of the rooftop.

5.8 Calculating the use of CFL and LED light bulbs

In this section, the following is going to be analysed:

1.Energy difference: Calculation to identify the difference of the energy between Compact Fluorescent Lamps (CFLs) and light-emitting diode (LEDs)

1a Identifying the economical consumption between two bulbs.

1b Cost saving between the two bulbs price difference and bulbs life duration span.

2. The maintenance savings between the two bulbs.

2.1 Changing of bulbs costs.

2.2 Maintenance labour cost.

3. Bulb cost

3.1 Identifying the cost difference in converting from CFL to LED

3.2 Identifying the total saving.

3.3 Identifying the global cost savings.

3.4 Identifying the annual saving.

4. Return on investment

    4.1 Identifying investment difference for the total project.

    4.2 Identifying the investment rebate timeframe.

5. Identifying the CO_2 e factor of Malta.

6. Identifying the CO_2 e annual reduction savings.

1. **Energy difference.**

Calculation of the difference of kWh consumption between one CFL and one LED, comparing the life of one LED. It is good to note that the life span of one LED is 50,000 hours whereas the life span of one CFL bulb is 10,000 hours (Principi and Fioretti, 2022).

Formula: (CFL watts – LED watts) / 1000 X LED life.

(15 watts – 8 watts) / 1000 x 50,000 hours = 350 kWh.

In conclusion, the savings difference would be 350kWh.

1a. Energy saving

Calculation of the energy saving in kWh for the totality of the project over the life of one LED.

Formula: ((CFL watts – LED watts) / 1000 x LED life) X total number of bulbs -

350 kWh x 60 bulbs = 21,000 kWh.

1b. Cost-saving

Calculation of the cost-saving in euro over the life of one LED lamp compared to one CFL lamp.

Formula: ((CFL watts – LED watts) / 1000 X LED life) X total number of bulbs) X energy cost in euro / kWh

350 kWh x €0.16 = €56.

2. **Savings in maintenance**

2.1 How many times would one need to change the bulb if one chose a CFL instead of the LED?

Formula: (LED life in hours / CFL life in hours) – First installation = number of changes

(50,000 hours / 10,000 hours) – 1 = 4 times more.

2.2 Calculate labour costs associated with changing one CFL over the life of one LED.

Formula: Number of changes x hour labour cost x necessary time to change one bulb

4 times x €18/hour x 0.25 hrs = €18.

3. **Bulb Cost**

3.1 Calculation of the costs associated with changing the CFL over the life of one LED

Formula: CFL cost X number of changes.

€4 x 4 times = €16.

Conclusion estimate for part 1

3.2 Calculation to find out the savings between the lifetime of one LED over the lifetime of one CFL:

Energy + maintenance + Bulb cost.

€56 + €18 + €16 = €90 will be saved if using LED bulb, 4 times longer life.

Now one has to subtract the difference of purchase cost as follows:

CLF cost is €4.

LED cost is €12.

Thus, the total difference between the two bulbs is €8.

€90 – €8 = €82 is the actual difference cost saving if using LED.

3.3 Calculation of the savings for the global project over the life of one LED.

Formula: Saving for one bulb x total number of bulbs.

€82 saving per one bulb x 60 LED bulbs = €4,920 total savings in a life of a bulb.

3.4 Calculation of the annual savings:

Formula: Total saving/number of years the LED will be used

LED total years usage = (LED life in hours / daily usage / 350)

50,000 hours / 12 hours per day / 350 = Approximately 12 years.

Annual savings = €4,920/12 years = €410 per year are saved using LED instead of CFL bulbs.

4. **Investment rebate**

Investment payback in the case that the owner decides to install the LED instead of the CFL, taking into account the costs.

4.1 Calculation of the investment difference for the totality of the project between LED and CFL.

Formula = (LED cost – CFL cost) x total number of bulbs.

(€12 (cost of one LED) - €4 (cost of one CFL)) x 60 Bulbs = €480. Therefore LEDs are more expensive than using CFL bulbs.

4.2 Calculating the period to get a payback on investment difference.

Formula: investment difference / annual saving

€480 (investment rebate) / €410 (annual savings) = €1.17.

€1.17* 12 = 14. This means that it will take approximately 14 months for Return of Investment from energy consumption saving cost.

5. **CO_2 Equivalent Calculation**

In the event that the business owner decides to switch from CFL to LED, the ice-cream parlour would become more environmentally friendly, would emit less CO_2 and would save money on the electricity bill. All this by simply changing different type of light bulbs. In Malta, it is stated that for every 1 kWh consumed, 0.89 kilos of CO_2e is generated (Malta Independent, 2022).

6. **The amount of carbon footprint reduction**

Formula: kWh saving x-factors

21,000 kWh x 0.89 = 18,690 kg of CO_2e = 18.69 tonnes of CO_2e.

A lifetime of a single LED bulb will reduce 18.69 tonnes of CO_2e.

Therefore, sixty bulbs will save 18.69 tonnes of CO_2e in 12 years.

This means that 1.56 tonnes of CO_2 per year is saved.

(18.69 tonnes of CO2e / 12 = 1.56 tonnes of CO2e per year).

5.9 Calculation of the consumption of water use and how much it costs

Months	Business Season Low medium high	Daily Water consumption Cubic M	Total month consumption Cubic M	Well water bowser refill	Water from the tap water supply	Total Savings
				€1.71	€2.37	
January	**Low**	**0.7**	**21**	**€35.91**	**€49.77**	**€13.86**
February	**Low**	**0.8**	**24**	**€41.04**	**€56.88**	**€15.84**
March	Medium	0.9	27	€46.17	€63.99	€17.82
April	Medium	0.9	27	€46.17	€63.99	€17.82
May	Medium	1	30	€51.30	€71.10	€19.80
June	High	1.2	36	€61.56	€85.32	€23.76
July	High	1.2	36	€61.56	€85.32	€23.76
August	High	1.3	39	€66.69	€92.43	€25.74
September	High	1.1	33	€56.43	€78.21	€21.78
October	Medium	1	30	€51.30	€71.10	€19.80
November	**Low**	**0.7**	**21**	**€35.91**	**€49.77**	**€13.86**
December	**Low**	**0.6**	**18**	**€30.78**	**€42.66**	**€11.88**
Total				**€584.82**	**€810.54**	**€225.72**

Table 4: Water consumption calculation table.

Since rainfall is usually in January, February, November and December this would cover for the winter season when the business is low. Thus, it could be said that during the business' low season, the gelateria would be using the rainwater which came at no cost from the previously collected rainwater.

As a result, if the low months' usage of water is covered by rainfall, the business will save either €143.64 from the cost of the bowser, or €199.08 from purchasing water from the Water Services Corporation (WSC) depending on which service on uses.

Therefore, one needs to consider that the water from the well needs the pump to supply water in the taps. Now, the pump consumes 746 Watt per hour (WpH). It is estimated that the pump is used for about five hours daily during a typical 12-hour shift.

Formula: watts x hours / 1000 = kWh.

746 WpH x 5 hr / 1000 = 3.73 kWh.

The tariff paid for electricity from Enemalta is €0.16 / kWh.

As a result, the well water cost must be increased by

3.73 kWh x €0.16 = €0.60 /hour.

Therefore, the cost of power used to pump water to the taps is €3.00 (€0.60 x 5hrs = €3.00) per day. As a result, the total cost of electricity required for the water pump is roughly €1,050 per business year (350 days).

This concludes that for the water to be sustainable, the pumps must be powered by electricity generated by solar panels. Water from the well will be unsustainable without the solar panels.

5.10 Non-biodegradable waste

The table shows the annual weight of non-biodegradable waste generated from the Gelateria. Each month has a specific season, indicating whether it is a weak, medium or strong business season. The weight is in kilos and shows the total amount of waste consumed in each month. The grand total of annual waste generated is that of 708,754 kilos. It also shows that the waste is separated in accordance with the Malta Waste Regulations, sub-law 549.63 (MTA, 2022).

Season	Slow season	Slow season	Mid-season	Mid- season	Mid-season	Peak season	Peak season	Peak Season	Mid-season	Mid-season	Slow season	Slow season	
Month	January	Febuary	March	April	May	June	July	August	September	October	November	December	
weight	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	
Total waste/kg	42645	49468	53732	56291	62261	72496	75054	85289	73349	57144	49468	31557	100%
Amount of recycle waste /kg	14926	17314	18806	19702	21791	25373	26269	29851	25672	20000	17314	11045	35%
Amount of glass waste /kg	8529	9894	10746	11258	12452	14499	15011	17058	14670	11429	9894	6311	20%
Amount of mixed waste /kg	19190	22260	24179	25331	28017	32623	33774	38380	33007	25715	22260	14201	45%
Total Amount of waste	42645	49468	53732	56291	62261	72496	75054	85289	73349	57144	49468	31557	

Table 5: Non-biodegradable waste table.

5.11 Biodegradable waste calculation

The following table shows the annual weight of biodegradable waste generated in the Gelateria. Each month has a specific season, indicating whether it is a weak, medium or strong business season. The weight is in kilos, in accordance with the Malta Waste regulations, sub-law 549. 63 (MTA, 2022). The table shows the different types of food waste generated at the Gelateria each month. The month of August is the busiest month with an average generation of 55,159 kilos of organic waste. The least busy month is December with an average consumption of 12,687 kilos. Most food waste consists of fruit peelings, which account for about 45% of total bio-waste, followed by 25% eggshells, 10% coffee pods and 5% paper napkins. Other food waste, consisting of expired and spoiled food accounts for 15%.

Season	Slow season	Slow season	Mid-season	Mid- season	Mid-season	Peak season	Peak season	Peak Season	Mid-season	Mid-season	Slow season	Slow season	
Month	January	Febuary	March	April	May	June	July	August	September	October	November	December	
Weight	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	
Total organic waste /kg	**18478**	**21435**	**34750**	**36405**	**40266**	**46885**	**48540**	**55159**	**47437**	**36957**	**31992**	**12687**	**100%**
Fruit peel	*8315*	*9646*	*15638*	*16382*	*18120*	*21098*	*21843*	*24822*	*21347*	*16630*	*14396*	*5709*	**45%**
Egg shells	*4620*	*5359*	*8688*	*9101*	*10067*	*11721*	*12135*	*13790*	*11859*	*9239*	*7998*	*3172*	**25%**
Waste food	*2772*	*3215*	*5213*	*5461*	*6040*	*7033*	*7281*	*8274*	*7116*	*5543*	*4799*	*1903*	**15%**
Coffee pods	*1848*	*2143*	*3475*	*3640*	*4027*	*4689*	*4854*	*5516*	*4744*	*3696*	*3199*	*1269*	**10%**
Paper napkins	*924*	*1072*	*1738*	*1820*	*2013*	*2344*	*2427*	*2758*	*2372*	*1848*	*1600*	*634*	**5%**
Total Amount of organic waste	**18478**	**21435**	**34750**	**36405**	**40266**	**46885**	**48540**	**55159**	**47437**	**73913**	**31992**	**12687**	**467947**

Table 6: Biodegradable calculation table.

According to a study conducted by the Food Standards Agency in the United Kingdom, organic waste produces between 15 to 25 kg of compost for every 100 kg of food waste (Rattray, 2022). One can consider generating compost from food waste and negotiating a trade with a farmer who supplies the gelateria with strawberries. This will not only assist to reduce food waste's carbon impact, but it will also help the business generate more money by composting food waste.

The market price of compost is at an average of €1.65 for every kilo of compost. According to the auditor's calculation, the gelateria consumes 467,947 kg of Bio-organic waste per year. Thus, the gelateria will consume an average of 60kilos of compost. This means if the compost is sold at the market average price, this will amount to a total of €100 worth of compost. Therefore, if compost is sold to the farmer at a reduced price of €1.50 per kilo, this will amount to a total of €90. Now, the price of the strawberries is €1.50 for every 200 grams according to the owner's given price.

Bartering the compost with strawberries means that the owner will get 13.2 kilo of strawberries. Factoring in that the owner of the gelateria usually purchases 150 kilograms of strawberries when in season, this means that 8.8% of the usual purchase will be gained from food waste.

5.12 Waste generated in the gelateria

The below table is showing all the waste generated by the gelateria, divided into three seasons: a). the peak season which are the summer months, b). the medium season which are Spring and Autumn and c). the low season which is winter. This table also includes the organic waste stream percentage having an average of 56%. This amounts to 92.19 kilos of carbon units and 99.57 kilos of carbon footprint per year. Generating compost will help to reduce the bio-organic waste carbon footprint and generates extra income to the business.

Season	**Month**	**Bio-organic waste**	**Non-biodegradable waste**	**Organic waste stream**	**Total waste**	**Carbon units**	**Carbon footprint**
		kilos	kilos	Percentage	Kilos	kilos	kilos
Peak Season	June	46,885	72,496		119,381		
	July	48,540	75,054		123,594		
	August	55,159	85,289		140,448		
Total		**150,584**	**232,839**	**64.7%**	**383,423**	**95.86**	**103.52**
Mid-Season	March	34,750	53,732		88,482		
	April	36,405	56,291		92,696		
	May	40,266	62,261		102,527		
	September	47,437	73,349		120,786		
	October	36,957	57,144		94,101		
Total		**159,410**	**302,777**	**52.6%**	**462,187**	**115.55**	**124.79**
Slow Season	November	31,992	49,468		81,460		
	December	12,687	31,557		44,244		
	January	21,435	42,645		64,080		
	February	21,435	49,468		70,903		
Total		**87,549**	**173,138**	**50.6%**	**260,687**	**65.17**	**70.39**
Average		**132,514**	**236,251**	**56%**	368,765	**92.19**	**99.57**

Table 7: Total waste calculation table.

5.13 Food waste to be generated into compost

The average organic waste stream of the gelateria has reached a volume of 56%. This volume, as explained earlier, is composted in a 310 litre (lt) composter with the help of a composter that helps to convert the organic material into compost faster. The mixture consists of mesophilic and thermophilic bacteria, moulds and yeasts derived from different types of microbial cultures, all naturally present in the soil in extremely small quantities. This process helps to decompose the food waste produced at the gelateria more quickly into compost. The gelateria must invest in a composter of 310 litre that costs €105 and a starter composter pack that costs €12.50, which will amount to a total cost of €117.50. The invoice is attached in the appendix 2.

Chapter 6: Discussion - The Evaluation and assessment of the operation's outcomes

6.1 Calculation to determine the annual quantity of carbon unit and carbon footprint produced

The Carbon dioxide equivalent (CO_2e) is used to symbolise diverse greenhouse gases as a single carbon unit. The auditor has examined CO_2e produced from the waste consumed by the gelateria—an amount that will represent how much CO_2e is produced that will affect the global warming by the quantity of greenhouse gases produced (Ecometrica, 2012).

The quantity of greenhouse gas can be represented as CO_2e by multiplying the quantity of the greenhouse gas by its global warming potential. Therefore, 1 kg of methane produced from waste is expressed as 0.25 mole of CO_2e (1 kg * 0.25 mole = 250 g CO_2e/unit), therefore the quantity is 0.25 kg (Ecometrica, 2012).

It was calculated that during the peak season 95.86 kg of carbon per unit/year is produced, and another 115.55 kg carbon per unit/year during the mid-season with 65.17 kg carbon per unit/year in the slow season. This results in an average 92.19 kg of carbon units produced per year.

The atomic weight of a carbon atom is 12 amu or atomic mass units and the atomic weight of oxygen is considered to be 16 amu or atomic mass units, so the total atomic weight of CO_2 is (C)12 + (O)16 + (O)16 = 44 grams calculated with the formula (12 + (16 * 2) = 44 grams of CO_2). The percentage of carbon can be calculated by dividing the mass of carbon over the mass of carbon dioxide 12/44 = 0.27. Table 7 shows the total waste generated in three different seasons, referred to as "peak", "mid" and "low", the two categories of waste generated as bio-organic waste that can be converted into compost and non-biodegradable waste, and an indication of the organic waste stream as a percentage.

Therefore, every 1 kg of CO_2 can be expressed as 0.27 kg of carbon units, as this is the amount of carbon in CO_2. Meaning that the carbon footprint produced during the peak season is 103.52 kg (383,423kg waste during the peak season x 0.27 kg of CO_2); carbon footprint during the mid-season reaches 124.79 kg (462,187 waste during the mid-season x 0.27 kg of CO_2), and during the slow season it reaches 70.39 kg (260,687 kg waste during the slow season X 0.27 kg of CO_2). Therefore, the average carbon footprint per year from the waste reaches the amount of 99.57 kg.

6.2 Calculations of the total investment made to reduce the carbon footprint

One will interpret the reports and studies to determine how the business can be more environmentally friendly by investing and making the company more sustainable. The engineer's report on electricity use stated that instead of keeping 70 square metres of unused roof space, it would be far wiser to cover it with solar panels. He concluded that by installing 30 panels, the gelateria will save €4,788 in electricity costs each year. The space will generate revenue that will support the company's investment in greater sustainability and decrease the carbon footprint. The return on investment of €19,000 (without government subsidies) will be achieved in less than four years. The gelateria will save 8,346 kg of carbon footprint annually generated by the power station, reducing its carbon footprint by 38% (see Engineer’s Report in Appendix 1).

The auditor suggested a change-over from CFL to LED bulbs and calculated as shown above that this saves electricity and is also environmentally friendly. As the literature review pointed out, CFL bulbs need to be discarded of with care and that their removal will lead to a more sustainable business.

The auditor has calculated how much electricity will be saved if the owner replaces the light bulbs. The difference in consumption between a CFL bulb and an LED bulb over the life of an LED was obtained from the formula (CFL watt - LED watt) / 1000 x LED life. This calculation shows that the difference between the two bulbs is 350 kWh. There are a total of 60 light bulbs in the building. To determine how much the gelateria can save with a total of 60 light bulbs, the formula ((CFL watts - LED watts) / 1000 x LED lifetime) X total number of light bulbs were used.

To determine the amount of energy saved in kWh if the LED is used for the full project during the lifespan of an LED, first one needs to calculate the amount of energy saved in kWh if the LED is used for the entire project.

This calculation is as follows:

(CFL watts - LED watts) / 1000 X LED lifespan, (15 watts - 8 watts) / 1000 x 50,000 hours = 350 kWh, 350 kWh x 60 bulbs = 21,000 kWh.

Thus 21,000kWh will be saved.

The parameters between a life span of one CFL and an LED are 10,000 hours for a CFL bulb and 50,000 hours for LED bulb, using the formula:

(LED life in hours / CFL life in hours) – First installation = number of changes.

This calculation will indicate that LED has a life span of four times more than a CFL.

6.2.1 Bulb investment calculations

The following is a calculation of the consumption difference between one CFL and one LED over the life of one LED in kWh.

Formula to convert watts into hours:

Watts = (kWh x 1,000 / hrs), therefore in this case the formula will be as follows:

(CFL watts – LED watts) / 1,000 X LED life;

((CFL)15 watts – (LED) 8 watts) / 1,000 x 50,000 hours = 350 kWh.

Calculation of the energy saving in kWh for the totality of the project over the life of one LED.

Formula: ((CFL watts – LED watts) / 1000 x LED life) X total number of bulbs:

350 kWh x 60 (Bulbs) = 21,000 kWh. Therefore, the total saving will be 21,000 kWh X €0.16 = €3,360.

The total amount of 60 LED bulbs will consume 21,000 kWh during their life span. Considering that the electricity expense is €0.16 per 1 kWh, the expense will amount to €3,360.

6.2.2 How much will the business save from maintenance

The auditor studied how much the company could save in maintenance costs if the light bulbs were changed from CFLs to LEDs. Using the entitled formula: (LED lifetime in hours / CFL lifetime in hours) - initial installation = number of changes. Therefore (50,000 hours / 10,000 hours) -1 = 4 times.

The results show that four CFLs must be used for every LED, so the currently installed bulbs have an 80% shorter lifespan ((50,000 hrs -10,000 hrs) / 50,000 x 100 = 80%). As a result, if an LED has a four-fold longer lifespan than a CFL, the owner's CFL bulbs must be replaced four times in the current circumstance. A CFL bulb costs €4.00, so 60 bulbs cost €240, but LEDs cost €12 a piece, so 60 bulbs cost €720. The difference between the two is that LEDs cost €480 more, but they last four times longer. Therefore, the CFL will cost €960 more since these will have to be replaced four times per life span (€240 x 4 = €960) when compared to LEDs. With a price difference of €720 - €240 = €480, LED investment will cost €480 more. Kindly see Table 8.

Quantity of Bulbs	Quality of Bulbs	Value in € per Bulb	Total Value in €
1	CFL	€4.00	€4 x 1 = €4
60	CFL	€4.00	€4 x 60 = €240
1	LED	€12	€12 x 1 = €12
60	LED	€12	€12 x 60 = €720
Price difference between CFL and LED:			
€720 - €240 = €480			
Investment savings in the long run:			
(€240 x 4 = €960)			
€960 - €720 = €240			

Table 8: CFL versus LED savings.

The LED bulbs also give the company an advantage in other costs, such as reducing the maintenance costs of replacing the bulbs, since the LED has a life four times longer than a CFL. Therefore, one should factor in the cost of changing the bulb by calculating what an electrician would charge to change a bulb. The time needed to change the bulb must be taken into account. It is estimated that it takes about 15 minutes.

CFL Bulbs

The following formula must be used: the number of changes multiplied by the hourly labour cost (see Chapter 5.8) multiplied by the time it takes to change a light bulb. For example, 60 bulbs would be changed in 15 hours (60 bulbs x 0.25 hours = 15 hours). It has been already estimated that CFL need to be changed four times during their lifespan with an hourly charge of €18.

The working is as follows:

4 x €18 x 15 hours = €1,080

LED Bulbs

In contrast, LED maintenance for 60 bulbs would cost €270 provided that these do not need to be changed four times during their lifespan (€18 x 15 hours = €270).

Consequently, the CFL's maintenance expenses are €1,080, but an LED's maintenance costs €270, a significant difference of €810.

The number of bulb changes is four times X Labour cost / hr (see Chapter 5.8 for labour cost working) which is €18 x 0.25 hr = €4.50. Each time there is a bulb change there is a €4.50 charge. Therefore, since the life span of an LED bulb is four times as much longer when compared to a CFL bulb, one would save €18 on maintenance charge per life span of an LED bulb.

Therefore, changing all the bulbs will amount to €18 x 60 Bulbs = €1,080 in comparison €270 based on the lifespan of LEDs.

As a result, the savings from the cost of an LED is calculated by adding the various expenses of energy + Maintenance + Bulb cost, resulting in €3360 + €960 + €1,080 = €5,400 in savings.

Therefore, to find the total difference in the cost between the two bulbs, one has to calculate on 60 bulbs as follows:

LED cost = €720

CFL cost = €240

Total difference = €480

Finally, €5,400 - €480 = €4,920

Calculation of the annual savings = Total saving/number of years the LED will be used; therefore, the LED total years usage = (LED life in hours / daily usage / 350), the total lifespan of an LED is 50,000 hours, hour usage of electricity is of approximately 12 hours.

Therefore 50,000 hours / 12 hours per day / 350 = Approx. 12 years.

Annual savings = €4,920 /12 hrs = €410.

The auditor is calculating the return of investment in the case the owner decides to install the LED instead of the CFL, factoring in the costs.

Starting off by estimating the investment difference between LED and CFL for the entire project, the following calculation was used:

Investment difference = (LED cost – CFL cost) x total number of bulbs,

(€12 - €4) x 60 (Bulbs) = €480.

To calculate the time to get a return on investment, the following formula must be used:

Return-on-investment = investment difference / annual saving

Therefore €480 / €410 = €1.17 * 12 = Approx. 14 months. Therefore, the return of investment if bulbs are changed will be 14 months.

6.2.3 Usage of LEDs over CFLs to reduce the carbon footprint

Assuming the owner wishes to upgrade from CFL to LED lights, the company will become more environmentally friendly since it generates fewer carbon emissions and saves money on power bills. According to Maltese estimations, for every 1 kWh utilised, 0.89 kg of CO_2e is created (Malta Independent, 2022).

6.2.4 The amount of carbon footprint reduction when installing LEDs

The auditor has calculated the carbon footprint reduction using the formula: kWh saving x factor

21,000 kWh x 0.89 = 18,690 kg of CO_2 e = 18.69 tonnes of CO_2e

60 LED bulbs will reduce 18.69 tonnes of CO_2e in their lifetime. Therefore, by changing all 60 bulbs, the gelateria will be saving the environment 18.69 tonnes of CO_2 e.

Description	**CFL Bulbs**	**LED Bulbs**
Bulb estimated lifespan	10,000 hours	50,000 hours
Watts	15	8
Carbon Footprint	56.07 kg CO2e	31.15 kg CO2e
Carbon Footprint Generated / business year (12 hours operation for 350 business days)	(0.18 kg CO2e / 12hrs / 1bulb x 350 business days = (0.18 x 350) = 63 kWh/yr. ∴ 63 kWh x 0.89 = 56.07 kg CO2e 1 bulb: 56.07 kg CO_2e / yr.	(0.10kg CO_2 e / 12hrs / 1bulb x 350 business days = (0.10 x 350) =35 kWh/yr. ∴ 35 kWh x 0.89 = 31.15 kg CO_2 e 1 bulb: 31.15 kg CO_2e / yr.
Cost per bulb	€4	€12
Cost of energy / business year (12 hours operation for 350 business days)	€10.08 / yr. (12 hours x 0.015 kWh x €0.16 = €0.0288 per day; €0.0288 x 350 business days = €10.08) 1 bulb: €10.08 / yr.	€5.38 / yr. (12 hours x 0.008 x €0.16 = €0.01536 per day; €0.01536 x 350 business days = €5.38) 1 bulb: €5.38 / yr.
Energy Efficiency	More than incandescent bulb but less than LED bulb	A lot more than CFL's and incandescent bulbs
Turns on instantly	No	Yes
Affected by switching on and off	Yes – may reduce lifespan	No

Table 9: Comparison between CFL and LED bulbs.

6.3 Water consumption calculation

6.3.1 Pump electricity consumption calculation and carbon footprint generated during operation

Water use at the gelateria is being measured. The gelateria does not utilise the courtyard well. The auditor determined that using the well benefits the business and, if the owner installs solar panels, this can help to reduce carbon emissions.

This is because a water pump is needed to pump water from the well, and the electricity consumption of the pump must be calculated. Enemalta company charges €0.16 per kilowatt-hour for electricity (Gravino, 2022).

Therefore, the water cost of the well must be increased by 3.73 kWh x €0.16 = €0.60/hour. The daily cost of the electricity used to pump the water to the taps is €3.00 if used for 5 hours daily. As a result, the total price of energy required for the water pump is around €1,050.00 (€0.60 x 5 hours = €3; €3 x 350 days = €1,050) per year for 350 working days because the gelateria closes for holidays 15 days out of the year.

As a consequence, the carbon footprint of the pump is 37,600 kWh x 0.89 = kg CO_2 e = 33.46 tonnes CO_2e using the formula: kWh savings x factor results in the pump generating 33.46 tonnes CO_2e per year.

6.3.2 Water usage in the gelateria during operation

The use of the well water might be beneficial to the company. The well has a capacity of 40 cubic metres. Data from the Maltese Islands Weather website reveals that rainfall during the slow months of November, December, January, and February is sufficient to meet all water demands for corporate operations.

The table below shows the amount of rain fall in Malta during the year of 2021. The auditor used this chart to calculate how much the average amount of water collection will be in a year. The calculation indicated that the amount of water collection will cover the average consumption during the business's low season.

Month	Millimetres of rain falls
January	**100**
February	**60**
March	45
April	20
May	15
June	5
July	0
August	15
September	60
October	85
November	**90**
December	**110**
Year	600

Table 10: Rainfall calculation for the year 2021 (MIW, 2022).

The auditor assumes that rainfall during the four months preceding the low business season will cover all consumption since this is an estimate of whether rainfall will be enough to fill the well with the necessary volume.

Estimating how much the business will save on water costs if the owner decides to utilise well water sustainably, an investment of €800 would be required to clean and maintain the well and install all necessary plumbing.

When using well water collected from the rain, the business will be saving the following:

a). €143.64 that would otherwise be spent through charges by the bowser service, or

b). €199.08 stemming from the cost from the WSC as per current charges.

Thus, one can conclude that natural rainwater collected in the well has a value of either €143.64 or €199.08 depending on which service one would use – the bowser or the WSC.

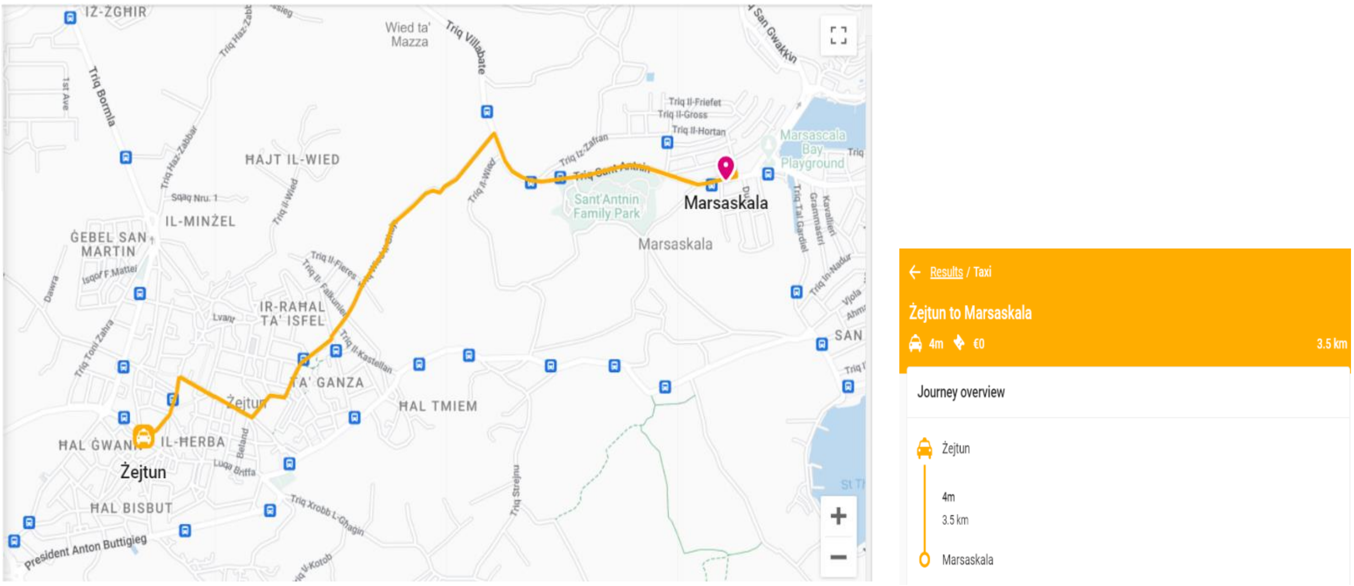
Through this research, on the onset, one would easily think that water purchased from the bowser is better than purchasing water from the WSC.

However, is this really the case?

The following will dive into this study using various estimations.

One must study if well water usage is truly sustainable. If one does not use solar panels, well water would be more expensive to extract. However, if solar panels are used it would be more sustainable. Thus, for well water to be sustainable, pumps must be powered by solar panels otherwise it would be too expensive if well water were to use electricity from Enemalta.

The annual water savings would amount to €369.36 (€810.54 (WSC) - €441.18 (bowser refill from March to October) or 46% less cost as shown in Table 4. Even at a cost of €800 for maintenance (see Estimate in Appendix 3), the well amortised after 2 years. Considering the cost of €1,050 per year to run the electric pump, the cost of water from the well refilled by the bowser will be that of €441.18. By adding the cost of the electricity consumed by the pump will increase the cost of water more than what can be obtained from WSC at a cost of €810.54. This is because one must include the cost of the electricity that the water pump generates to pump the water from the well. So one can only consider using the well if the pump uses electricity from the solar panels and is also more sustainable to use. Also, one should consider that the bowser generates a carbon footprint during the transportation and unloading of the water into the well. This is because of the burning of the fuel.



Map 1: Map showing the distance between Marsascala to Zejtun.

The bowser will consume 160 litres (lt) of diesel every 100 kilometres, according to the information given by the water supplier; when looking for a more specific occurrence, it was discovered that the information provided was accurate (B.V., 2022). The distance between Marsascala where the gelateria is situated and Zejtun from where the water supplier gets the water, as shown in Map 1, there is a distance of 3.5 km. The cost of diesel is €1.21 per litre, but this cost will not affect the research. What will affect the research is the amount of CO_2e used for the transportation and the pumping of water.

It is estimated that 0.63 litres of diesel will be burned during the delivery, and 0.17 litres during the unloading of water used by the pumps - for every litre of diesel burned, it consumes 2.62 0f CO_2e (Fleetnews, 2022).

Therefore, the total carbon footprint created by the bowser for water transportation is 0.63lt + 0.17lt = 0.80lt, 0.80lt x 2.62 = 2,096 CO_2e.

The auditor concluded that the cost savings would be insignificant if using electricity from the service provider. As a result, it is better if a solar panel is used to power the well's electric pump since it will decrease the carbon footprint.

6.3.3 Utilising the biowaste in compost

The waste in the work area, in the laboratory and in the serving area every day for a year were weighed and classified into different categories (see Table 7). The Table shows the different months divided into three seasons: low load, medium load, and high load from January to December 2021. The auditor will only analyse the food waste for the case study.

Bio-waste accounts for 35% of the total waste generated by the gelateria and amounts to 467.94 tonnes per year. The bio-waste was divided into different categories for the purpose of analysis: 45% of fruit peel, 25% of eggshells, 10% of coffee pods, 5% of paper napkins used only in the work area and 15% of other expired or spoiled food waste. A compost heap can regenerate this waste. According to research conducted by the auditor, organic waste produces between 15 and 25 kilogrammes (kg) of compost for every 100 kg of waste (Rattray, 2022).

The auditor has asked a local compost producer about Rattray's study to compare this with a local scenario. He argued that the compost production depends on the type of waste being used. The producer said that not all biowaste provides the same amount of compost but in his case, it seems that for every 100 kg it would usually provide an average of 12 to 14 kg. This would result in an average conversion factor of about 0.13 (Conversion Factor Formula: 13 kg /100 kg makes a conversion factor of 0.13).

For example, the compost market price of a local producer named Sherries is €1.65 for every kilogram (Sherries, 2022). So, if the gelateria starts turning the biowaste into compost, the biowaste weight of 468 kilos will give an average of about 60 kg of compost (468 kg X 0.13). If the Gelateria composts the biowaste and successfully generates 60 kilos of compost each year, this compost is given an average of €100 (60 kg x €1.65 = €100) worth in return.

Thus, if the gelateria manages to exchange compost for strawberries and the farmer receives an average discount of 9.5 per cent at a reduced price of €1.50 per kilo of compost to encourage a deal, the gelateria benefits from an average of 12 kilos of strawberries. The strawberries cost is €1.50 for every box of 200 grams, therefore, compost exchange worth of €90 for 60 kg of compost, the gelateria benefits from 60 boxes of strawberries at 200 grams each amounting to a total of 12 kg. This means that 8 per cent of the strawberries that gelateria usually buys would come from regenerated waste.

Chapter 7: Conclusion and recommendation

7.1 Final conclusions showing how specific changes will help reduce the company's carbon footprint and, at the same time, reduces costs so that the investment pays for itself in just a few years

Waste: - The gelateria consumes 99.57kg CO_2e per year, of which 56 percent is a biodegradable waste. Converting bio-waste to compost will save 55.76kg CO_2e. The compost will provide €90 worth of strawberries to the business, with a total investment of €155 as a start-up operation and €50 yearly for the composter enzyme powder. In roughly 20 months (1 year 8 months), the investment will be repaid.

Solar panels: - The results suggest that using the 70m^2 rooftop will save 8,346kg CO_2e per year. The company saves €4,788 per year on power expenses, which means that 33.5 per cent of the electricity bills are saved, while the investment in solar panels totals to €19,000. The investment will be repaid in roughly four years.

Water: The gelateria will save 33,460 kg CO_2e annually by using well water and refilling it with the water bowser service and by using solar energy to operate the water pump. In doing so, the business will save:

a). €369.36 from the WSC bills. This was calculated as follows:

- the annual bill from WSC which amounts €810.54, less the annual bowser bill which would amount to €441.18.
- The auditor then quantified the monetary value of rainfall using the charges of the bowser service (€1.71 per cubic meter) and quantified well water consumption for the months of January (21 cubic meter), February (24 cubic meter), November (21 cubic meter) and December (18 cubic meter). This can be seen in Table 4. Therefore, the price of rainfall would be €143.64 (21m^3 +24 m^3+21 m^3+18 m^3 = 84 m^3; 84 m^3*€1.17 = €143.64). Thus, if one adds €441.18 and €143.64 this would amount to €584.82.

b). €1,095 saved from the water pump energy consumption bills since solar panels would be used, which consume less energy.

The use of bowser to reach consumption will be of seven times a year. The bowser would generate 14,672 kg CO_2e (0.63lt + 0.17lt = 0.80lt, 0.80lt x 2.62 = 2,096 CO_2e; 2096 x 7 = 14,672 kg CO_2e) when transporting water.

Therefore, the electricity from WSC would generate 33,460 kg CO_2e and the bowser transporting water would generate 14,672 kg CO_2e. Therefore, the actual CO_2e difference is of 18,788 kg CO_2e.

The maintenance and installation of a pump and pipes to utilise the well water would amount to €800. The return of investment to cover investment will be in 2 years as the savings from water bill charges is €369.36 per year, this without including the meter charges.

Bulb: - The results reveal a clear lead. The gelateria would save 1,560 kg CO_2e per year and another €410 per year in electricity costs if bulbs are switched from CFL to LED. The LEDs cost €720 and the maintenance cost of replacing CFL bulbs is €1,080 (see Chapter 6.2.2). This would add up to €1,800 per year since the CFLs have a shorter lifespan. The savings in electricity costs will offset the investment over the course of four years.

7.2 Final results have been determined

As a result of this research project, the gelateria will be able to lower its carbon footprint to a total of 120,639.76kg CO_2e per year by investing €21,755. This will result in a total savings of €5,657.36 per year, implying that the whole investment will pay off in three and a half years.

Annual	Waste	Solar Panels	Water	Bulbs	Total
CO_2e Savings	99.57 Kg	8,346 Kg	33,460 Kg	1,560 Kg	**43,465.57Kg**
Investment	€155	€19,000	€800	€1,800	**€21,755**
Return Of Investment (ROI)	1 year 8 months	4 years	2 years	4 years	**Average 3 years**
Money Savings	€90.00	€4,788	369.36	€410	**€5,657.36**

Table 11: Table showing the determination of savings through investments.

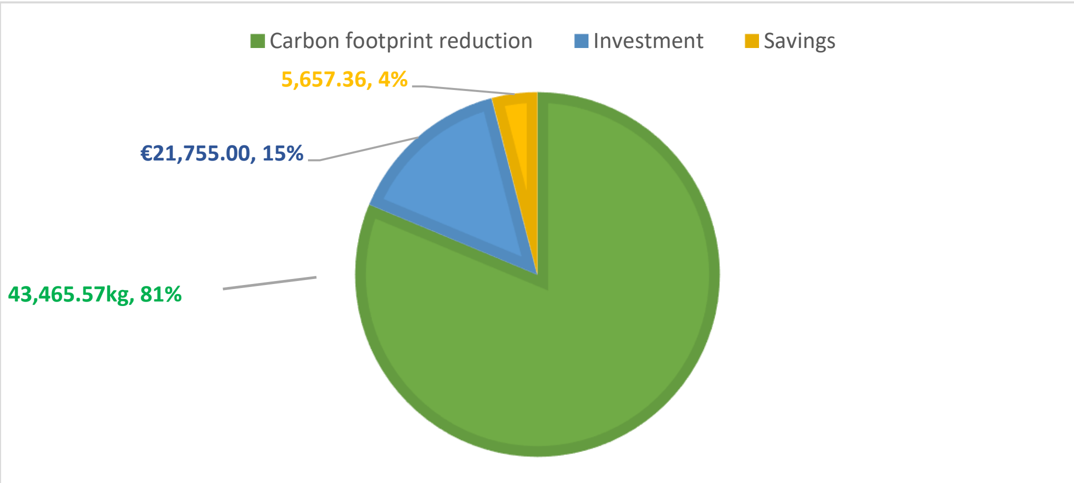


Chart 1: Pie chart displaying the findings in Table 11.

7.3 Limitation to the study

There are some limitations where it concerns this research which include the following:

- The output of Photovoltaic panels varies depending on the weather.
- The amount of water captured fluctuates depending on the amount of rain that falls.
- A compost heap can only digest a portion of the organic waste stream.
- Full organic waste stream digestion necessitates the installation of a digester, which is currently prohibitively costly.
- This field has not been widely studied and therefore there is a lack of literature and research.

7.4 Scope for the future studies

This study project potentially paves the way for similar studies by other small business owners who are looking into ways how to change their businesses into more sustainable ones in compliance with the EU's European Green Deal standards.

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Appendix 1 Engineer report

Ing Daniel Camilleri B.Eng (Hons), M.Sc (Brunel)

e-*mail*: daniel.camilleri05@gmail.com

This report is an energy consumption case study for a Gelateria.

ELECTRICAL CONSUMPTION

Electricity consumption for the year January 2019 – January 2020 was gathered from the energy bills as per below. The dates have been chosen as a typical year. The period following this could not be used due to Covid 19.

Table for Consumption

Bill number	Consumption / KWh	Bill Amount
1	14502	€2,366.19
2	7608	€1,482.94
3	12819	€2,416.38
4	10676	€1,961.53
5	2392	€2,651.64
6	8227	€1,358.43
7	3907	€1,192.95
8	5171	€848.07
	Total Bill for consumption	€14,278.13

Total Units Consumed: per year Total is **65,302 kWh** or an average of around 180 kWh per day.

CO2 GENEREATION

According to the local service provider (Enemalta) data, that may be obtained publicly from (https://www.enemalta.com.mt/environment/fuel_mix_for_energy_distribution/), generated electricity comes at a carbon cost of 378 gCO_2/kWh.

Taking this value for the energy consumed over a period of 1 typical year as presented above the carbon being generated as a direct cost of the electrical consumption is 24,684$kgCO_2$

PV POWER GENERATION

Standard production rate for PVs in Malta as specified by the Energy Regulator is 1600kWh/kWp. In this case to offset the generated 65302kWh you need around 40kWp of panels.

Taking 30 Panels of the current standard market available panels are 460W[1](13.8kWp) generating around 22,080kWh saving 8346$kgCO_2$ or around 38% of the current use. This would require an area of around 70 SQM.

Taking the total Bill of € 14,278 that would turn out to be saving of approximately €4,788 per year taking a simple proportion of the bill. Although this is not an exact figure since the bill needs to be subdivided into the rates of actual bands (of consumption) per bill, this value may be taken as a fair assumption.

The approximate cost for a system of 30 x 460W panels, excluding any grants is around €19,000 that gives an ROI of 4 years.

HOT WATER CONSUMPTION

Average of hot water used per day is around 150 to 200lt daily from May to September or during peak season whilst between October to March or during low season this is around 500lt per week. In the months of April to May the daily hot water usage is of around 100lt.[2]

Using Solar water heater of 300 Litres would cover the daily hot water needs, especially since the highest use is during the summer months. Moreover, since most of the hot water is used in the early afternoon till evening, this makes for a perfect use case for the solar water heater.

[1] Larger capacity panels are available but with the same efficiency so the footprint requirement would still be similar.

[2] Data obtained from operator.

An average water heater has as currently installed on the premises has a 1.5kW electrical element. Assuming 12 hours operation a day and a diversity of 0.6, the approximately electrical usage for hot water generation is around 10.8kWh per day.

With the use of the solar water heater this would also be offset and saving another 1490Kg CO_2 per year

Yours Sincerely,

Ing. Daniel Camilleri

Appendix 2 Composter invoice

GREENSCAPES

Greenscapes Garden Centre

Zebbug Road

Attard

Malta

Tel: 21378833

Vat no: MT2304-5517 EXO no: 3053

Invoice #870501

24 Feb 2022 12:12pm I Greenscapes Garden Centre

1	Composter 310Ltr Green [F]	@ €105.0	€105.00
1	Miracle-Gro Compost Maker [F]	@ €12.50	€12.50
	Subtotal		€99.58
	Tax (Full, 18%)		€17.92
TOTAL 2 items			€117.50

Issued by: Sonia at POS 1

€117.50

https://greenscapes.vendhq.com/loyalty/claim/hnrtop

Thank you for your custom

greenscapes.com.mt

POS powered by scope.com.mt

Appendix 3 Well Estimate

Crystal Pools
38, Triq L-Immakulata Kuncizzjoni Zabbar
Malta ZBR1513 MT
info@crystalpools.com.mt
VAT Registration No.: MT 2582 5913

Estimate

ADDRESS
Gelateria

ESTIMATE NO. 1346
DATE 11/05/2022

SKU	DESCRIPTION	QTY	RATE	AMOUNT
	Supply and install of a water pump 746WpH complete with all necessary pipe works	1	677.97	677.97

SUBTOTAL	677.97
TAX	122.03
TOTAL	**EUR 800.00**

Accepted By

Accepted Date

Payments:
Crystal Pools
IBAN - LT213250072832229113
BIC - REVOLT21
Cheques payable to Alistair Abela

Appendix 4 Technical report

Description	Qty	Power in watts	1PH / 3PH	Usage
Air Condition Lab	1	4800	3 PH	High
Air condition Counter	1	5500	3 PH	High
Air Condition service area	1	5500	3 PH	High
Cold room	1	3000	3 PH	High
Montecatore	1	2000	1 Ph	Medium
Ageing Machine	1	8000	3 PH	Medium
Pasturizer	1	1500	3 PH	Medium
Blast Freezer	1	1200	3 PH	Medium
Microwave	1	2000	1 PH	Low
Single door Upright fridge	1	260	1 Ph	Normal
Mixer	1	570	1 Ph	Normal
Mini Oven	1	2150	1 Ph	Normal
Waffle machine	2	1800	1PH	Medium
Bubble waffle	2	1750	1 PH	Medium
Coffee Machine	1	3400	1 PH	High
2 Door Fridge	2	900	1 PH	Normal
Display fridge	1	780	1 PH	Normal
Single door Freezer	1	900	1 PH	Normal
Single door fridge	1	440	1 PH	Normal
Panna Machine	1	550	1 PH	Low
Milk shake units	4	800	1 PH	Medium
Granita Units	2	1600	1 PH	Normal
Soft Ice cream Machine	1	1700	3 PH	Low
Display Freezer	2	4000	3 Ph	Normal
Light		1500	1 PH	High
CCTV Alarm		1000	1 PH	Always On

High 16 – 24 hr / day

Medium 6- 8 hr / day

Low 2 – 4 hr / day

Normal 18 hr / day