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INDUSTRIAL SYSTEMS ANALYTICS

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CARBON FOOTPRINT CALCULATION IN THE RESTAURANT SECTOR

Case Friends & Brgrs

Master's thesis for the degree of Master of Science in Technology

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Andreas

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ABBREVATIONS

CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalents
CSR	Corporate Social Responsibility
GHG	Green House Gas
GWP	Global Warming Potential
HVAC	Heating, Ventilation and Air-Conditioning
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land-Use Change and Forestry
N_2O	Nitrous Oxide

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ABSTRACT

The objective of this case study was to investigate the environmental impact of a Finnish restaurant chain. The purpose was to provide the case company with information about its carbon footprint, how it is caused, and how it can be reduced. A greenhouse gas emission calculation model was built. The model calculated the GHG emissions from the case company's product raw materials and its processes during year 2018. The processes included electricity and energy usage, water consumption, HVAC, waste treatment, ware transports and some other miscellaneous materials. The calculations resulted in a total carbon footprint of 1611 tCO_2e, which is equal to an emission intensity of 0.23 $kgCO_2e$ / €. Of the total carbon footprint, 76.2% was caused by the product raw materials, and 23.8% by the processes. Beef meat alone caused 55% of the total emissions. The carbon footprint of the case company's basic product, The Classic Brgr, was 2.34 $kgCO_2e$, while the Chicken Brgr has a carbon footprint of 0.96 $kgCO_2e$ and the Vegan Brgr 0.50 $kgCO_2e$. Of these emissions 0.25 $kgCO_2e$ per burger was caused by the processing, and the rest by the product raw material.

KEYWORDS: restaurant carbon footprint, GHG emission calculation

1 INTRODUCTION

Sustainability is a very hot topic in today's world. Scientists are warning for the consequences of our current way of living. People are more than before reacting to this message from the scientific world and are demanding action from politicians. Companies are also forced to adopt more environmental-friendly ways of working, as sustainability is becoming an important part of the company branding. About two thirds of customers are willing to pay more for food that is considered sustainable (Namkung & Jang 2017, Kwok et al. 2016). But investing in sustainable practices is not necessarily an economic burden for a company. Research shows that there is a positive correlation between sustainability efforts and financial performance (Frías-Aceituno & Martínez-Ferrero 2015).

One of the ways that companies can improve their sustainability is by reducing their carbon footprint (Kwok et al. 2016). It is therefore important to know the company's carbon footprint, so that targets can be set, and improvements measured. The carbon footprint of a restaurant business has two main categories: the raw material (ingredients) and the restaurant's processes. The restaurant processes carbon footprint is caused by for example energy, transports, HVAC etc.

The term carbon footprint means the total amount of greenhouse gases caused by an activity, process, product etc. According to the Kyoto protocol there are six greenhouse gases (GHGs): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The gases are assigned a certain GWP value (Global Warming Potential) according to how much they are estimated to heat the atmosphere during a period of 100 years from release. Carbon dioxide, methane and nitrous oxide are the most significant greenhouse gases. The carbon footprint, or GHG emissions, are expressed in the unit carbon equivalents (CO_2e), i.e. how much carbon dioxide emissions would have the same warming effect. (UNFCCC 2008)

This thesis is a case study for the Finnish restaurant chain Friends & Brgrs. The case company does not in the current state have a clear strategy regarding environmental issues. The calculation of the company's carbon footprint is crucial information in the process of creating an environmental strategy, and that is the motivation of this thesis. The case company has already put effort on the sustainability matters, for example by changing from disposable plates and glasses to porcelain. Sustainability issues are important to the company. The ingredients used in the company's Finnish restaurants is 95% domestic, and the food is basically additive-free. The company already has a very strong position in Finland as an environmentally responsible company. In a yearly customer survey conducted by Taloustutkimus in 2018 Friends & Brgrs ranked number one in its market segment in the corporate social responsibility category. The company aims to stay in the pole position in this area. With the increasing competition in Finland, the company must work systematically on the environmental issues, and this thesis aims to address this need. (Friends & Brgrs 2019b)

1.1 Objective of the thesis

The main objective of this thesis is to calculate the GHG emissions caused by the case company. With the help of the results of the thesis the company should get a broader insight into its environmental impact. These insights can then be used in the process of formulating a long-term environmental responsibility strategy. The information acquired in the thesis process will be shared with the case company management, thus increasing the company's knowledge in the environmental aspects of the business.

The objective of the thesis will be achieved by developing a GHG emission calculation model. The model should be tailor-made for the case company's operations. The GHG emission category of the company's operations are to be identified and using the calculation model each category's emissions should be investigated.

Another objective of the thesis is to provide concrete advice to the case company about how it can reduce its GHG emissions. A scenario will be simulated, using the GHG emission calculation model, to find out how the carbon footprint of the company would be affected by certain improvement actions.

1.2 Research questions

Three research questions were established for the thesis, in order to clarify the objective of the study. The research questions reflect the need of information that the case company has. The case company needs to know what its current environmental impact is, what is causing the impact and how can the environmental performance be improved.

The first research question of the thesis is formulated as follows:

"How large is the case company's carbon footprint?"

The second research question goes as follows:

"What is the share of the factors contributing to the company's GHG emissions?"

The third research question is:

"How could the company reduce its GHG emissions?"

1.3 Structure of the thesis

The thesis is structured as follows:

Chapter 1 introduces the thesis topic and explains the reason for the thesis. The research objectives and the research questions are stated. The structure of the thesis is laid out and the case company is introduced.

Chapter 2 is the theoretical framework of the thesis. The reasons for adopting environmental-friendly practices are stated. Scientific research on the GHG emission impact areas are reviewed.

Chapter 3 describes the methods used in the thesis. The structure of the carbon footprint calculation and the calculation method of each GHG emission area is presented.

Chapter 4 presents the results of the study. The GHG emissions of the company, the emission impact areas and the products are presented, as well as the results from the simulated improvement scenario.

Chapter 5 includes the discussion of the thesis results. The major findings of the study are interpreted, as well as the limitations of the study and the suggestions for improvement of the model and future research need.

Chapter 6 presents the conclusions of the thesis.

1.4 Case company

Friends & Brgrs is a Finnish burger restaurant chain company. The company was founded by six friends who wanted to make great burgers and fries. The first restaurant was opened in Pietarsaari in 2014. As of March 2019, the company operates eight restaurants located in Finland, Denmark and Germany, and the company has about 180 employees. (Friends & Brgrs 2019a)

The company operates in the fresh casual segment. In the fresh casual segment, there is a strong focus on the quality of the food, great customer service, cozy and relaxed interior, as well as active communication with customer via social media, all while still keeping the price level relatively low (Chain Store Age 2016, Knowledge Leader 2014). At Friends & Brgrs the application of fresh casual means that all ingredients are fresh and locally sourced. The food is prepared from scratch on site, meaning for example that every restaurant has its own bakery and meat handling room. It also means that additives are avoided as far as possible, so at the moment the standard menu is completely additive-free. (Friends & Brgrs 2019a)

The vision of Friends & Brgrs is to become an international burger restaurant chain known for making the best fresh casual burgers and fries. The mission of the company is stated as follows:

> "We started Friends & Brgrs for people just like you. People who like great burgers. People like us. That's why we bake our own buns, triple-cook our fries and grind the meat ourselves. We use the best ingredients we can find and buy them from people we know and trust. No shortcuts and no compromises. There are easier ways to make burgers and fries, but not better." (Friends & Brgrs 2019a)

The strategy of the company is to expand by opening multiple new restaurants each year. At the moment the growth is focused on the Finnish market, where the company has a strong brand. In an extensive customer survey by Taloustutkimus in 2018, Friends & Brgrs got the highest overall rating in its segment. (Friends & Brgrs 2019b)

2 THEORETICAL FRAMEWORK

The theoretical framework reviews literature on sustainability drivers, explains the basics of the greenhouse effect, and defines the various greenhouse gas emission areas in the restaurant business.

2.1 Sustainability drivers

Sustainability is widely used word, and it is important to define the meaning of the word. In a study by Kwok et al. (2016) three distinct categories, in which restaurants can improve their sustainability, were identified. The first category is the food and its ingredients. Organic, local and sustainably grown ingredients are considered as *green* or environmentally friendly. The food aspects are important especially for people who are conscious about their health. The second category is the environment, which includes minimizing carbon footprint, reducing environmental damage, recycling, composting, water and energy efficiency, minimizing waste and avoiding disposable cutlery. The third category is the administrational aspects: training staff in sustainable operation, building systems for environmental performance tracking and improvement as well as certification to various kinds of sustainable restaurant programs.

A study by Arana et al. (2015) investigated various drivers for companies to implement an Environmental Management System (EMS), and which drivers that in fact lead to meaningful sustainable practices implementation. The study concluded that companies which have internal drivers for implementing an environmental management system are more successful in the implementation of sustainable practices compared to companies whose reason for EMS implementation is mainly external demands. In companies where the driving factors are internal, the staff is more motivated and involved in the development and implementation of the sustainable practices, and this is key to achieving results. External driving factors, for example legal requirements, seem to result in less efficient implementation of sustainable practices.

2.1.1 Global warming

The Intergovernmental Panel on Climate Change, IPCC, published the special report *Climate Change of 1.5°C* in October 2018. The report has gotten wide attention from media, politicians and individuals. The report is addressing the consequences of a global warming of 1.5°C and a global warming of 2°C compared to pre-industrial global mean temperature. According to the report the negative consequences of a 2°C global warming are significantly worse than the consequences of a 1.5°C warming. Examples of negative consequences of global warming are extreme regional temperatures, heavy precipitation, sea level rising and species extinction. Global warming also affects human health, livelihoods, food security, water supply, human security and economic growth negatively. The conclusion of the report is that humanity must take strong action to stop global warming at 1.5°C. In practice this means reducing the emission of carbon dioxide and other greenhouse gases. (IPCC 2018)

2.1.2 Customer perspective

The customer base is becoming increasingly concerned about the environmental impact of their choice of restaurant and are also willing to pay more for products that have less negative impact on the environment (Kwok et al. 2016). A study by Tommasetti et al. (2018) concludes that there are identifiable factors that make customers choose sustainable restaurants, and by working on these factors the customer behavior can be influenced. Kwok et al. (2016) suggest that restaurants should create a menu that includes items suitable for customers who are concerned about the environmental impact of the food. These customer groups were identified as women, people who have children, young people and people who are conscious about their health. In addition to these groups a study by Namkung & Jang (2017) also mentioned education and above-average socioeconomic status as typical traits of so-called green consumers. These are the customers who seem more likely to be influenced by environmental aspects in their choice of restaurant.

The study by Namkung & Jang (2017) found that 68.3% of customers were willing to pay more for food that they considered green, or environmentally friendly. This resonates with the findings of Kwok et al. (2016), who found that about two thirds of customers prefer locally grown food and would dine more often in a restaurant if it offers local food. However, these two studies, Namkung & Jang (2017) and Kwok et al. (2016), showed differing results regarding how much more customers are willing to pay. According to Namkung & Jang (2017) approximately 26.3% of customers were willing to pay 10% more for eating at a green restaurant, while Kwok et al. found that only 7.6% were willing to pay 12% more. Anyway, it can be concluded that a minority of customers are willing to pay extra, but only a little extra.

According to a survey made by the US based National Restaurant Association, NRA, about 50% of today’s customers are affected by the restaurant company’s focus on waste reduction, food donation and recycling when they choose where to eat (NRA 2018).

Kwok et al. (2016) point out that it is important that restaurant companies communicate their sustainability efforts actively and effectively, thus making sure that customers are indeed aware of the company’s effort, especially the efforts that are not obvious to the customer.

2.1.3 Operational and financial performance

Investing in sustainability efforts does also have several other benefits for the restaurant company. Examples of these are reduced operational costs, improved brand and customer ratings, increased customer’s purchasing and contribute to the company’s long-term financial success. (Kwok et al. 2016)

In an international empirical research by Frías-Aceituno & Martínez-Ferrero (2015) the relationship between corporate social responsibility (CSR) and financial performance was studied. The results showed that CSR clearly impacts the financial performance positively. It was also concluded that that companies that perform well financially invest more in CSR, which again leads to better financial performance. There is a bi-directional positive correlation between CSR and financial performance. CSR in this study was defined as factors impacting society, human rights, environmental and corporate governance.

2.2 Carbon footprint and global warming

This section explains the greenhouse effect and the most important terms regarding the subject. The carbon footprint of various sectors in Finland are described.

2.2.1 The greenhouse effect

About one third of the radiation of the sun is reflected by the atmosphere, and never reaches the earth. Two thirds of the radiation pass the atmosphere and reach the surface of the earth, where part of it is absorbed and part of it is reflected back towards the atmosphere. The radiation reflected by the Earth's surface is of longer wavelength than the sun's radiation, due to the earth's cold temperature compared to the sun. The reflected radiation is therefore infrared radiation. Part of this reflected radiation is again reflected back to Earth by the atmosphere. This is the greenhouse effect, and it is crucial for life on earth. Without the greenhouse effect Earth would not be habitable, it would be too cold. Since the Earth is warmer than the surrounding space, infrared radiation is all the time emitted from the Earth's surface. For the climate to stay in balance, the heat gain by the sun radiation and the heat loss from Earth's surface radiation need to be equal. The problem of global warming arises when too much of the radiation is reflected back to Earth by the gases in the atmosphere, which means that more heat energy is added to the atmosphere than what leaves it. This makes the Earth's surface and the atmosphere warmer. Greenhouse gases are gases that increase the atmosphere's ability to reflect radiation, and thus they contribute to global warming. The most significant greenhouse gas is water vapor, with CO_2 being number two. (IPCC 2017)

The term carbon footprint means the total amount of greenhouse gases caused by an activity, process, product etc. According to the Kyoto protocol there are six greenhouse gases (GHGs): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The gases are assigned a certain GWP value (Global Warming Potential) according to how much they are estimated to heat the atmosphere during a period of 100 years from release. Carbon dioxide, methane and nitrous oxide are the most significant greenhouse gases. The carbon footprint, or GHG emissions, are expressed in the unit carbon equivalents (CO_2e), i.e. how much carbon dioxide emissions would have the same warming effect. Carbon dioxide is given the GWP value 1, and the values for the other gases have been determined by comparing the radiative forcing (W/m$^{2)}$ from the emission of 1 kg of the gas at ground level. (UNFCCC 2008, EPA 2019a, Statistics Finland 2018)

The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (F-gases). Methane has a GWP of 25, nitrous oxide 298 and the fluorinated gases have a GWP of 12-22800. (Statistics Finland 2018)

2.2.2 Greenhouse gas emissions in Finland

The greenhouse gas emissions in Finland in year 2017 was 55.4 $MtCO_2e$ (million tons of carbon dioxide equivalents). This number does not include the LULUCF sector, which had a net carbon removal of about 27.1 $MtCO_2e$. The total net emissions are therefore 28.3 $MtCO_2e$. The energy sector has the most emissions, 74%, followed by agriculture at 12 % and industrial processes and products use at 11%. Waste management accounted for 3% of the emissions. The development of the emissions over time can be seen in Figure 1. The emissions have declined 15.9$MtCO_2e$ since the comparison year 1990. The carbon removals by the LULUCF sector have been quite stable during the period. (Statistics Finland 2018)

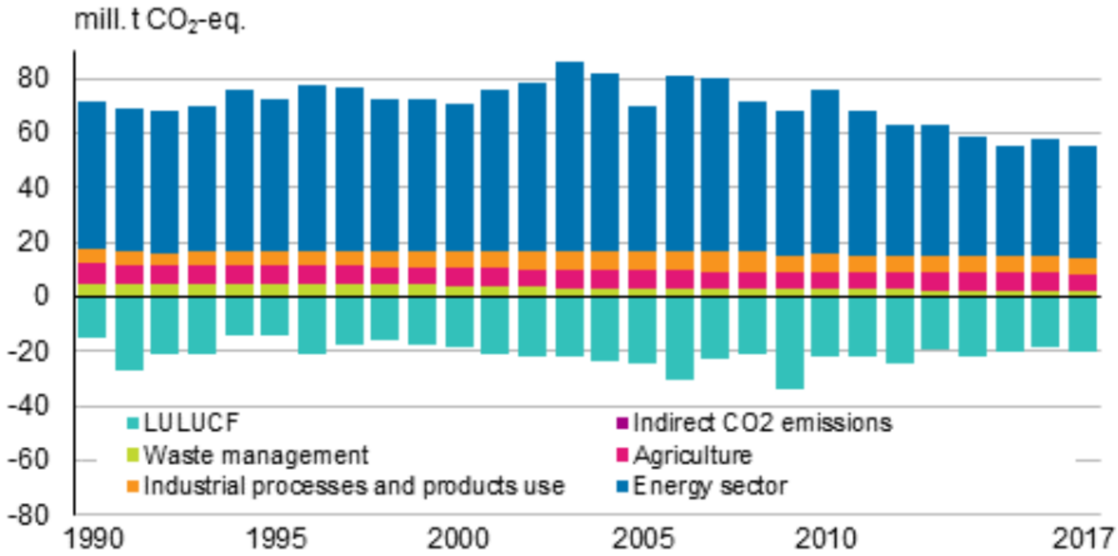

Figure 1. Finland's greenhouse gas emissions and removals per sector during years 1990 to 2017, expressed in million tons of carbon dioxide equivalents. (Statistics Finland 2019a)

According to Seppälä et al. (2009) the restaurant services in Finland in 2002 had a GHG emission intensity of 0.4 kgCO_2e/€. For comparison it can be mentioned that the GHG emission intensity of for example air transport services were 1.3 kgCO_2e/€, private transportation vehicles 1.5 kgCO_2e/€, clothing 0.4 kgCO_2e/€ and hotel services 0.5 kgCO_2e/€. The greenhouse gas emission intensity number describes how much greenhouse gas emissions are caused by each euro spent on the service.

A study by Virtanen et al. (2011) calculated the emissions of different food products and services in Finland. The study concluded that the total average daily emissions per person from food was 7.7 kgCO_2e, of which 4.7 kgCO_2e was consumed in the household. When the CO_2e / € ratio for different categories was investigated, it was found that domestic food products had an average emission of 2.0 kgCO_2e / €, and respective imported food products was a bit lower at 1.8 kgCO_2e / €, suggesting that imported food would be beneficiary from a global warming perspective. Domestic meat products had the highest GHG emission intensity, 2.7 kgCO_2e / €, while grain products were at 1.8 kgCO_2e / € and vegetables 1.5 kgCO_2e / €. (Virtanen et al. 2011)

2.3 Restaurant carbon footprint areas

In this chapter the carbon footprint areas of the restaurant business are described.

2.3.1 Ingredients

The climate impact of different food ingredients varies significantly. The emissions from food ingredients that are relevant to the case company can be seen in Table 1. The numbers in the table are mainly from a source that reviewed the Finnish food production (Salo et al. 2019) and is complemented by a Swedish study (Röös 2012) on the ingredients that were not mentioned in the Finnish study.

It can be noted that meat, and especially beef, causes significantly more greenhouse gas emissions than other food. According to the studies, pork and broiler are more environmental-friendly meat options. The reason for the relatively high emissions from meat is that to produce 1kg of meat, about 10kg plant-based animal food is required (Reijnders & Soret, 2003). In 2015, the average meat consumption in Finland per person was 79kg, resulting in a daily consumption of just over 200g. 35.1 kg of this was pork, 21.6kg broiler and 19.2kg was beef. (Luke 2016)

Table 1. Estimated greenhouse gas emissions from various food in CO2 equivalents. (* Salo et al. 2019, ** Röös 2012)

Food	kg CO_2e/kg
Beef	15*
Cheese	10*
Pork	5*
Broiler	5*
Vegetable oil	3*
Egg	2,5*
Fish	1,5*
Sugar	1,1*
Dried beans	0,7*
Vegetables	0,2*
Butter	8**
Potato	0,2*
Milk	1*
Cream	4**
Flour, grain	0,5*
Spices	1**
Coffee, tee	3**
Soft drinks	0,2*
Onion, root crops	0,2**
Fruits (domestic)	0,2**
Fruits (imported)	0,6**
Tomato, cucumber (greenhouse in winter)	5*

Studies have come to differing results regarding the carbon footprints of food. The carbon footprint ranges for selected food products is shown in Figure 2.

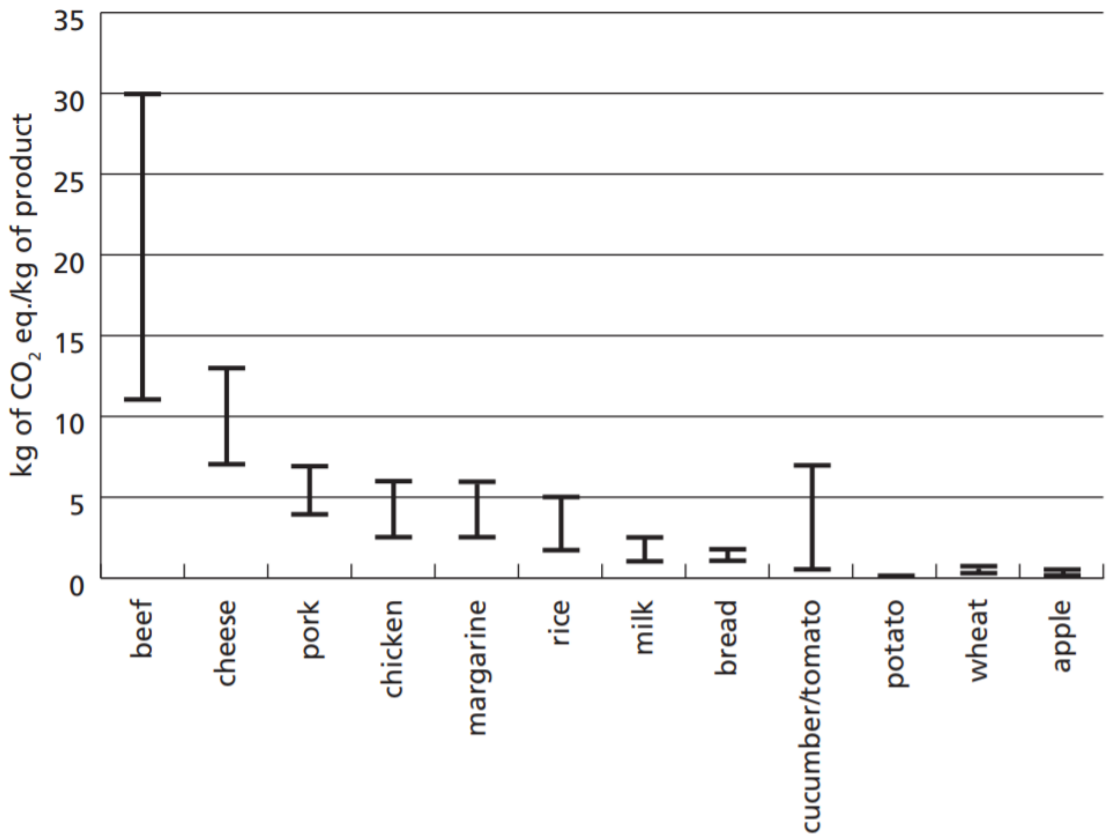

Figure 2. Carbon footprint ranges of selected food products (Katajajuuri 2009).

2.3.2 Energy

The electricity supply in Finland is quite special compared to the other Nordic countries. The energy production is based on a wide range of energy sources, both renewable and fossil. Finland is at the moment significantly depending on imported electricity, as can be seen in Table 2.

Table 2. Annual electricity production in Finland by power source. (Statistics Finland 2019b)

Power source	GWh	%
Nuclear power	21 889	25
Hydro power	13 145	15
Wind power	5 857	6,7
Solar power	584	0,7
Net imports	19 936	22,8
Combined heat and power	26 001	29,7
Total	87 412	100

The emissions vary significantly from year to year. The reason is that the origin of the imported electricity varies depending on the supply-and-demand situation. If, for example, there is a lot of Swedish or Norwegian hydro power electricity available, the GHG emissions of the electricity used in Finland is lowered. In Table 3 the CO_2, CH_4 and N_2O emissions of the electricity used in Finland 2013-2015 is presented. Converted to carbon dioxide equivalents the total average GHG emission per kWh is 184 gCO_2e. (Ympäristöhallinto 2019)

Table 3. Average GHG emissions from the production of the electricity used in Finland in 2013, 2014 and 2015. The numbers include the emissions of the imported electricity. (Ympäristöhallinto 2019)

gCO$_2$e / kWh			
	CO$_2$	CH$_4$	N$_2$O
2013	208	0,69	0,006
2014	161	0,39	0,003
2015	142	0,45	0,0004
Average	171	0,5	0,003

There are significant differences in the GHG emission levels from various electricity generation technologies, as seen in Figure 3. The GHG emissions from one's electricity consumption can be drastically reduced by choosing renewable or nuclear electricity instead of fossil fuel electricity.

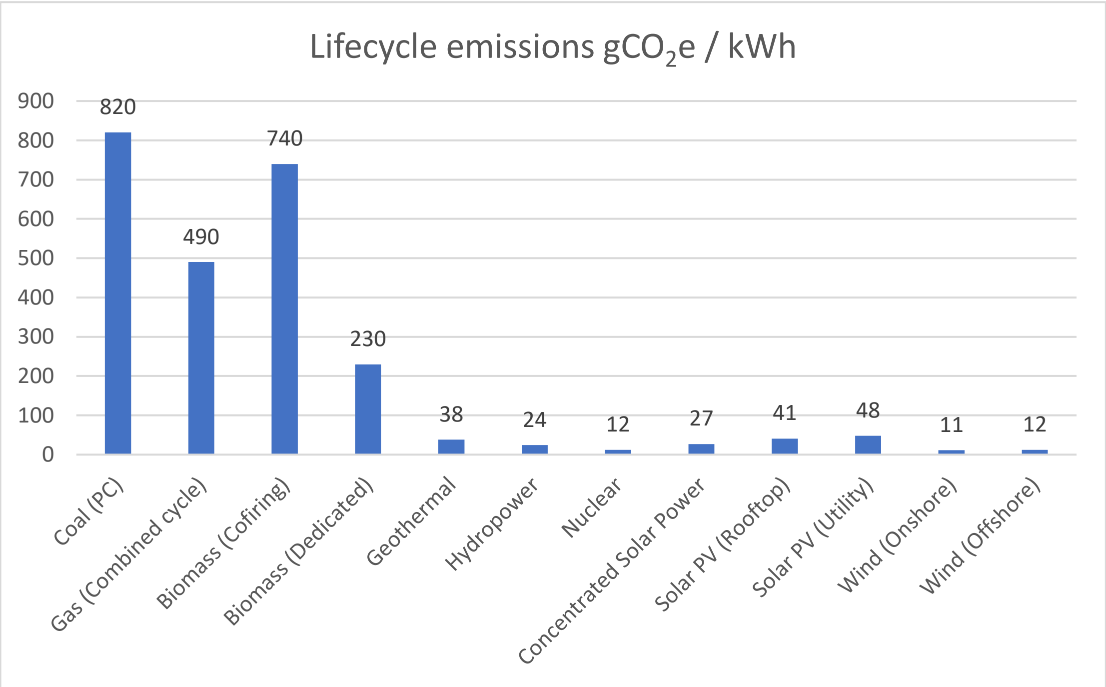

Figure 3. Lifecycle GHG emissions from currently available electricity generation technologies. The numbers are the calculated median emissions. Biomass has significant emissions, but the carbon absorbed by new growing plants should be considered, which makes biomass a carbon-low or neutral fuel. (Schlömer et al. 2014).

EPA (2019) identifies five main categories of energy consumption in a restaurant; food preparation, HVAC, lighting, refrigeration and sanitation. The biggest category is food preparation, followed by HVAC. The shares of these categories are shown in Figure 4.

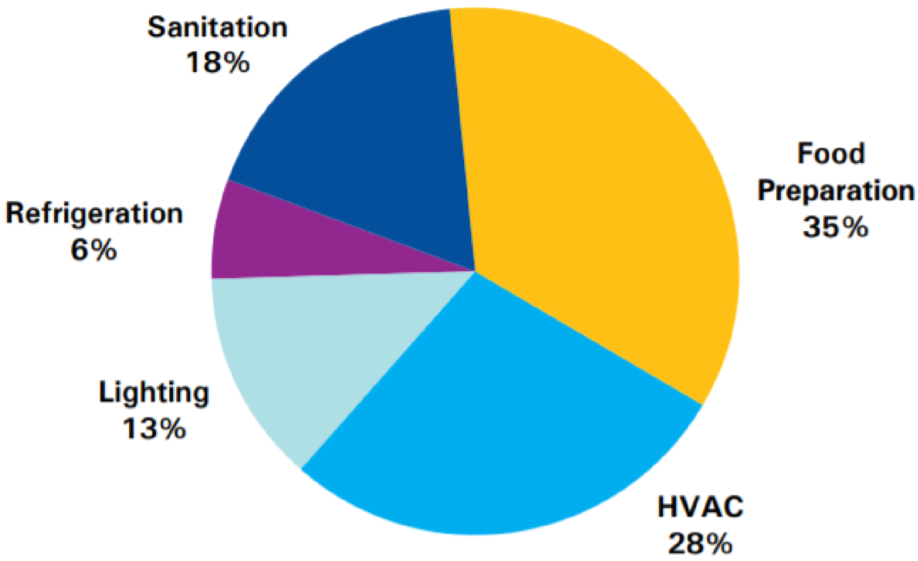

Figure 4. Average energy consumption categories in a restaurant in the USA. (EPA 2019b)

The case company does not have any data on the categories' share of the energy consumption. However, the food preparation is estimated to have an even bigger share of the energy consumption, since the case company prepares the food from scratch in the restaurants. The food preparation process is longer than the average, and therefore the food preparation energy consumption is estimated to be more energy-intensive than the average.

2.3.3 HVAC

According to the energy certificate guide developed by the Finnish Ministry of Environment the energy needed for heating of office buildings built in year 2006 is 118,64 kWh / m^2. This includes the conductive heat loss, heat loss from air leaks and the energy needed for heating the supply air. The spaces are heated with district heating, which has an emission intensity of 149 gCO_2e/kWh. (Ympäristöministeriö 2018, Energiateollisuus 2018)

The restaurant kitchen is demanding when it comes to ventilation. The case company's standard kitchen requires an exhaust flow rate of 1.6 m^3/s. During the cold season the supply air needs to be heated, which requires a significant amount of energy. Nowadays restaurant ventilation systems are often equipped with grease separation technologies, for example ozone generators or UV lights. These technologies enable the use of ventilation heat recovery, which can save 50 - 80% of the supply air heating costs (Juodis 2006).

2.3.4 Water supply and waste water treatment

The Swedish Institute for Food and Biotechnology made a life cycle analysis that compared the environmental impact of tap water to that of bottled water. The environmental impact of tap water in the Stockholm area was investigated. The study showed that the energy needed for the production and distribution of one liter of tap water in Stockholm was 2.4 kJ, which is equal to 0.67 kWh per m^3 water. About 50% of the energy was used to produce the water and the other 50% for the distribution. Additionally, the production energy of the chemicals used in the water production added 0.6 MJ per m^3, which is equal to 0,167 kWh per m^3. This sums up to a total energy need of 0.83 kW / m^3. (Angervall et al. 2004)

Another Swedish study (Jutterström 2015) investigated the carbon footprint from the Norrvatten drinking water production and distribution. According to the study, the GHG emissions were 43.63 gCO_2/m^3. The study concluded that the chemicals that are used in the water cleaning process are causing most of the emissions. However, the emissions from the production of the chemicals depend largely on the emissions from the electricity used in the production of the chemicals. The study was made in Sweden, where electricity production has lower average emissions than in Finland.

Hot water is used for a couple of purposes in a restaurant. Dishwashing, cooking and cleaning are the main purposes. In Finland the facility lessor generally takes care of the water heating process and provides the tenant with a hot water supply. The hot water is usually heated with district heating. District heating energy in Finland has an average emission intensity of 149 gCO2e / kWh. (Energiateollisuus 2018)

A study commissioned by the Finnish Ministry of Environment (Laitinen et al. 2014) studied the technologies used by the waste water treatment plants in Finland. The study found that the energy used for the treatment of waste water was dependent on the size of the treatment plant. Small plants had an energy consumption of 1.55 kWh / m^3, medium sized plants 0.67 kWh / m^3 and large plants 0.41 kWh / m^3. The total average energy consumption for the treatment of waste water was 0.45 kWh / m^3.

2.3.5 Transportation

In 2017 transportation caused about 12 MtCO_2e, which is about 20% of the GHG emissions in Finland. This includes road transportation 93.5%, rail transportation (diesel only) 0.5%, flight transportation 1.6% and water transport 4.3%. Only domestic transportation is included in the numbers, as instructed by the IPCC. Electrical trains are not included in these numbers, as their emissions are included in the emissions from energy production. (Lipasto 2017a)

Driving with ware transportation trucks in Finland causes on average 799 gCO_2e / km. On a yearly basis the transportation with trucks causes emissions of around 3.2 MtCO_2e, which accounts for 29.4 % of the emissions from road transportation. (Traficom 2018)

The emissions from the ware transportation by road depends on what kind of vehicle is used. Larger trucks are more efficient when measuring the emissions per tonkilometer. The emissions also depend on whether the truck is driving on the highway, in the city or in distribution. The emissions also vary with degree to which the truck is loaded. The gCO_2e / tkm emissions for various transportation trucks under various driving conditions is presented in Table 4 and Table 5. (Lipasto 2017b)

Table 4. Emissions from fully loaded trucks, expressed in gCO_2e / tkm. (Lipasto 2017b)

	Max load (t)	Highway driving	City driving	Distribution driving
Distribution truck 6t	3,5	88	108	104
Distribution truck 15t	9	49	74	67
Semitrailer 40t	25	38	66	-
Combi trailer 60t	40	30	55	-
Combi trailer 76t	51	28	50	-

Table 5. Emissions from 50% loaded 16t distribution truck and 70% loaded 60t combi trailer, expressed in gCO_2e / tkm. (Lipasto 2017b)

	Max load (t)	Highway driving	City driving	Distribution driving
Distribution truck 15t (50% load)	9	97	126	116
Combi trailer 60t (70% load)	40	39	68	-

To calculate the emissions per tonkilometer of a distribution transport, Formula 1 can be used. (Lipasto (2017b).

$$e_x = (e_a + ((e_b - e_a) / l_c \times l_x)) / l_x \quad (1)$$

where

e_x is the emissions per tonkilometer with load x [gCO_2e/tkm]

e_a is the emissions per kilometer without load [gCO_2e /km]

e_b is the emissions per kilometer with full load [gCO_2e /km]

l_c is the truck load capacity [t]
l_x is the load x [t]

A study by Hartikainen et al. (2013) concluded that GHG emissions from food transportation are not so significant compared to the emissions from food production. It is more important *what* you eat than where it comes from, if only the GHG emission aspect is considered.

2.3.6 Other materials

Other materials include packaging materials, napkins, detergents and similar products that are consumed by the customers or the restaurant staff. Information about the emissions from these miscellaneous materials are challenging to calculate, due to a vast number of various products. For these kinds of materials, it can be beneficiary to calculate the emission intensity, i.e. the emissions per euro spent on the material. This method is used for example by Seppälä et al. (2009).

2.3.7 Waste

In a study by Kaysen et al. (2012) the food waste handling in the hospitality sectors in Finland, Sweden, Norway and Denmark was analyzed. As a result of the study, it was estimated that the total food waste from the hospitality sector in these countries was 680,000 tons per year. 456,000 of this was estimated to be avoidable food waste, i.e. food waste that could be prevented. Finland alone caused 140,000 tons per year of total food waste, of which 94,000 tons per year could have been avoided. According to a report by the European Commission the total food waste in the food service industry in the EU was 11 million tons, which makes up 12% of all food waste in the EU. The report noted significant differences in food waste amounts between the EU countries. (Stenmarck et al. 2016)

The environmental impact of waste recycling and incineration was studied by Myllymaa et al. (2008). Among other things the study the researchers calculated the greenhouse gas emissions from bio waste and from mixed waste. The emissions are shown in Table 6.

Table 6. GHG emissions from mixed waste and bio waste. The GWP for methane is 25 and for nitrous oxide 298. (Myllymaa et al. 2008)

	$kgCO_{2bio}$ / t	$kgCO_{2machinery}$ / t	$kgCH_4$ / t	kgN_20 / t	$kgCO_2e$ / t
Mixed waste	5	3	0.05	-	9.25
Bio waste	87.3	-	0.987	0.051	127.17

In the UK a research was conducted by Moult et al. (2018) to evaluate and compare the alternative ways that food waste can be handled. The study included a life cycle assessment, that calculated the greenhouse gas emissions for each food waste disposal alternative. The study identified the following options for food waste disposal: donation, animal feed, anaerobic digestion, composting, incineration, landfill with 70% CH_4 capture and gas utilization, landfill with 70% CH_4 capture and flaring, and landfill with 0% CH_4 capture. The aspects that were included and excluded in the life cycle analysis can be seen in Figure 5.

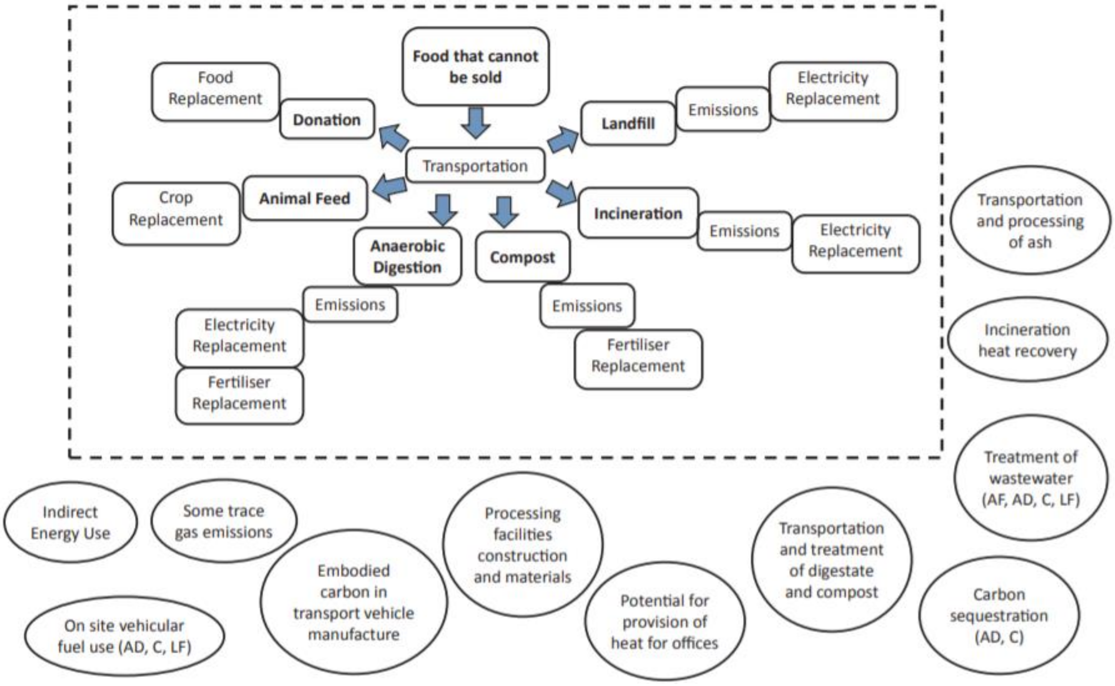

Figure 5. Boundaries of the food waste disposal emissions life cycle analysis (Moult et al. 2018).

The study by Moult et al. (2018) concluded that the best food waste disposal option is by far donating the food for people to eat it. The emissions from transporting the waste food to a food redistributing center were of basically no significance compared to the benefit in saving the emissions embodied in the food during its production. The researchers noted that donating the waste food is easily the best option even when only half of the donated food is actually eaten by humans. The relative emissions for each waste disposal alternative can be seen in Figure 6.

Disposal Option	Food Type					
	Bread	Cheese	F&V	Fish	Meat	Weighted Avg.
Donation	100%	100%	100%	100%	100%	100%
Animal feed	24%	7%	1%	41%	5%	6%
Anaerobic digestion	20%	4%	5%	19%	4%	6%
Composting	3%	1%	-1%	5%	1%	1%
Incineration	11%	2%	-2%	1%	1%	1%
Landfill, 70% CH_4 capture with gas utilisation	-44%	-7%	-12%	-26%	-7%	-10%
Landfill, 70% CH_4 capture with flaring	-61%	-10%	-16%	-36%	-10%	-14%
Landfill, 0% CH_4 capture	-227%	-37%	-61%	-136%	-36%	-53%

Figure 6. Net mitigation as percentage of the embodied food emissions for various food categories. The percentage tells how much of the emissions embodied in the food can be utilized with the different disposal options. “F&V” is the abbreviation for fruits and vegetables. Donation of waste food to charities or food banks is by far the most environmentally friendly way of disposal. If this is not possible, the second-best option is using the waste for feeding animals. As one can clearly see, landfill is not an environmental-friendly option, not even with modern CH_4 capture. (Moult et al. 2018)

In their review of the food waste management in the hospitality sector Filimonau & De Coteau (2019) also recognized rising popularity of food waste donation. In year 2013 more than half a million tons of food waste was donated to charity globally. This number includes donations from both restaurants, grocery stores and individuals. There are, for reasons of food security, legal restrictions on how outdated food can be handled. These restrictions have been under criticism, and change is happening. Food donation is nowadays more widely accepted as a means of food waste reduction (Stenmarck et al. 2016). However, Filimonau et al. (2019) warns that food waste donation should be applied with caution, as there is a risk that hospitality businesses renounce their responsibility for excess food minimization and pour all the responsibility on charity organizations. Charity and voluntary organizations do not always have the resources necessary for the safe handling and storage of the food.

As a result of their extensive study of the food waste management in the hospitality sector Filimonau & De Coteau (2019) propose a managerial framework for the mitigation of food waste. The framework is a draft that should be revised and modified to fit a specific business. The framework recognizes three main process steps; pre-kitchen, kitchen and post-kitchen. Within the main processes there are subprocesses, which each of them can be improved on multiple levels. The processes can be improved through operational measures, in-house competencies and staff training. It can be noted that the framework proposes that the highest potential financial savings happen in the pre-kitchen and post-kitchen phases. This emphasizes the need for accurate sales forecasting and the handling of excess food from customers. The framework is shown in Figure 7.

Operational stage	Pre-kitchen (pre-consumption)				Kitchen				Post-kitchen (consumption)	
Operational area	*Demand forecasting*	*Procurement*	*Stock management*	*Menu design*	*Storage*	*Preparation*	*Plating*	*Serving*	*Sale / Customer service*	*After sale / After service*
Operational measures to reduce food waste	Maintaining continuous 'cold chain'- input from all stakeholders required									
	Regular food waste monitoring - input from all stakeholders required									
	Evidence-based forecasts	Short and responsive food supply chain	Demand-driven stock forecasting	Analysis of recipes	Contemporary technology and modern facilities	'Skilful' cooking	Portion control	Full plate service versus buffet service	Education and awareness-raising	Revenue maximisation for unsold food via use of technology (e.g. 'Too Good To Go' smartphone app)
	Use of (more advanced) demand forecasting models			Portion size planning						Food re-use / redistribution
				Use of seasonal ingredients						
				Re-use ingredients			'Skilful' plating			Food recycling
										Food recovery
Core in-house competencies required	Understanding of demand drivers	Knowledge of suppliers and negotiation skills	Regular stock inventory	Knowledge of menu engineering	Knowledge of kitchen equipment	Knowledge of cooking and food serving techniques		Understanding the implications of the adopted business model and addressing them pro-actively	Knowledge of consumer behaviour and principles of behavioural economics	Knowledge of appropriate (technological) solutions and how to access these
Training needs	Managerial and chef training		Chef training		Kitchen staff and chef training	Chef training		Managerial, chef, kitchen and waiting staff training	Waiting staff training	Managerial, chef, kitchen and waiting staff training
Estimated initial investment cost	High		Low	Medium		Low		Medium	Low	Low/Medium
Estimated potential financial savings	High				Medium	Low		Medium	High	

Figure 7. Managerial framework for food waste mitigation in the hospitality business sector. (Filimonau & De Coteau 2019)

2.3.8 Business travels

Business in travels are a necessity in many businesses today. Especially when a business has multiple operational locations, there will unavoidably be some travelling. Co-presence is especially beneficial when it comes to negotiations and making financial deals, as there is a need to create personal trust in these matters. Business travelling is however causing significant GHG emissions. Therefore, travelling should be substituted by digital communication tools when possible. When travelling is necessary public transportation should be used always when possible. (Poom et al. 2016)

The GHG emissions from flying consist almost only of CO_2-emissions, with other greenhouse gases causing less than 1% of the total emissions (Lipasto, 2017c). Therefore, the GHG emissions from flying can be assumed to be equal to the CO_2-emissions. The International Civil Aviation Organization ICAO has developed a flight emission calculator, where the emissions from a specific flight route can be calculated. This calculator takes only CO_2-emissions into account. (ICAO 2019)

3 METHODS

In this thesis the *case study* is used as a research strategy. This chapter aims to describe the methodology used in the thesis. The theory of the case study methodology is briefly reviewed, and the design of the GHG emission calculation model is explained.

3.1 Case study methodology

The case study as a research method has been defined by Yin (1994). Yin points out the circumstances in which a case study research is beneficiary. The case study is useful in research situations where a contemporary phenomenon with real-life context is studied, and especially in situations where the relevant behaviors cannot be manipulated (Yin 1994: 9). The case study is a viable option when the questions asked are “how?” and “why?”. The case study methodology was used in this thesis, as the study investigates a contemporary phenomenon (carbon footprint) at a specific case company. The questions asked in the study are of the “how?” and “why?” type, as the objective of the study is to find out how large the carbon footprint of the case company is, how it is caused and how it can be reduced.

The research design of a study can be explained as follows:

> In the most elementary sense, the design is the logical sequence that connects the empirical data to a study's initial research questions and, ultimately, to its conclusions. Colloquially, a research design is an action plan for getting from here to there, where here may be defined as the initial set of questions to be answered, and there is some set of conclusions (answers) about these questions. Between "here" and "there" may be found a number of major steps, including the collection and analysis of relevant data. (Yin 1994: 19.)

The research design of this thesis follows the five steps pointed out by Yin (1994):

1. Defining the research questions: the research questions of this thesis are described in chapter 1.2.

2. The purpose of the study: to investigate the carbon footprint of the case company.

3. The unit of analysis: in this case the case company's operations in Finland.

4. The logic linking the data to the purpose: the GHG emission calculation model is created to fulfill the purpose and answer the research questions.

5. The criteria for interpreting the findings: the results should be interpreted with caution and the unavoidable errors should be considered.

3.2 Emission calculation model technical implementation

The GHG emission calculation model was created in Google Sheets. The reason for using Google Sheets was that it is the main software used in the case company's operations, and thus the model is compatible with other data used by the company. Google Sheets is also very flexible, enabling a swift modification of the tool whenever needed. It also provides easy creation of infographics and reports, which is key when working with sustainability efforts.

3.3 Calculation of the contributing categories

This section explains how the GHG emissions from the case company's operations were calculated. The background and scientific literature behind the calculations are described more thoroughly in the theoretical framework chapter. The emissions were calculated for the case company's operations in year 2018.

The total carbon footprint of the case company was calculated by adding the carbon footprint of contributing categories mentioned in this chapter. To further calculate the total carbon footprint of each product, the processing emissions (electricity, water, HVAC etc) were added to the raw material emissions. The processing emissions were distributed among the products according to how demanding the processing of each product is, and the amount of each product that was sold. This is further described later on in this section.

Electricity GHG emissions were calculated based on the average emissions caused by the production of the electricity provided by the Finnish electricity grid, 184 gCO_2e / kWh (Ympäristöhallinto 2019). This electricity usage is the electricity supplied by the restaurant's own switchboard, i.e. the electricity that the company pays for directly. The user input was the total electricity consumption over the period. The data was available from the electricity invoices.

Water GHG emissions were calculated based on the emissions caused by the electricity needed for the cleaning of supply water, the electricity needed for heating hot water by 60°C and the electricity needed for the treatment of waste water. All of the water is assumed to be going down the drain. The water used for products is neglected, since its share is so small. The user input was the total water consumption and the hot water consumption. The emissions from supply water were calculated from the emissions of the electricity needed to produce the water, 0.83 kW / m^3 (Angervall et al. 2004). The waste water greenhouse gas emissions were calculated with the intensity 0.45 kWh / m^3 (Laitinen et al. 2014). The energy needed for heating water from the initial temperature to the wanted temperature was calculated according to Formula 2:

$$Q = \frac{mc\Delta T}{3600} \tag{2}$$

where Q is the energy (kWh), m is the mass (kg) of the water, c is the specific heat (kJ/kgK) and ΔT (K) is the temperature change. The emissions of the water heating were calculated with the emission intensity of district heating, 149 gCO_2e / kWh (Energiateollisuus 2018).

HVAC GHG emissions were calculated based on the energy needed for the heating of the restaurant space plus the energy needed for heating of ventilation supply. The emissions from heating the restaurant space was calculated using an average value for heating of facilities in Finland, 118.64 kWh / m^2 (Ympäristöministeriö 2018). The restaurant spaces are heated with district heating, which has an emission intensity of 149 gCO_2e/kWh (Energiateollisuus 2018).

The emissions from heating of the supply air was calculated based on the energy consumption needed to heat the supply air from the outside temperature to 17.5°C. Some restaurants have ventilation heat recovery, and this was considered in the calculations. The needed temperature change of the supply air was calculated separately for each month. The outside temperature for each month was calculated from the average monthly temperature, which was corrected with half of the difference of night-time and day-time temperatures, since the ventilation is not active in night-time. The outside monthly temperatures used in the calculations are shown in Table 7. The ventilation heat recovery is 50%, and the exhaust air temperature is 25°C, because of the hot air from the kitchen. The supply air is heated with district heating, which emission intensity is 149 gCO_2e / kWh. The ventilation is active 14 hours per day, 362 days a year. The energy consumption of the supply air heating for a restaurant with ventilation heat recovery is found in Table 8 and for a restaurant without heat recovery in Table 9.

Table 7. Monthly average outside temperatures (°C) during ventilation run-time. (Ilmatieteen laitos 2019a, Ilmatieteen laitos 2019b)

January	February	March	April	May	June	July	August	September	October	November	December
-8.8	-8.6	-2.8	3.3	9.7	14.9	17.9	15.7	10.3	4.3	-2.7	-8.8

Table 8. Kitchen ventilation supply-air heating energy for a restaurant with ventilation heat recovery. During May, June, July, August and September no external energy is needed for heating of the supply-air, since the recovery heats the supply air enough. The yearly supply-air heating energy consumption of a restaurant with ventilation heat recovery is 37251 kWh.

Month	Active-time average outside temp. (°C)	Exhaust air vs. outside air temp. diff. (°C)	Recovered temperature (°C)	After-recovery temp. (°C)	Heating need (°C)	Heating power (kW)	Heating energy per day (kWh)	Active days per month	Energy need per month (kWh)
January	-8.8	33,8	16,9	8,1	9,4	18,2	255	31	7893
February	-8,6	33,6	16,8	8,2	9,3	17,9	251	28	7034
March	-2,8	27,8	13,9	11,1	6,4	12,4	173	31	5374
April	3,3	21,8	10,9	14,1	3,4	6,5	91	29	2651
May	9,7	15,4	7,7	17,3	0,2	0,3	5	31	147
June	14,9	10,2	5,1	19,9	-2,4	0	0	30	0
July	17,9	7,2	3,6	21,4	-3,9	0	0	31	0
August	15,7	9,4	4,7	20,3	-2,8	0	0	31	0
September	10,3	14,7	7,4	17,7	-0,1	0	0	30	0
October	4,3	20,7	10,4	14,7	2,9	5,5	77	31	2393
November	-2,7	27,7	13,9	11,2	6,4	12,3	172	30	5160
December	-6,8	31,8	15,9	9,1	8,4	16,3	228	29	6598
									37251

Table 9. Kitchen ventilation supply-air heating energy for a restaurant without ventilation heat recovery. During July no external energy is needed for heating of the supply-air, but during the rest of the months external heating is needed at least to some extent. The yearly supply-air heating energy consumption of a restaurant without ventilation heat recovery is 132814 kWh.

Month	Active-time average outside temp. (°C)	Exhaust air vs. outside air temp. diff. (°C)	Recovered temperature (°C)	After recovery temp. (°C)	Heating need (°C)	Heating power (kW)	Heating energy per day (kWh)	Active days per month	Energy need per month (kWh)
January	-8.8	33,8	0	-8.8	26,3	50,9	712	31	22084
February	-8,6	33,6	0	-8,6	26,1	50,4	706	28	19757
March	-2,8	27,8	0	-2,8	20,3	39,3	550	31	17045
April	3,3	21,8	0	3,3	14,3	27,6	386	29	11193
May	9,7	15,4	0	9,7	7,9	15,2	213	31	6591
June	14,9	10,2	0	14,9	2,7	5,1	72	30	2153
July	17,9	7,2	0	17,9	-0,4	-0,7	-9	31	-294
August	15,7	9,4	0	15,7	1,9	3,6	50	31	1553
September	10,3	14,7	0	10,3	7,2	13,9	195	30	5851
October	4,3	20,7	0	4,3	13,2	25,5	358	31	11084
November	-2,7	27,7	0	-2,7	20,2	39,1	547	30	16414
December	-6,8	31,8	0	-6,8	24,3	47	658	29	19088
									132814

Waste GHG emissions were calculated from the emissions of bio waste treatment and mixed waste treatment. The user input was weight of bio waste and weight of mixed waste during the period. The emission intensities for the waste handling were 9.25 $kgCO_2e$ / t for mixed waste and 127.17 $kgCO_2e$ / t. (Myllymaa et al. 2008)

Ware transports of the company's operations were put in two categories; distribution transports and long-distance transports. In the distribution transports the emissions from the return trip were included, while in the long-distance transports it was assumed that the truck transportation capacity is utilized by another company on the return trip. In the distribution driving 30% of the driving is on the highway.

To calculate the emissions per tonkilometer of a distribution transport with selectable load Formula 3 was used. This formula is a modified version of Formula 1 provided by Lipasto (2017b). The modified formula also includes the emissions from the return trip. Using the formula, it can be calculated that a 50% loaded distribution truck with 9t capacity has an emission intensity of 213 gCO_2e / tkm in distribution driving. A combi-trailer, which is used for long-distance transports, has an emission intensity of 39 gCO_2e / tkm.

$$e_x = (2e_a + ((e_b - e_a) / l_c \times l_x)) / l_x \qquad (3)$$

where

e_x = emissions per tonkilometer with load x [gCO_2e / tkm]
e_a = emissions per kilometer without load [gCO_2e / km]
e_b = emissions per kilometer with full load [gCO_2e / km]
l_c = truck load capacity [t]
l_x = load x [t]

Data on the amounts of transported goods and transport distances were provided by the case company. There were six categories of transported goods: waste, wholesale goods, beverages, meat, potato and material from the central storage in Pietarsaari. Waste, wholesale goods and beverages were considered distribution transports, while meat, potato and material from the central storage were considered long distance transports.

Business travelling GHG emissions were calculated based on emissions from travelling with train, car, flights within Europe and flights to USA. Additionally, emissions from hotel overnights were included. The emissions from the flights were derived from the Carbon Emissions Calculator provided by the International Civil Aviation Organization, which is an UN organization. The user input was distance of travels with train and car, flights in Europe, flights to USA and amount of hotel overnights. The GHG emissions from the modes of transport that are commonly used within the case company can be seen in Table 10. When calculating emissions from hotel overnights, the emission intensity 0.5 kgCO_2e / € (Seppälä et al. 2009) was used.

Table 10. GHG emissions from a few common modes of transport in business travelling (Lipasto 2017c, ICAO 2019). *Finnish national average. **Assuming that 2/3 of train trips are with Intercity trains and 1/3 of train trips are with Pendolino trains. *** Average emission level for common routes flown by the case company employees. **** Emission level of a long-distance flight, e.g. Helsinki - New York.

Mode of transport	kgCO2e / km
Car*	0.133
Train**	0.013
Flight (Europe)***	0.13
Flight (Long-distance)****	0.05

Product raw material GHG emissions were calculated based on the emissions caused by the production of the raw material of the products. Each product contains a number of components, and each component contains certain amounts of various raw material (ingredients), according to the case company's recipes. The emissions from each component were calculated. By adding the emissions from each component of a product, the emission of each product was calculated. The sales data from the whole year was provided by the case company. The total emissions from the products were calculated by multiplying the emissions from each individual product with the number of products sold.

To be able to calculate the total emissions of each product, all the other emissions (electricity, water, heating etc.) were added to the products' raw material emissions. The other emissions were distributed among the products, according to how demanding the preparation of each product is. In this way each product is carrying its proper share of the other emissions. The weights of the product groups used in the calculation can be seen in Table 11.

Table 11. Product groups' weights, i.e. how big share of other emissions (electricity, water heating etc.) the products are carrying.

Product group	**Weight**	**Explanation**	**Products**
Brgr (simple)	7	Overall, patty, bun	Brgr, Classic, Aioli, Vegan
Brgr (demand-ing)	8	Overall, patty, bun, fried topping	C&O, Bacon, Umami, BOTM
Double Brgr (simple)	10	Overall, patty x2, bun	Brgr, Classic, Aioli, Vegan
Double Brgr (demanding)	11	Overall, patty x2, bun, fried topping	C&O, Bacon, Umami, BOTM
Chicken Salad	4	Overall, patty	Salad, Kids'
Fries	10	Overall, frying x3	Fries
Topped Fries	12	Overall, frying x3, toppings	Topped Fries
Toppings (sim-ple)	1	Overall	Salad, Onion etc
Toppings (de-manding)	2	Overall, frying or similar	Caramelized onion, bacon etc.
Added patty	3	Overall, frying	Beef, vegan & chicken patty
Soft drinks	2	Overall, cooling	Soft drink
Drinks (ready)	1	Overall	Milk, juice etc.
Shakes	3	Overall, freezing	Strawberry, chocolate shake
Halloumi fries	4	Overall, frying	Halloumi fries
Dips	2	Overall, cooling	All dips

Other material GHG emissions were calculated based on general numbers of emission intensity (kgCO_2e / €) of a few categories of materials and services. These materials and services are categories with GHG emissions that are challenging to determine. Instead the general emission intensities of the categories were used, as described in chapter 2.3.6. Three categories were identified: *packaging material* 0.21 $kgCO_2e$ / € (Huhtamäki 2017), *detergents* 0.6 $kgCO_2e$ / € (Seppälä 2009) and *other random equipment* 0.5 $kgCO_2e$ / € (Seppälä 2009). The information about the money spent on these categories was provided by the case company.

3.4 Limitations of the model

The factors included in the GHG emission calculation model can be seen in Figure 8. The model included the emissions caused by the everyday *operation* of the company. Emissions from the construction of new restaurants were not included, nor emissions from manufacturing or maintenance of appliances and furniture.

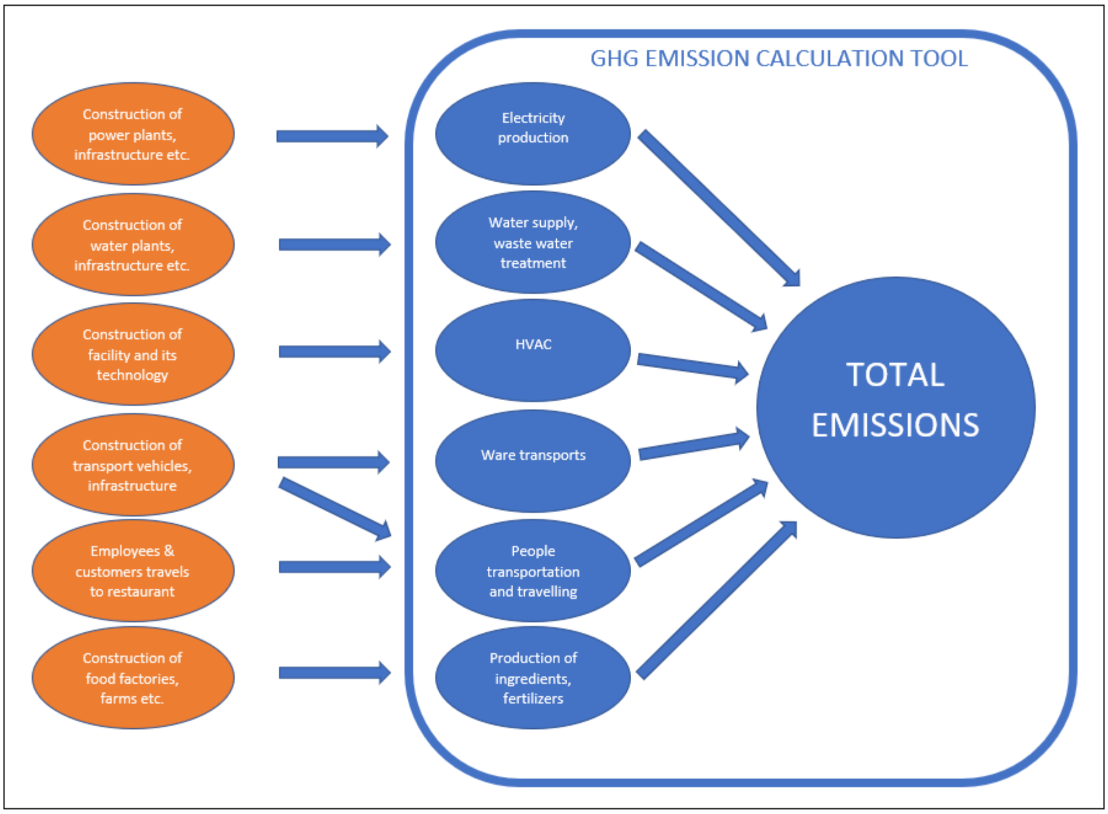

Figure 8. A principled representation of the limitation of the GHG emission calculation model.

The GHG emission calculation model was developed for the case company, a restaurant chain in Finland. If the model is to be used by other companies it may need some modifications, at least the emissions from the products, which is the most significant emission area, needs to be modified. Furthermore, the model was developed for the Finnish conditions, since the case company's main market is Finland. However, if provided with country-specific input factors, the model can easily be modified for other countries as well.

The time period considered in the greenhouse gas emission calculation was year 2018. In 2018 the case company operated on average 4.33 restaurants in Finland, as the fifth restaurant opened in the end of August 2018.

3.5 Improvement scenario simulation

If the case company wants to reduce its GHG emissions it should try to improve in all the emission categories. In this section the changes made in a hypothetical, but realistic improvement scenario are presented. These were the changed input used in the simulation, as compared to the actual input:

- Products: by developing and marketing new and better chicken burgers and vegan burgers, these more environmental-friendly product categories would each make up 20% of the sales, leaving only 60% beef burgers.

- Electricity: only nuclear electricity would be used in the restaurants. Electricity consumption would decrease 10% with the help of staff education and energy-saving routines and processes in the restaurant. For example: scheduled times for when appliances are switched on and off.

- Water: Hot water would be heated with nuclear electricity. Consumption would decrease 10% with the help of staff education and water-saving routines, processes and equipment in the restaurant. For example: proper cleaning hose and pistol.

- HVAC: ventilation heat recovery would be installed in all restaurants. Supply air would be heated with nuclear power electricity instead of district heating.

- Waste: education of staff, improvement of first-in-first-out routines and development of menu would reduce waste by 10%.

- Transports: emissions are reduced by 10% due to some transports using biofuel.

- Travels: travelling reduced by 10% thanks to better more online-based meeting technologies being used.

- Other materials: no changes.

4 RESULTS AND ANALYSIS

In this chapter the results from the calculation of the company's carbon footprint are presented and analyzed. The results from the simulation of the improvement scenario are also presented and analyzed.

4.1 Case company greenhouse gas emissions

According to the developed model, the total GHG emissions of the case company were **1611 tCO_2e** in 2018. The emissions of each emission category is shown in absolute numbers in Figure 9 and the share of each category in percent can be seen in Figure 10. The total average emission intensity of the case company's products was **0.23 $kgCO_2e$ / €**. The beef meat alone caused 55% of the total emisssions.

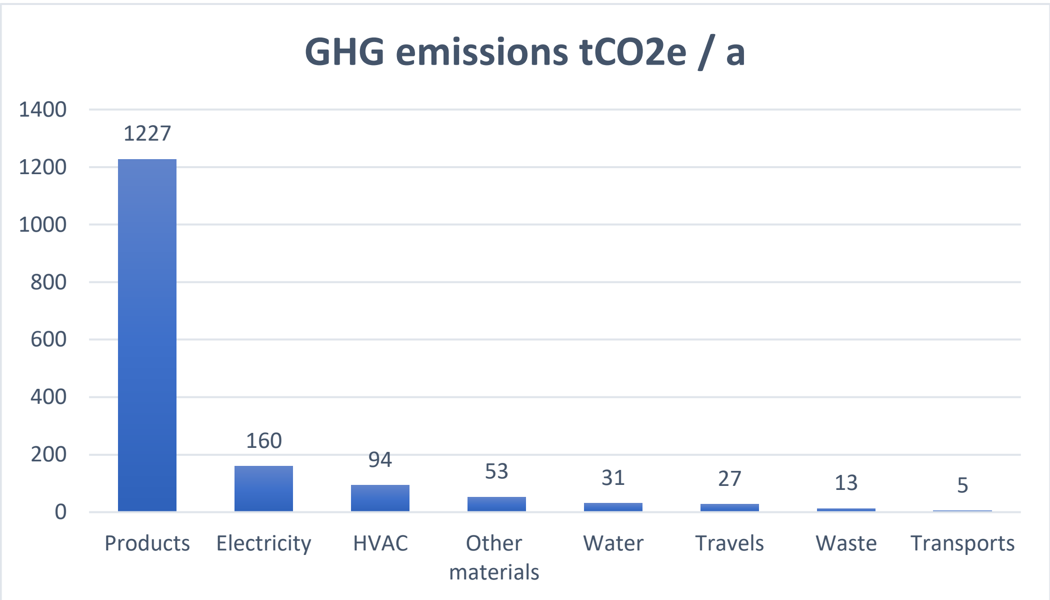

Figure 9. GHG emissions in tCO_2e per emission category caused by the case company's Finnish operations in 2018.

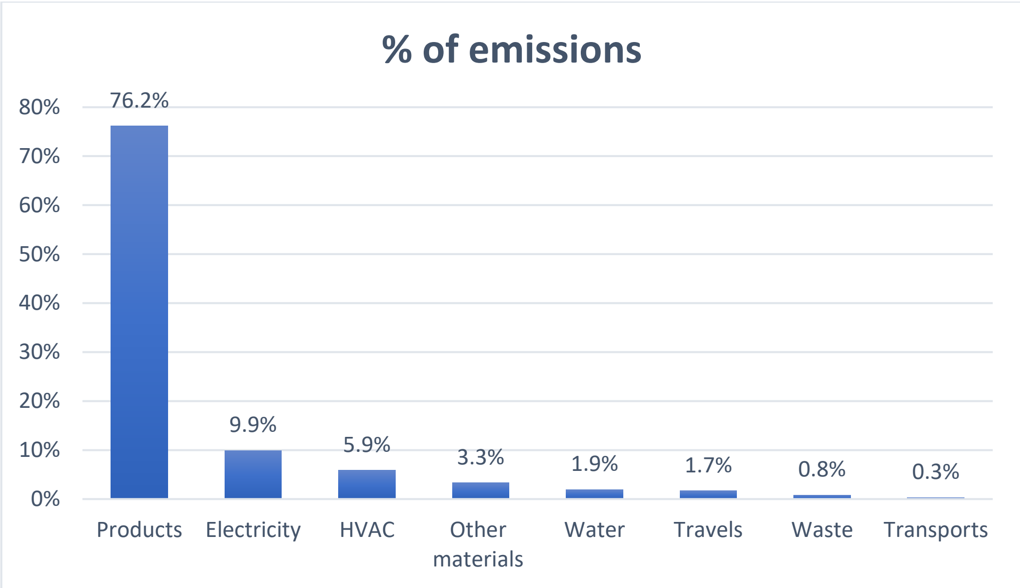

Figure 10. Emissions for each category in percent.

The product raw materials, i.e. the ingredients, are by far the biggest emission category, causing 76.2% of the total emissions. Electricity used in the restaurant operations causes 9.9% of the emissions, while HVAC causes 5.9%. Other materials, i.e. packaging material, detergents and other raw material, causes 3.3% of the total emissions. Water consumption causes 1.9% of the emissions, business travelling 1.7%, waste treatment 0.8% and ware transports 0.3%.

4.1.1 Internal operational emissions

When the emissions from the production of the ingredients of the products are excluded (emission category "products") it is possible to get insight into what the company directly can do to improve the sustainability of its internal operations. The company cannot directly impact the emissions caused by the production of the ingredients, but the emissions from the internal operations are within the company's control. The share of the emission categories from the internal operations are shown in Figure 11. The emissions from the internal operations are in total 383 tCO_2e.

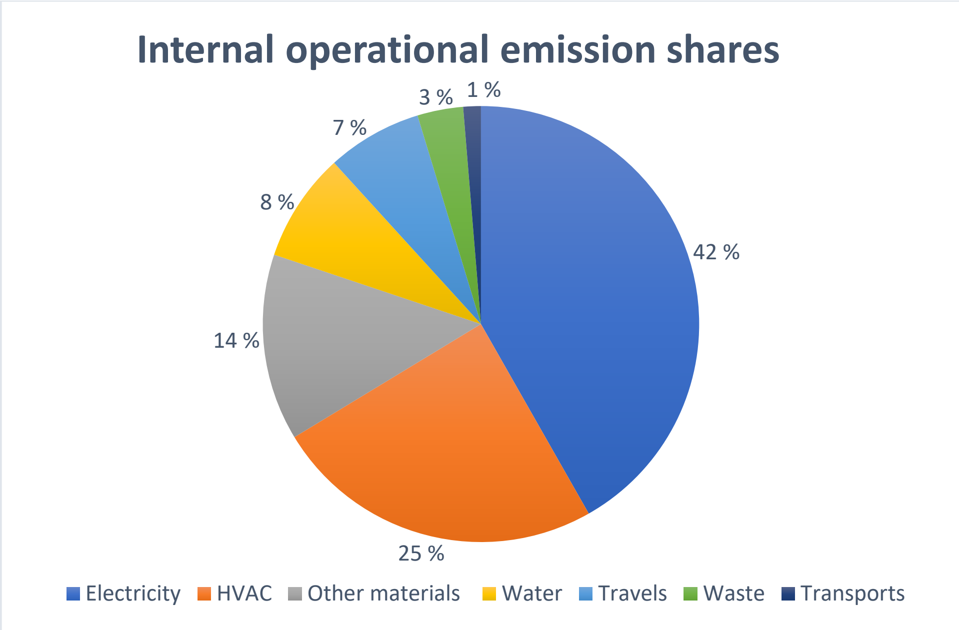

Figure 11. Each internal operation emission category's share of the emissions.

Direct electricity use causes 42% of the emissions from the company's internal operations. Electricity's share of the emissions is in fact even bigger, as electricity is used also in all basically the other categories, for example in running HVAC systems, producing packaging materials, cleaning water, travelling by train etc. It is therefore not trivial what source the electricity used in the restaurant has.

HVAC is the second biggest category with 25% of the operational emissions. Roughly 70% of the emissions of HVAC is caused by the kitchen ventilation supply air heating, and about 30% comes from heating the restaurant space. Of the emissions from water use roughly 95% is caused by the heating of hot water and 5% for the treatment of supply water and waste water. Waste treatment causes 3% of the operational emissions, of which 90% comes from the treatment of bio waste, and 10% from mixed waste treatment.

It can be noted that ware transports cause only 1% of the operational emissions. This is due to the fact that almost all the raw material is produced in Finland, which means that transport distance is minimized. After all the amount of material transported during the year is also quite small, around 68000 tonkilometer.

With 0.3% of the total carbon footprint, business travelling is the smallest emission category. The emissions from the different modes of travelling by the case company's staff can be seen in Figure 12.

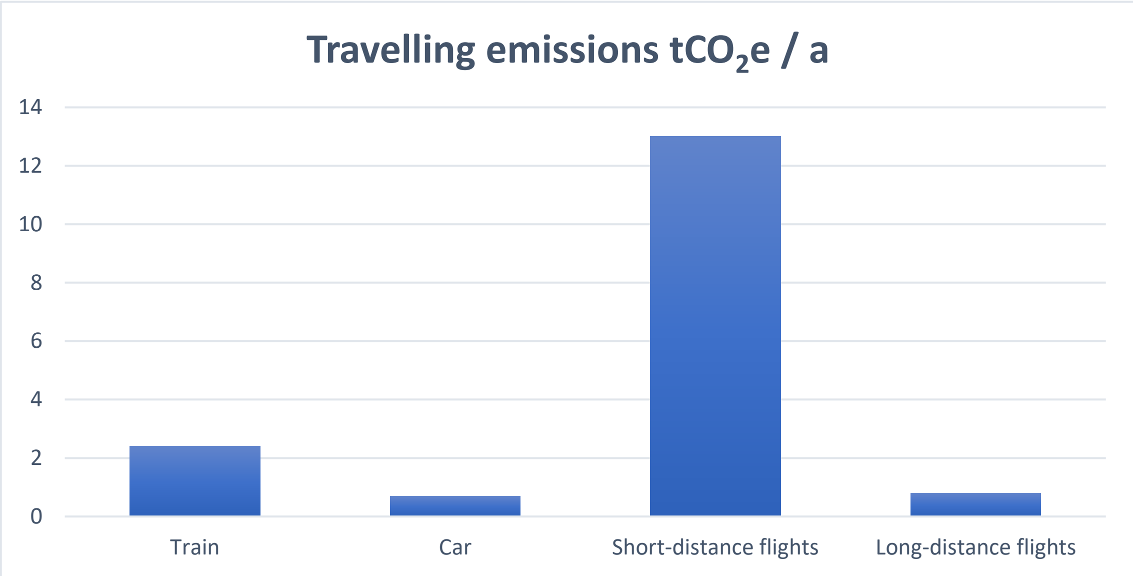

Figure 12. Total emissions from the case company staff's work-related travelling during year 2018. The total distance travelled with train was 180000 km, with car 5000 km, short-distance flights 100000 km and long-distance flights 15000 km.

4.1.2 Product emissions

The total greenhouse gas emissions from a product is the sum of the emissions from the raw materials used in the product and the emissions caused by the cooking and serving process. The cooking and serving process emissions include all the emissions from heating the facility, running the ventilation, heating cooking appliances, cooling, restaurant lighting, water use etc. These processing emissions are distributed among all the products sold according to how demanding the process of each product is. The raw material emissions and total emissions of representative products can be seen in Table 12. The share of each raw material component of the Classic Brgr can be seen in Figure 13.

Table 12. GHG emissions for selected products from the raw materials, the processing and the total product. Beef burgers cause more than twice as much emissions as a chicken burger, and about five times more than a vegan burger. The fries ingredients have a small amount of emissions, but their process is demanding, due to the energy-intensive triple-cooked method that is used by the case company. The majority of the GHG emissions from fries are therefore from the processing.

Product	**$CO_2e_{rawmaterial}$ (g)**	**$CO_2e_{process}$ (g)**	**CO_2e_{total} (kg)**
Classic Brgr	2089	250	2.34
Bacon Brgr	2197	286	2.48
Double Classic Brgr	4017	358	4.38
Double Bacon Brgr	4125	393	4.52
Kids Brgr	995	143	1.14
Chicken Brgr	725	250	0.96
Vegan Brgr	246	250	0.50
Chicken Salad	908	143	1.05
Fries	98	358	0.46
Beef patty (incl. cheese)	1928	107	2.04
Chicken patty	500	107	0.61
Vegan patty	51	107	0.16
Dips	95	72	0.17
Soft Drink	80	72	0.15

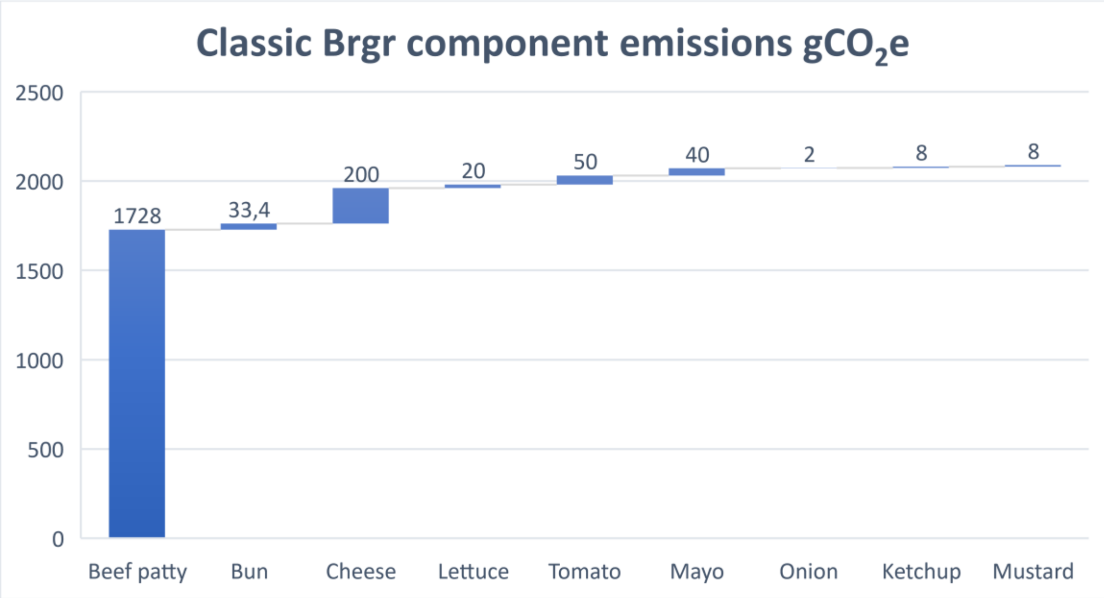

Figure 13. Raw material GHG emissions from each component of the Classic Brgr. About 83% of the emissions come from the beef patty.

When analyzing the carbon footprint of food, it is also relevant to compare the emissions to the energy content of the food. In Figure 14 the GHG emissions per gram of food of a few products are shown. In Figure 15 the GHG emissions per kilocalorie of the products are shown. The Vegan Brgr has by far the least emissions, both when comparing with weight and energy content. In the weight and energy content perspectives the Bacon Brgr has lower relative emissions than the Classic Brgr, due to the high energy content of bacon. The Fries have a relatively low amount of emissions per energy content, and the number would be very low if the production process would not be so energy-intensive.

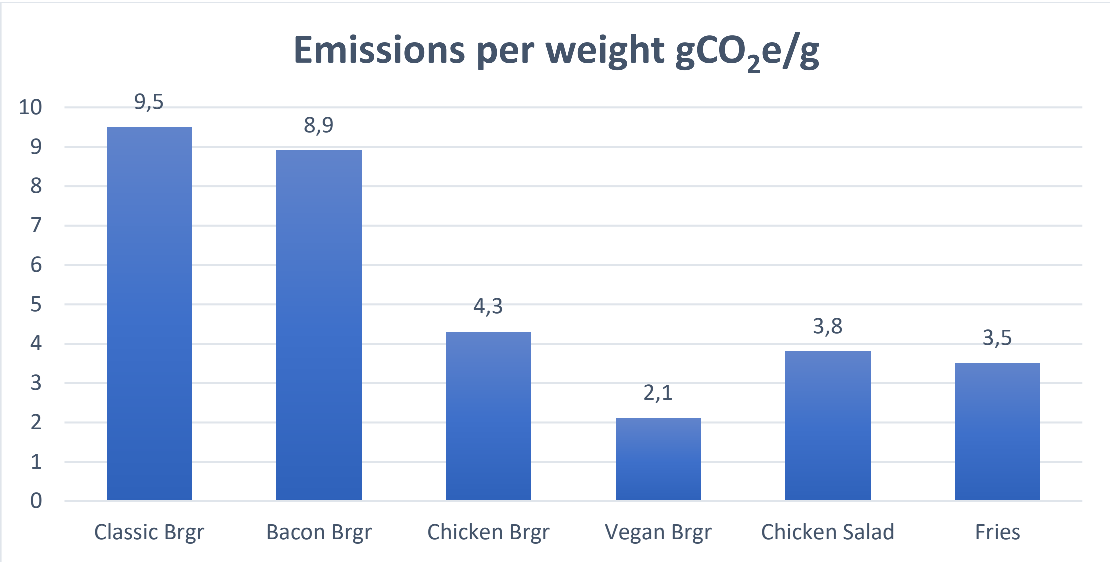

Figure 14. GHG emissions per weight unit of selected products.

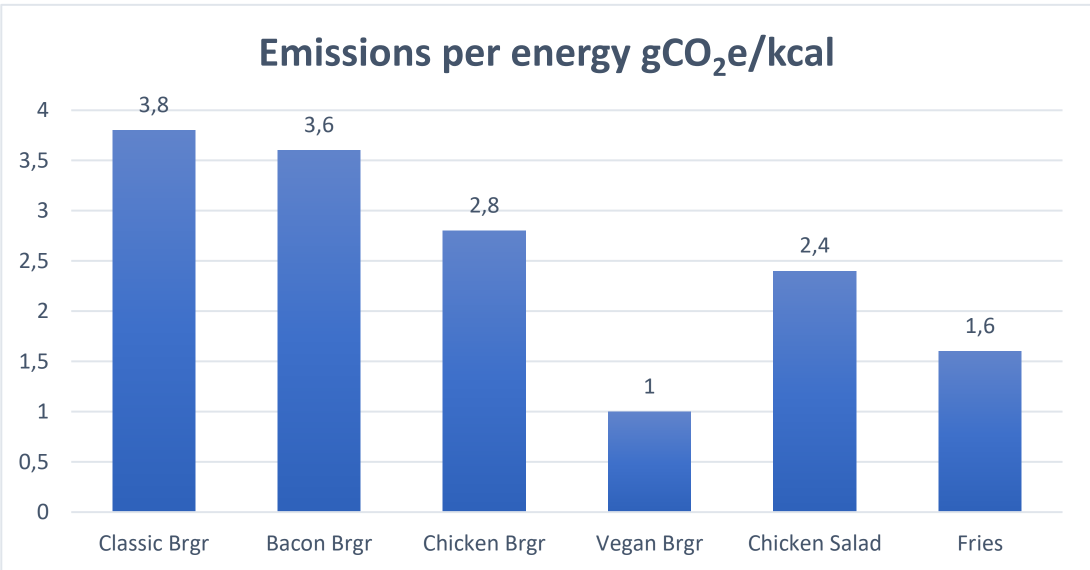

Figure 15. GHG emissions per energy unit of selected products.

4.2 Improvement scenario simulation results

According to the simulation of the improved scenario the total GHG emissions of the case company would be 1081 tCO_2e, which is a reduction of 530 tCO_2e or 33%. The simulated emissions of each emission category are shown in Figure 16 and the share of each category in percent can be seen in Figure 17. The emissions from the internal processes would be reduced by 64% according to the simulated scenario. The emission reduction in tCO_2e per category can be seen in Figure 18. The total average emission intensity of the case company's products would be 0.15 $kgCO_2e$ / €.

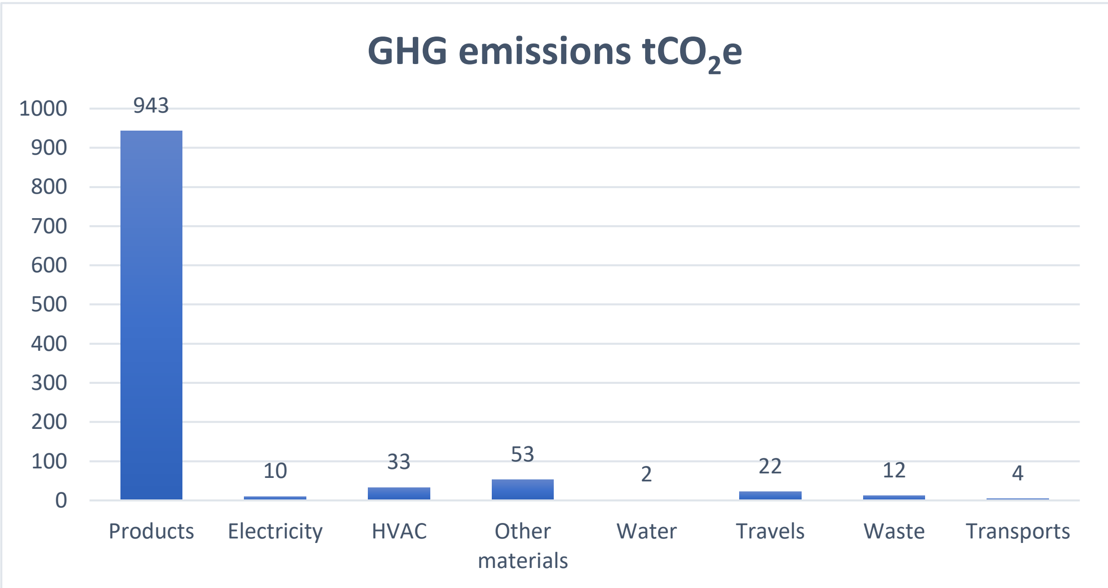

Figure 16. GHG emissions from the emission categories according to the simulated scenario.

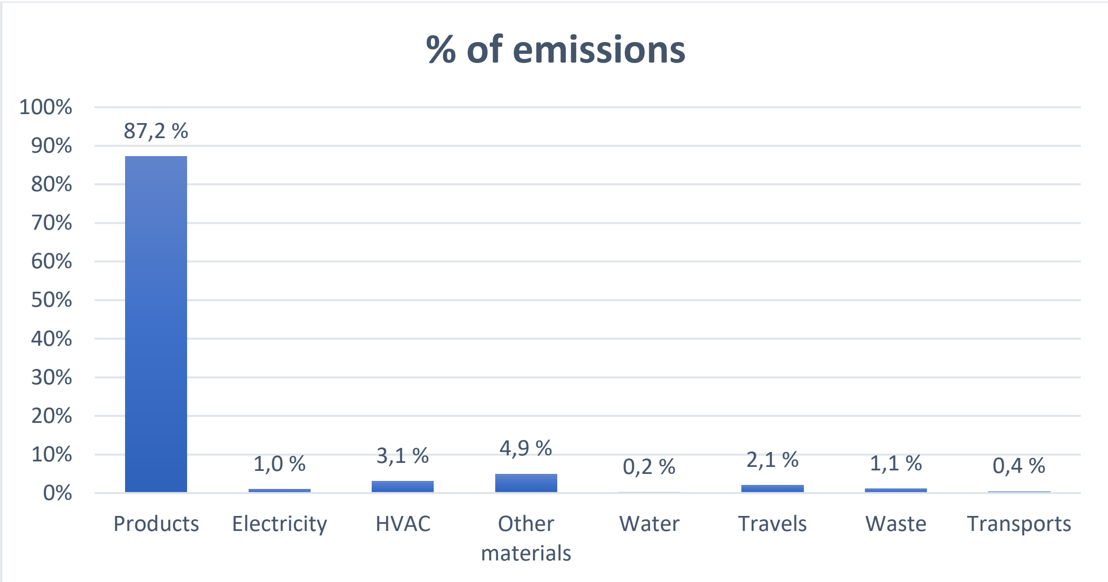

Figure 17. Emissions for each category in percent according to the simulated scenario. Even though the majority of the emission reduction comes from the product category, the share of emissions from the products would be larger, due to the drastic reduction of emissions from the electricity, HVAC and water.

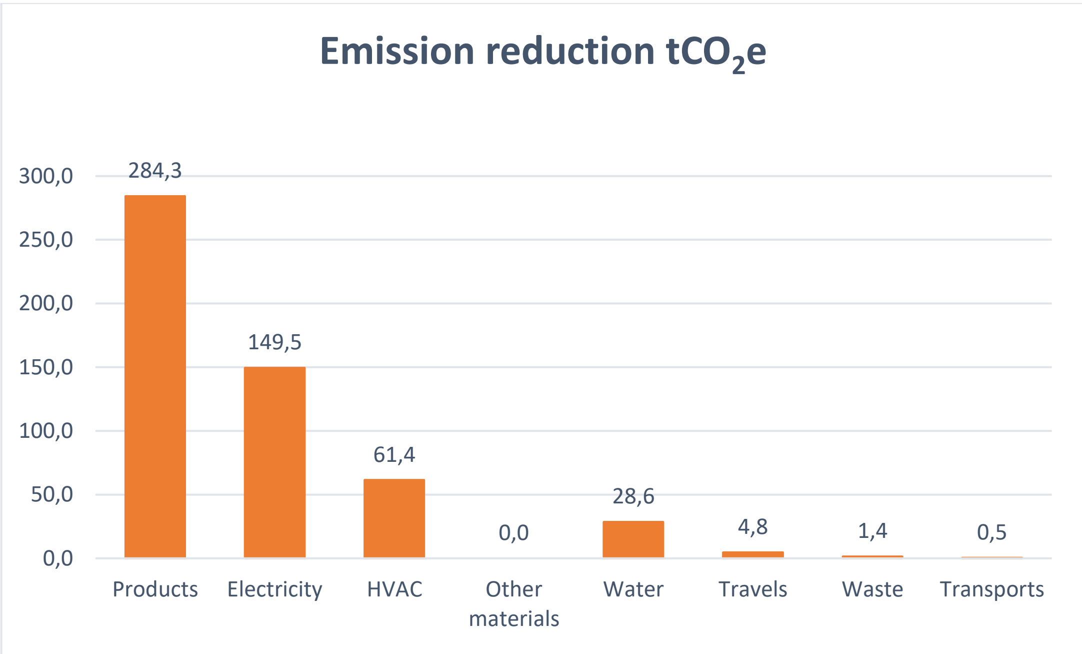

Figure 18. Emission reduction in the emissions categories according to the simulated scenario. Product emissions are reduced by 23%, electricity emissions by 93%, HVAC emissions by 65%, water emissions by 92%, travel emissions by 18%, waste emissions by 10% and transport emissions by 10%.

In the simulated scenario the GHG emissions caused by the processing of the products are reduced by 64%, which means that products with low raw material emissions are affected relatively most when it comes to emissions per weight and emissions per energy content. The simulated emissions per weight are shown in Figure 19. The simulated emissions per energy content are shown in Table 20.

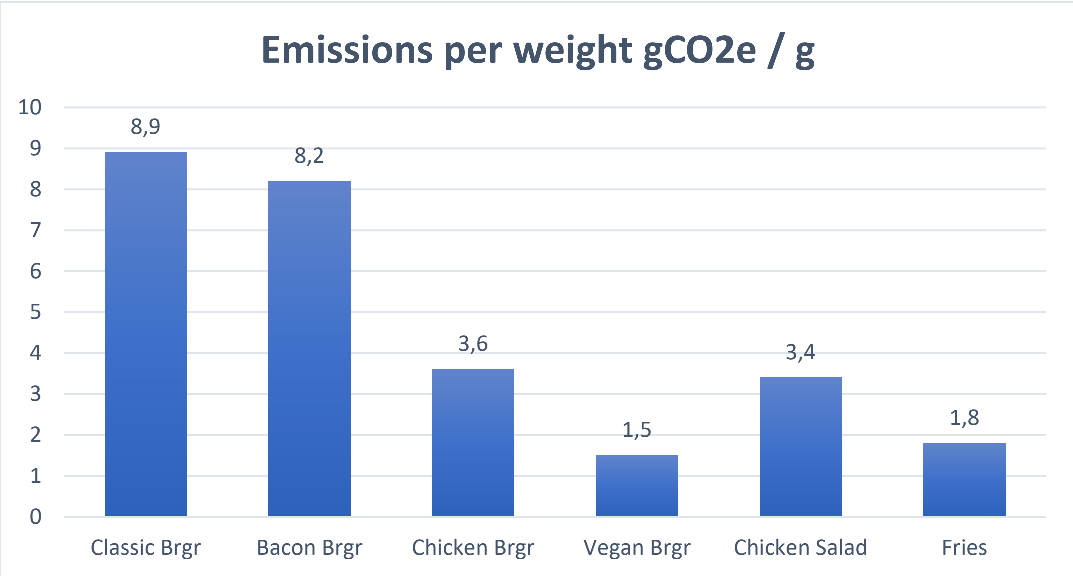

Figure 19. Emissions per weight for selected products according to the simulated scenario.

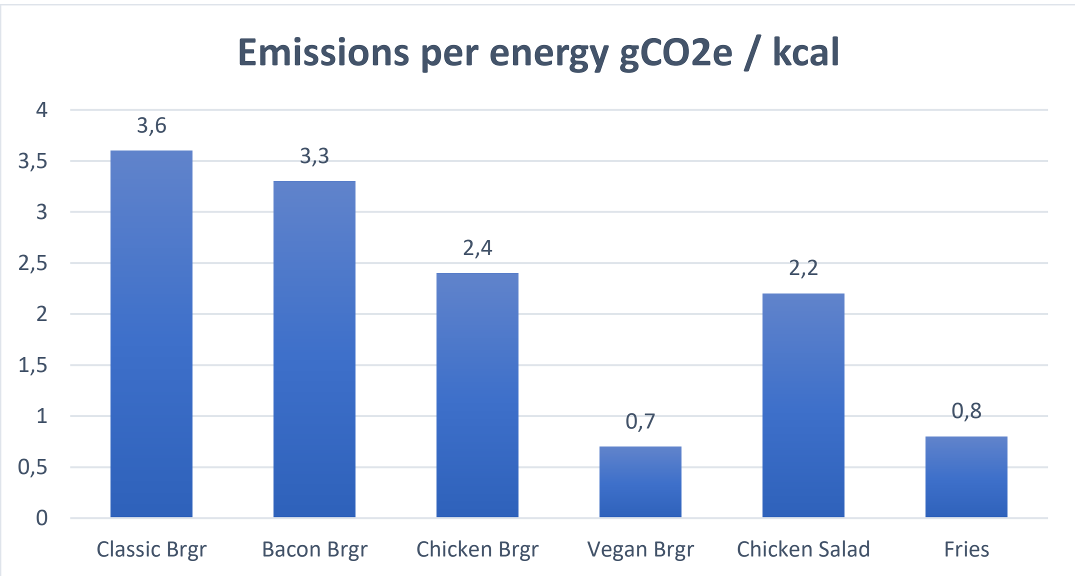

Figure 20. Emissions per energy content for selected products according to the simulated scenario.

5 DISCUSSION

The study concluded that the carbon footprint of the case company in year 2018 was 1611 tCO_2e. When comparing the total emissions to the sales of the company, this results in an average greenhouse gas emission intensity of 0.23 $kgCO_2e$ / € for the company’s products. This is significantly lower than the average restaurant services emission intensity 0.4 $kgCO_2e$ / € calculated by Seppälä et al. (2009). The reason for the lower emission intensity could be that the case company does not use any prefabricated food, and thus the process from food producer to restaurant customer is shorter than on average in the restaurant sector. 76.2% of the total emissions are caused by the food ingredients. Beef meat alone causes 55% of the total emissions.

The Classic Brgr, the case company’s basic burger, has a carbon footprint of 2.34 $kgCO_2e$, while the Chicken Brgr has a carbon footprint of 0.96 $kgCO_2e$ and the Vegan Brgr 0.50 $kgCO_2e$. 0.25 $kgCO_2e$ of the carbon footprint of a burger were caused by the operations, and the rest by the ingredients. The Double Classic Brgr has a carbon footprint of 4.38 $kgCO_2e$, the fries 0.46 $kgCO_2e$ per portion, a dip sauce 0.17 $kgCO_2e$ and a soft drink 0.15 $kgCO_2e$. This means that a Classic meal with dip sauce has a carbon footprint of 3.1 $kgCO_2e$. It is clear that chicken and vegan products are indeed more sustainable alternatives from the global warming point of view. Also, when looking at the GHG emissions per weight and per calorie the chicken and vegan products are beneficiary. The most effective way to reduce the company’s carbon footprint is to introduce and promote more chicken and vegan products.

The data on the emissions from beef meat production varies significantly. The emission factor used in this study was 15 $kgCO_2e$ per kg beef meat. As shown by Katajajuuri (2009) different studies have found the carbon footprint of beef to be between 11 $kgCO_2e$ / kg and 30 $kgCO_2e$ / kg. This variation in the beef carbon footprint data makes the results of the study significantly less reliable, as beef meat is such an important part of the case company’s products. More research should be made on the carbon footprint of food ingredients, and especially of beef, as it is the most significant source of GHG emissions.

Electricity and energy used for running the restaurant's appliances, the ventilation and heating of facility and water are together causing about 18% of the emissions. These emissions can be drastically reduced by switching to using electricity produced by nuclear or renewable power plants. The emissions from the energy and electricity will decrease automatically, as the Finnish energy production moves in a more environmental-friendly direction, with expanding nuclear power capacity and more renewables. This should also affect the emissions from the food ingredients positively, as energy and electricity of course are used in the complete value chain. The sourcing of domestic ingredients is therefore a strategy that will be even more sustainable in the future.

The study found that the GHG emissions of waste was only 0.8% of the total carbon footprint. It should be noted, however, that the waste amounts used in the calculations are only estimates. Empiric measurements of the waste amounts should be made to increase the reliability of the results.

GHG emissions from business travelling caused 1.7% of the total carbon footprint. Flights were the biggest contributor to the emissions. However, it should be noted that flying has the same emissions per kilometer as driving car, 133gCO_2e / km. Travelling by train causes 10 times less emission than flying or driving car, and from a global warming perspective train should therefore always be used when possible.

The ware transport emissions for the company's operations were only 0.3% of the total carbon footprint. The company uses almost only domestic ingredients, which reduces the transport emissions. This is not where the case company could significantly reduce its carbon footprint.

It should be noted that the carbon footprint calculated in this study does only account for the GHG emission from the case company's operations and the ingredients. GHG emissions from the whole value chain, for example the building of the restaurant facility and the kitchen appliances and restaurant furniture etc. are not included. It would be very complicated to calculate the emissions from the whole chain. The limit has to be drawn somewhere, and the limitation used in this study is quite clear and comparable.

The carbon footprint calculations are based on the company's operations in year 2018. The calculation should be updated each year, as internal input factors will change with the company expanding and external factors, for example emissions from electricity, will change each year.

6 CONCLUSIONS

The objective of this case study was to investigate the GHG emissions caused by the case company Friends & Brgrs. The ultimate goal was to increase the case company's insight into the environmental impact of its operations. The acquired insights are to be used in the formulation of an environmental responsibility strategy.

Three research questions were stated in the study: *What is the case company's carbon footprint?*, *What is the share of the factors contributing to the company's GHG emissions?* and *How could the company reduce its GHG emissions?*.

The research questions were answered by developing a GHG emission calculation model. The emission calculation model was created in Google Sheets, which enables swift modification and update of the model in the future. The GHG emission areas of the company's operations were identified and their carbon footprint calculated. A simulation of a potential scenario, in which the case company wanted to reduce its carbon footprint, was done using the emission calculation model. The model was limited to only include the operations and ingredients of the company. Emissions from production of facilities, appliances and similar were not included.

The study found that the case company's carbon footprint in 2018 was 1611 tCO_2e, which was equivalent to an emission intensity of 0.23 $kgCO_2e$ / €. 76.2% of the total emissions are caused by the food ingredients, and 23.8% from the operations, which includes energy, electricity, water, transports etc. Beef meat alone caused 55% of the total emissions.

The carbon footprint of the case company's basic product, The Classic Brgr, was 2.34 $kgCO_2e$, while the Chicken Brgr had a carbon footprint of 0.96 $kgCO_2e$ and the Vegan Brgr 0.50 $kgCO_2e$. Of these emissions 0.25 $kgCO_2e$ per product was caused by the processing, and the rest by the product raw material. It can be concluded that chicken and vegan products have significantly less global warming impact. The case company should introduce more chicken and vegan alternatives in case it wants to reduce its carbon footprint.

The carbon footprint of the operations, meaning emissions from energy, water etc., were reduced by 64% in the simulated improvement scenario. To achieve this reduction, the company should switch to electricity from nuclear power plants, install ventilation recovery in all restaurants, reduce electricity, water and waste consumption by 10%, travel 10% less and reduce transport emissions with 10% with the help of biofuel. However, to substantially reduce the total carbon footprint of the company, chicken and vegan products must get a bigger share of the sales.

In order to reduce the carbon footprint of the company's operations and prepare for future sustainability demands, the case company needs to formulate a sustainability strategy. Based on the findings of the study, the following concrete proposals are made to the case company:

- The carbon footprint of the products should be benchmarked with competing restaurant chains.
- More chicken and vegan products should be introduced and promoted.
- Nuclear or renewable electricity should be sourced.
- Ventilation heat recovery should be installed in all restaurants.
- The customer attitudes about the carbon footprint of the food could be investigated, in order to satisfy customer needs.
- The restaurant leaders and staff should be educated in sustainable practices.

To enable more reliable carbon footprint calculations, more research on the emissions of raw materials, in this case ingredients, should be made. Especially the carbon footprint intensity of beef needs to be investigated more thoroughly, as it has the highest global warming impact.

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