Greenhouse Gas Analysis of Gipsy Hill Brewing

Analysis of the greenhouse gas
emissions associated with Gipsy Hill Brewing by Zevero LTD 03/2023

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Abstract

An environmental assessment was undertaken for the greenhouse gas (GHG) emissions of three products sold by Gipsy Hill Brewing (Trail Pale, Swell Lager and Hepcat). The analysis is from cradle-to-grave and analyses three separate packaging types for each product. The results are split into stages of Ingredients, Packaging, Processing, Transportation, Use, and End-of-Life. Overall for Hepcat, there is 0.77kgCO_2e/L from beer packaged in 30L kegs, 1.14kgCO_2e/L from 440ml cans and 1.08kgCO_2e/L from 330ml cans. For Trail Pale, the sourcing of low-carbon ingredients means that packaging in 30-litre kegs results in -0.07kgCO_2e/L. In 440ml cans, Trail Pales overall GHG emissions are 0.30kgCO_2e/L and 0.24kgCO_2e/L for 330ml cans. For the Swell Lager, there is -0.05kgCO_2e/L for 30L keg, 0.31kgCO_2e/L for 440ml cans and 0.25kgCO_2e/L for 330ml cans. The study highlights the importance of regenerative agricultural practices within the brewing section and the significance this can have on overall product GHG emissions.

1 Introduction

1.1 Overview

Gipsy Hill Brewing is a South London-based brewery founded in 2013. The brewery prides itself on producing high-quality beer using locally sourced ingredients.

The brewing industry produces significant greenhouse gas emissions within the United Kingdom. The production of beer involves several stages that contribute to GHG emissions, including the cultivation and processing of ingredients, the production and transportation of packaging materials, the brewing process itself, distribution, use, and end-of-life of the final product.

There is growing interest in the environmental impact of companies, products and services throughout the industry. In this study, an environmental analysis was conducted to assess the greenhouse gas (GHG) emissions associated with the production of a specific beer product produced by Gipsy Hill Brewing.

By conducting environmental studies to quantify the GHG emissions associated with the production of products sold by breweries, Gipsy Hill and other breweries can be provided with data that can help them make low-carbon business decisions and reduce their overall environmental impact.

1.2 Aims and Objectives

The overall aim is to calculate the life cycle GHG emissions associated with Gipsy Hill Brewing's Trail Pale, Swell Lager and Hepcat Session IPA. This report will subdivide the GHG emission into life cycle stages for Gipsy Hill to understand where they can make further GHG emission reductions in the future across operations and their supply chain. Moreover, further implementation of techniques to reduce GHG emissions within their products will be highlighted in this report's main body.

1.3 Standard Compliance

This report is based on compliance conditions with GHG Protocol Product Standard [1, 2], introduced by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). A Product Footprint is a greenhouse gas emission analysis of a product that is sold by a given company. The analysis relates solely to the products analysed. The results are used to understand the full life cycle GHG emissions of a product and focus efforts on the greatest GHG reduction opportunities.

2 Scope of Study

2.1 Product Systems

Three products that are produced and sold by Gipsy Hill Brewing have been analysed in this study. Hepcat, which is within the core range sold by Gipsy Hill Brewing and is a 4.6% session IPA. Trail Pale and Swell Lager are both new products to be sold by Gipsy Hill with the intention of sourcing low-carbon ingredients to minimise the GHG emissions of the product. Due to the packaging of beer being a significant contributor to GHG emissions, all products have been analysed with 3 packaging types. The packaging types chosen relate to the most frequently sold by Gipsy Hill Brewing and are 330ml Aluminium Cans, 440ml Aluminium Cans, and 30L Steel Kegs. Table 1 shows the breakdown of items and their respective masses that make up the three packaging types.

2.2 Functional Unit

The functional unit for this study is 'One Litre of Packaged Beer'. The functional unit allows Gipsy Hill Brewing and other stakeholders to compare the studied products' GHG emissions.

2.3 System boundary

The system boundary for this cradle-to-grave life cycle assessment (LCA) of the products analysed encompasses all stages of the beer production process, from the extraction of ingredients to the end of life of the product. The study includes all direct and indirect GHG emissions associated with the ingredients, production, transportation, distribution, consumption, and disposal of the beer. Figure 1 shows the system boundary for the analysis.

2.4 Impact Factors

The scope of this assessment is limited to global warming potential (GWP) which is measured as a function of carbon

dioxide equivalent (CO_2e). This impact category uses the global warming potential of CO_2 as a reference value and analyses gases' environmental impact over a 100-year period (GWP1000). The GHG gases considered included: CO_2, CH_4, N_2O, HFCs, PFCs, NF_3 and SF_6.

Table 1: The breakdown of items and their respective masses that make up the three packaging types

Input name	Weight of item	Unit of measurement
Keg-30L		
Steel Keg	8.150	kg
Keg Caps	0.013	kg
Can-440ml		
Lid-440ml	0.002	kg
Can-440ml	0.010	kg
Label-440ml	0.002	kg
Box-12X440ml	0.0.37	kg
Box-Label	0.001	kg
Can-330ml		
Lid-330ml	0.002	kg
Can-330ml	0.009	kg
Label-330ml	0.001	kg
Box-12X330ml	0.280	kg
Box-Label	0.001	kg

3 Inventory Analysis

3.1 Data Collection and Uncertainty

Gipsy Hill Brewing provided records of all data necessary for the completion of the analysis. Where data had not already been collected or needed further detail, suppliers were contacted directly for activity data or industry averages were used and have been referenced. All data collected in this study from Gipsy Hill Brewing refers to the period of Jan 22 to Dec 22.

Emission factors are the GHG emissions per unit of activity data, and they are multiplied by activity data to calculate GHG emissions. Due to the available data from specific suppliers and other published reports in the industry, emission factor data in this study were collected from various published sources, including life cycle databases, published product inventory reports, government agencies, industry associations, company-developed factors and peer-reviewed literature. A full breakdown of sources is detailed in the supplementary data. To ensure accuracy in emission results all emission factors used are checked with consideration of the Location, Time Frame, Supply Chain and Completeness. Any data uncertainties that have been raised are highlighted throughout this report in their related sections.

- **Location** Different locations can create variances in GHG emissions. Therefore, a hierarchical approach was used in order to obtain the most accurate emission factor (country region, country, continent or global), depending on the availability of data.

- **Time Frame** The latest available and appropriate emission factors are used within the analysis. The creation and updating of emission factors can differ between each study, as a result, the emission factors used within a study can be across a range of different years. Where appropriate, the most recent emission factor was used.

- **Supply Chain** Where available, this study looked to use supplier-specific data for supply chain GHG emissions. Supplier-specific emission factors are reviewed against the Product Life Cycle Accounting and Reporting Standard to ensure accuracy. Supplier-specific emission factors are prioritised over location-specific emission factors.

- **Completeness** Due to the variation in sources of GHG emissions factors, each source is reviewed internally by Zevero to ensure that all appropriate emission contributors are accounted for within the scope of the source as well as checks for the exclusion of delayed and offset emissions.

3.2 Allocation Approach

Companies often generate multiple products through processes therefore emissions must be subdivided (allocated) to respective products based on either the physical characteristics of the co-products such as mass/energy content or based on their market values (economic allocation). Within this study, multi-output allocation was performed where operational activity data was collected on the facility level. Due to all products made by Gipsy Hill Brewing being beer and having comparable economic value per functional unit, volume allocation was used in multi-output scenarios. Further information can be found in section 3.5, where for example. electricity and gas consumption was collected site-wide and allocated to the volume of beer produced within the same time period.

The end-of-life allocation of inventory data (i.e. ingredients used in the making of the products) relates to the sources used for life cycle datasets. Multiple sources were used however all sources were reviewed and adapted (if necessary) to relate to the cut-off approach. The cut-off system model is based on recycled content. In this system model, wastes are the producer's responsibility and there is an incentivisation to use recyclable products, that are available burden free. This approach was chosen to highlight the benefit of sourcing low-carbon ingredients throughout the brewing industry [3].

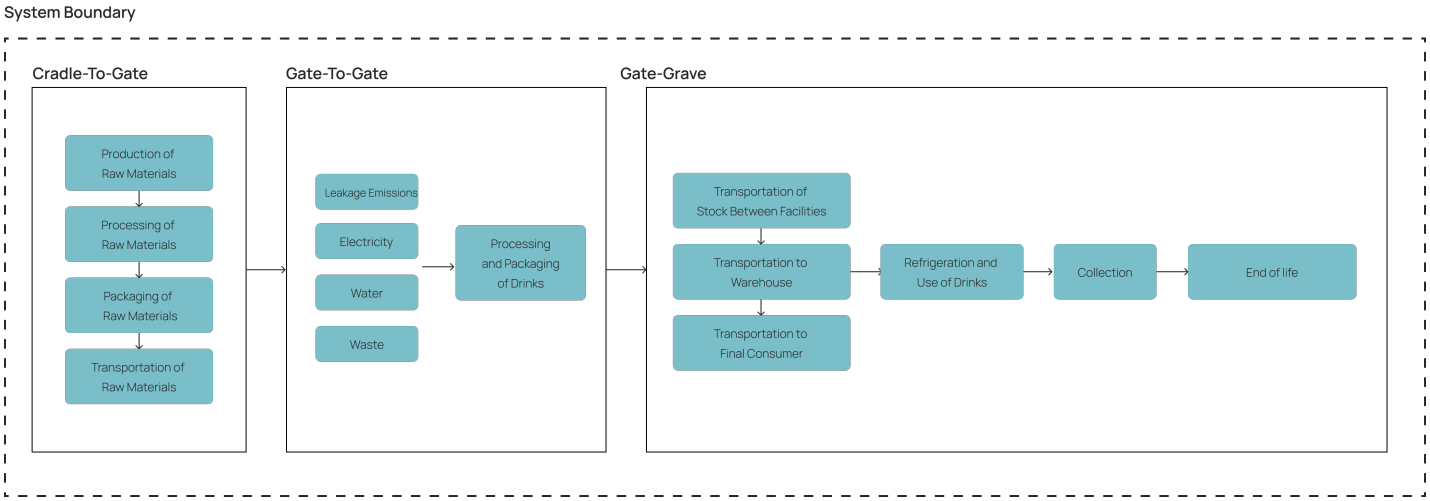

Figure 1: The system boundaries for Gipsy Hill Brewing's activities.

3.3 Category Model description

The below describes the inventory data used within the analysis for each category within the studied product's life cycle.

3.3.1 Ingredients

Within the brewing process, ingredients are purchased from suppliers and delivered to Gipsy Hill Brewing to be made into beer. Recipes for each product were collected from Gipsy Hill Brewing. For each product used, information was collected on the supplier, supplier location, and origin location via Breww management software to ensure the appropriate emission factor was used. The category of 'ingredients' is made up of separate GHG emission stages up to Gipsy Hill Brewing's facility. Farming or manufacturing of the ingredients that are purchased, the processing to turn ingredients into the finished products purchased as well as the packaging and transport of products. Regarding transportation, there is variation in whether GHG emission factor sources include or exclude transportation from the origin to the final destination. Therefore, if transportation is excluded, Zevero calculates this within purchases with the same methodology as in section 3.6.

A full breakdown of the ingredients used will not be shared in this report due to the sensitivity of this information in recipe creation. However, all malt, hops, yeast, processing aids and cleaning chemicals have been included as primary ingredients of this report. Further to the primary ingredients that make up the products, the gases (carbon dioxide, nitrogen, oxygen and argon), as well as the cleaning ingredients, have been included.

There are losses within the packaging process, meaning that the volume of brewed beer does not equal the final packaged volume. For Gipsy Hill Brewing a packaging efficiency factor was used of 85% for both can and keg packaging types. These numbers have been taken from an average batch efficiency rate calculated throughout 2022.

3.3.1.1 ingredients Selection

The Trail Pale and Swell Lager ingredients have been sourced to highlight the potential saving in GHG emissions. Within the ingredients, there are three unconventional ingredients that have been used: regenerative barley from WildFarmed spent hops and recycled yeast.

- **Wildfarmed Barley**

  WildFarmed was founded in 2018 and prioritises soil health and biodiversity in its crops. The company works with farmers to implement regenerative practices such as intercropping, cover cropping, and reduced tillage, which improve soil health, reduce erosion and sequester carbon. WildFarmed barley is sourced from a network of farmers who have implemented regenerative practices.

  WildFarmed commissioned a report from BeZero to analyse the GHG emissions from their products. The study shows that there are net negative GHG emissions due to Wildlfarmed's regenerative agriculture practices increasing the rate of soil carbon sequestration compared to the former land management techniques. The breakdown of GHG emission results from the study are as follows: ingredients -3.048kgCO_2e/kg, Transportation 0.410kgCO_2e/kg and Packaging 0.003kgCO_2e/kg. Within the report, The IPCC Guidelines for National Greenhouse Gas Inventories (Volume 4: Agriculture, Forestry and Other Land Use) have been used to calculate the changes in carbon stocks from land use.

  Processing emissions from the study were retracted and the primary data from Warminster Malt for the floor malting process was added to turn one kg of barley into malt (0.166kgCO_2e/kg). Notably, the study by BeZero was carried out on maize (turned into flour), whereas Gipsy Hill is using Barley (turned into malt). However, after review, comparable techniques between the two crops mean that it is assumed the same level

of sequestration is produced within barley crops.

- **Spent Hops and Recycled Yeast**

  Spent hops are the residual hop material that has been removed from the wort after boiling and fermentation. Gipsy Hill Brewing is reusing spent hops within Trail Pale and Swell Lager. Due to the ingredients being a waste product, the associated GHG emissions from the use of the spent hops are zero. Similarly, recycled yeast is the yeast that has been harvested from a previous batch of beer and then reused to ferment a new batch of beer. Again, due to this being a waste product the accosting GHG emissions are zero from its use.

3.4 Packaging

For packaging materials, the process of analysis is similar to that outlined in section 3.3.1. The GHG emission arising from packaging types Can-330ml and Can-440ml have been analysed specifically to the supplier Gipsy Hill Brewing purchases cans from [4]. Due to a Can-440ml not directly being analysed within the study, results have been linearly interpolated from the Can-330ml and Can-500ml analysed within the report.

Also considered for can container types were can labels and cardboard boxes used in shipment. 440ml cans are sold in packs of 12 whereas 330ml cans are sold in packs of 24. Keg caps were also included for Keg-30L.

In contrast to aluminium can packaging, which is not reused, keg packaging can be used multiple times. The resulting GHG emission from keg packaging arises from the transport, use and cleaning of each keg. Figures for keg GHG emissions have been derived from the study conducted by The IVL Swedish Environmental Research Institute in 2022 [5].

The IVL study examines the life cycle environmental and economic sustainability of steel and plastic beer kegs. For raw materials, construction, transportation, use and waste management all figures were taken directly from the study. In terms of the transport methodology of steel kegs, the paper found that the kegs are primarily transported via trucks. The steel kegs are first transported from the manufacturing plant to the brewery, where they are filled with beer. The filled kegs are then transported to various end customers, such as bars and restaurants. The GHG emission from this phase of the study was taken out, to avoid double counting with section 3.6. Once the kegs are emptied, they are collected and transported back to breweries. The study estimates 80 uses before kegs are sent to a recycling facility, where they are melted down and turned into new steel products.

3.5 Processing of Products

Once raw ingredients arrive at Gipsy Hill Brewing's facility they are processed into beer. Day-to-day operational activities at Gipsy Hill Brewing generate different sources of GHG emissions. For every GHG emission category relating to on-site GHG emissions, figures were obtained via monthly or quarterly meter readings and utility bills across the period of Jan to Dec 22. Total GHG emissions per functional unit were then calculated by mass allocation to the number of litres of product brewed within the respective timeframe.

- **Natural Gas**

  Natural gas consumption data was gathered via invoices and metre readings from Gipsy Hill Brewing. Natural gas is an important fuel source for most breweries, providing a reliable and cost-effective means of generating heat for a variety of applications. The majority of natural gas consumption in brewing can be attributed to its use in boilers, which are responsible for heating the brewing vessels and generating steam for various processes. Boilers are essential for maintaining consistent temperatures throughout the brewing process, ensuring optimal conditions for fermentation and product quality.

- **Electricity**

  Much like natural gas, electricity consumption data was also gathered via invoices and metre readings. Electricity is a key resource in modern brewing operations, powering a wide range of equipment and systems throughout Gipsy Hill Brewing. The majority of electricity consumption in brewing can be attributed to refrigeration, pumping, packaging and lighting.

  Refrigeration systems are essential for maintaining the proper temperature and humidity levels for ingredients, finished products, and brewing equipment. These systems require a significant amount of electricity to operate, with estimates suggesting that refrigeration can account for up to 20-30% of a brewery's total electricity consumption [6].

  Pumping is another major application of electricity in brewing, with pumps being used to transfer materials throughout the brewing process, including water, wort, and finished products. Pumps require electricity to operate, and the specific amount of energy consumed can vary depending on factors such as flow rate and distance.

- **Fermentation**

  As yeast metabolises sugars in fermentation vessels CO_2 is released as a by-product. The amount of CO_2 released will depend on the time of fermentation, the ingredients used and the alcoholic rating of the beer which all differ for each product. Data for the fermentation GHG emissions were calculated based on the

chemical formulas for turning glucose into ethanol and the ABV of each product.

- **Water Demand**

  By mass, water makes up around 90% of the weight of the final product and is used in high volumes in the brewing process as well as being used for cooling and cleaning. Both water supply and water treatment quantities were assumed to be equal as even if water is not treated on-site, the water will be treated downstream of the brewery. The quantity of water used as an ingredient in the beer was gathered from recipe sheets. Water used within the cleaning and other processing aspects in Gipsy Hill Brewing was calculated by subtracting the total of all water metre readings from the total volume of water used as ingredients within the year.

- **Refrigerant Leakages)**

  Due to refrigerants having high GWP, leakage of refrigerants can cause additional GHG emissions to products. Refrigerant leakage quantities were gathered from top-ups within the period, with the assumption made that the mass of top-ups is equal to leakage mass. For Gipsy Hill, top-ups were recorded in maintenance records. A single top-up of R410A refrigerant (16.5kg) was recorded within the period. Previously, no top-ups have had to be made, therefore the quantity of leaked refrigerant is equal to 16.5kg and is averaged over a 36-month period.

- **Waste**

  GHG emissions arising from waste treatment include the transportation, sorting, reprocessing and disposal of any given material. The mass of waste produced by Gipsy Hill Brewing was analysed for general, mixed recycling and glass with the treatment type for each category considered within the calculation. Food waste arising from the spent grain is collected by a local farmer to be used as animal feed and has been considered negligible, thus excluded from the study.

3.6 Transportation

The transportation category within this study includes all transportation involved in products after they leave Gipsy Hill's facility. Gipsy Hill Brewing uses a combination of company-owned vehicles and third-party logistic (3PL) providers to deliver their products. For 3PL delivery methods, all commerce and trade sales have been analysed. Distances were calculated from the Gipsy Hill Brewing warehouse facility to the end destination. Every delivery for the reporting year was analysed via Radar's point-to-point API, with the method of transportation and the weight of each delivery included in the calculations.

Gipsy Hill Brewing deliver sold items purchased in the local area by company-owned vans. This allows distances to be reduced due to not having to transport products to excess warehouses related to third-party logistic services. Vehicle fuel cards were analysed to understand the litres used within the reporting year by company-owned vehicles. Twelve vans are operated by Gipsy Hill Brewing of which ten are diesel and two are petrol.

The final GHG emissions for transportation were calculated from a weighted average of the number of GHG emissions of each delivery type compared to the weight delivered from the respective types.

3.7 Use Phase

Downstream GHG emissions of how a consumer handles the brewery product and packaging have been considered within the analysis. GHG emissions relating to the use of sold products occur from the end use of products sold by Gipsy Hill Brewing. The average electricity consumption used in refrigeration from end users and CO2 for the pumping of kegs has been considered in the analysis. Refrigeration electricity consumption has been estimated to be 0.28kWh per functional unit [7]. The CO2 used to pump kegs has been estimated to be 9g per litre sold [8].

3.8 End of Life

The end of life of sold products is the GHG emissions occurring from the waste disposal and treatment of products sold. All primary and secondary packaging were included in the analysis, as seen in Table 1. For Gipsy Hill Brewing, the GHG emissions relating to the disposal, transportation and treatment of beer packaging were considered. For more information on the end-of-life allocation of waste data, see section 3.2.

4 Results

All results within this report are shown in terms of the functional unit. This section further subdivided results into the life cycle categories, as well as a summary results section.

The overall results are shown for each product in Figure 2 and Figure 3 respectively, which highlights Keg being the lowest emitting item for all products, with net negative results for Trail Pale and Swell Lager due to the type of barley used.

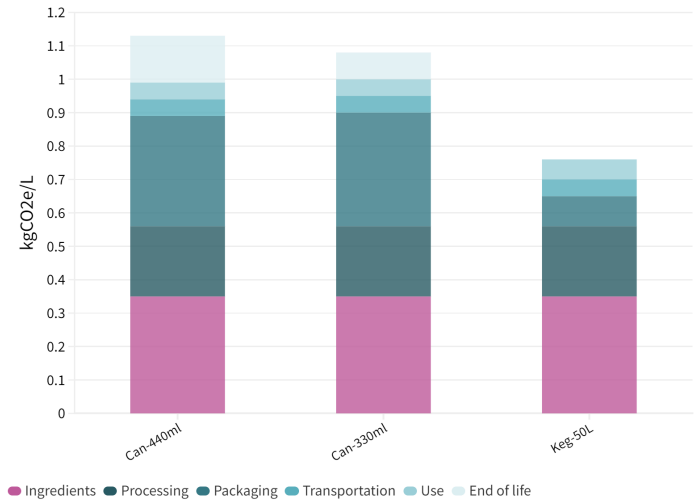

Figure 2: The breakdown of GHG emissions relating to Hepcat

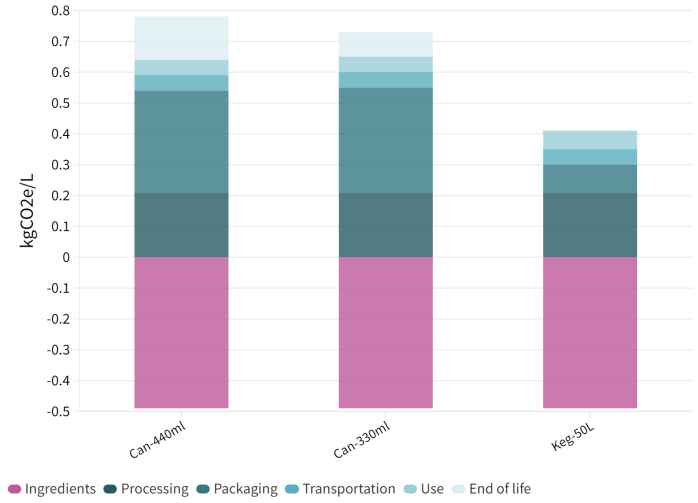

Figure 3: The breakdown of GHG emissions relating to Trail Pale

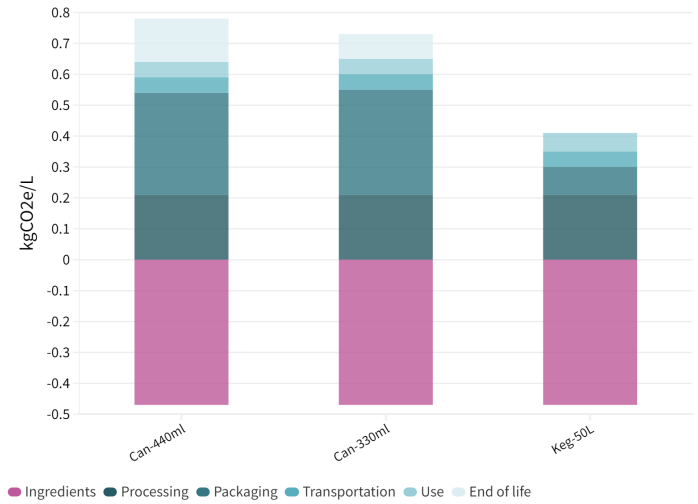

Figure 4: The breakdown of GHG emissions relating to Swell Pale

4.1 Ingredients

The GHG emissions from Hepcat's ingredients are 0.35kgCO_2e/L for all packaging types. The GHG emissions from the Trail Pale and Swell Lager are lower at -0.49kgCO_2e/L and -0.47 respectivelykgCO_2e/L. The significant disparity is due to the use of WildFarmed barley compared to conventional.

Figure 4 gives a full breakdown of the GHG emission for ingredients used per functional unit. Where the same ingredients have been used for both products, a mean average has been displayed.

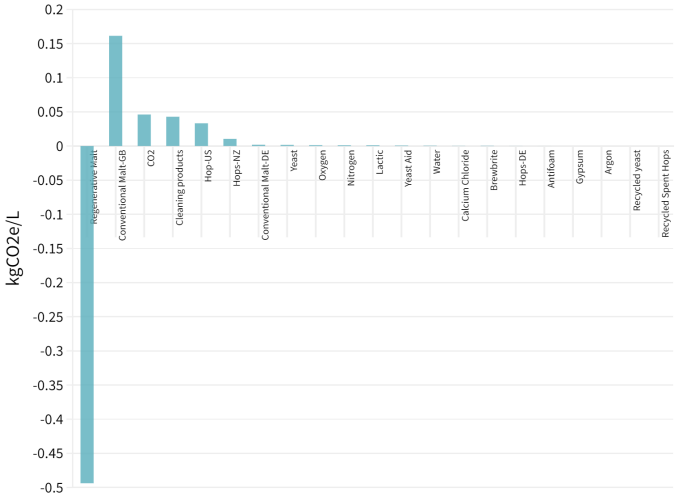

Figure 5: The breakdown of GHG emissions relating to the ingredients included within the study

4.2 Packaging

The breakdown of GHG emissions associated with packaging material is highlighted in Figure 5. For both products, the Cans-440ml and can lid makeup 68.5% of the packaging, 12-pack cardboard boxes 24.9% and Can labels 6.3%. The overall packaging of Cans-440ml is 18.7% lower than Cans-330ml. This disparity is because as the size of the can decreases, the surface area to volume ratio increases, leading to a higher proportion of material needed to produce the same amount of beverage. This increased material usage results in a higher carbon footprint during the manufacturing process.

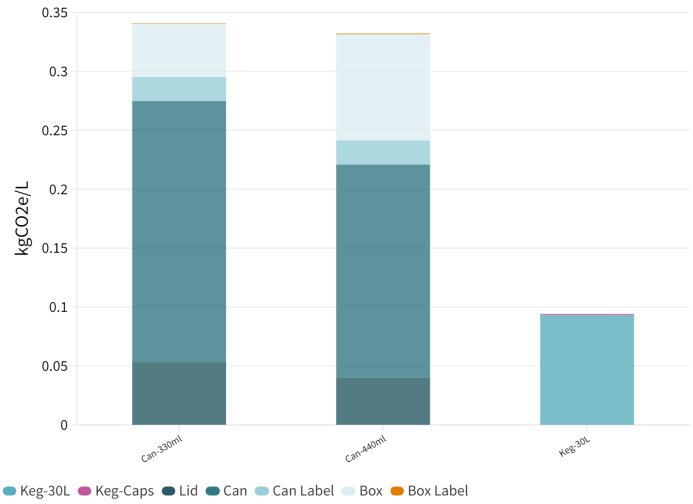

Figure 6: The breakdown of GHG emissions relating to the packaging included within the study

4.3 Processing

For both products, the largest contributor of GHG emissions from processing comes from natural gas. (34%). The majority of natural gas consumption is dedicated to boilers as described in section 3.5, with estimates suggesting that up to 80% of a brewery's natural gas usage is attributed to this application. For other processing of Trail Pale, 15% of GHG emissions are a result of electricity used in the production of beer. Other significant contributors are fermentation at 12 and 3% from refrigeration leakage. Figure 6 shows the fall breakdown from each GHG emission source.

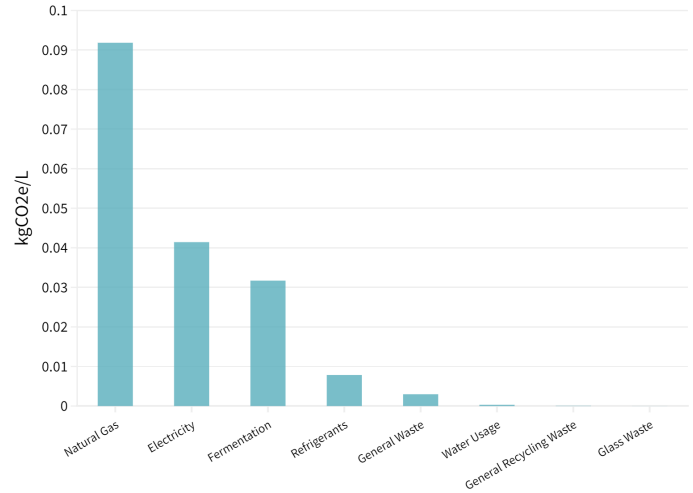

Figure 7: The breakdown of GHG emissions relating to the processing included within the study

4.4 Transportation

The GHG emissions from transportation are constant for each product but differ for each packaging type. A significant proportion of deliveries from company-controlled vehicles are within the London area, significantly decreasing the average delivery kilometres of each product.

Per functional unit, Keg-30L have the highest emissions at 0.055kgCO_2e/L, Can-440ml at 0.048kgCO_2e/L and Can-330ml equal to 0.046kgCO_2e/L. These variations in GHG emissions from transportation are linearly correlated to the packaging mass needed to transport each functional unit.

4.5 Use Phase

Due to kegs having to be refrigerated and pumped, Kegs-30L have the highest emissions from the use phase for both products (0.06kgCO_2e/L). The Can-440ml and Can-330ml have the same GHG emissions (0.05kgCO_2e/L) due to the electricity consumption being equal for all packaging types (0.28kWh per functional unit).

4.6 End-of-life

Figure 6 shows the GHG emissions arising from the end of life of the products sold, broken down by packaging item for each packaging type. Notably, due to the cardboard being a significant contributor to the end of life GHG emissions, the 330ml cans are shown to have a lower footprint than the 440ml cans because of being packed in sets of 24 compared to 12.

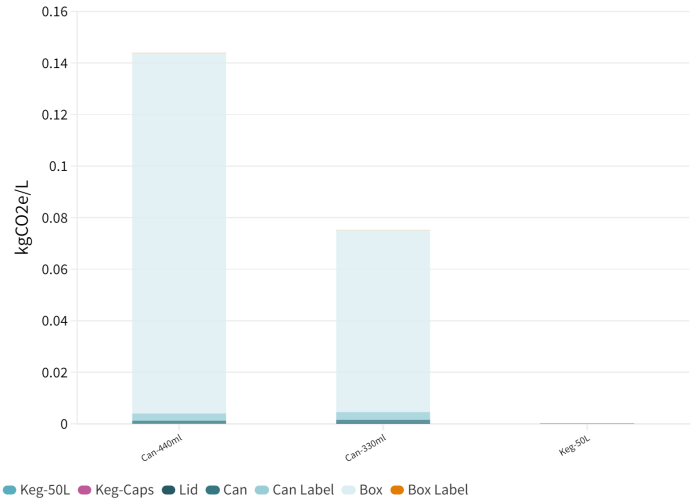

Figure 8: The breakdown of GHG emissions relating to the end of life of packaging included within the study

4.7 Sensitivity Analysis

Parameter choices used when modelling includes a certain degree of uncertainty. To analyse the effect of different uncertainties, a sensitivity analysis was conducted for various aspects of each product and packaging type. For each sensitivity analysis, the effect was recorded on each product's GHG emissions and shown as a GHG emission increase compared to the base scenario analysed.

• Scenario 1: The total sequestration of carbon from the Wildfarmed barley was decreased by 10%. This Scenario has been analysed due to the significance of malt within the analysis of Trail Ale and Swell Lager.

• Scenario 2: The number of cleaning chemicals per functional unit increased by 20%. This Scenario has been

analysed due to the uncertainty of the exact amount of chemicals used within the cleaning process per batch.

• Scenario 3: The energy use within refrigeration has increased by 20%. This Scenario has been analysed due to the unavailability of primary data from customers on refrigeration energy consumption.

Table 2: Sensitivity analysis results, showing positive change in GHG emissions for each Scenario 1, 2 & 3 compared to the base scenario

Product	Scenario 1 ($kgCO_2e/L$)	Scenario 2 ($kgCO_2e/L$)	Scenario 3 ($kgCO_2e/L$)
Trail Ale			
Keg-30L	0.08	0.01	0.01
Can-440ml	0.08	0.01	0.01
Can-330ml	0.08	0.01	0.01
Swell Lager			
Keg-30L	0.07	0.01	0.01
Can-440ml	0.07	0.01	0.01
Can-330ml	0.07	0.01	0.01
Hepcat			
Keg-30L	0.00	0.01	0.01
Can-440ml	0.00	0.01	0.01
Can-330ml	0.00	0.01	0.01

The sensitivity analysis shows that a decrease in sequestration levels of 10% for Wildfarmed barley, will increase GHG emissions per functional unit for Trail Ale and Swell Lager by $0.07kgCO_2e/L$ and $0.06kgCO_2e/L$ respectively for all packaging types. This is seen as significant, therefore Gipsy Hill should work with Wildfarmed to try and keep environmental analysis of Wildfarmed's products accurate and up to date, with best practices being on farm direct measurement of carbon stocks.
Both Scenario 2 and Scenario 3 do not have a significant effect on the results of the analysed product. Scenario 1 shows a small increase in the ingredients category due to the increase in chemicals used for cleaning. Scenario 2 only affects the Use phase of all products, with the increase in electricity consumption being equivalent to an increase of $0.01kgCO_2e/L$.

5 Discussion

The results show the GHG emission significance in each stage of Gipsy Hills products' life cycle. Due to the regenerative barley from WildFarmed, used in Trail Ale, there is an average of $0.83kgCO_2e/L$ difference between the products made with regenerative barley (Trail Ale and Swell Lager) and Hepcat which is not. This highlights the importance of the selection of low-carbon ingredients for breweries and shows a path to minimising the impact of the supply chain. The specific process of Gipsy Hill Brewing using regenerative barley within their supply chain to reduce GHG emissions is "carbon insetting". This refers to sequestering carbon within a company's own value chain, by doing so, companies can reduce the net carbon footprint of their products.

The results also highlight other stages having a high contribution to overall results. Processing is 27% of the total GHG emissions per functional unit of Hepcat Keg-30L, of this natural gas is the highest contributor. Despite its widespread use, natural gas is a non-renewable resource and has a significant contribution to overall GHG emissions. As such, it is important for Gipsy Hill to use Natural Gas efficiently as well as looking to explore alternative sources of energy, such as biomass and biogas, to reduce its reliance on natural gas in the future.

The packaging materials chosen by breweries will not only affect the associated cradle-to-gate GHG emissions of the material, but also the transportation, use, and end-of-life of each product. The results highlight beer that has been kegged to have the lowest overall GHG emissions compared to canned. Although other packaging types have not been analysed within this study, most notably glass bottles (not sold by Gipsy Hill Brewing), Keg is widely regarded as the most low-carbon conventional way of packaging beer.

Communication to the public for Gipsy Hill should be clear that there is a level of uncertainty of results, as described within the main body of this report. Gipsy Hill and Zevero should continue to work to consistently be improving the methodology and data while continuing to adhere to the principles of life cycle assessment reporting for product carbon footprinting.

6 Conclusion

An environmental assessment was undertaken for the greenhouse gas (GHG) emissions of three products sold by Gipsy Hill Brewing (Trail Pale, Swell Lager and Hepcat). The analysis is from cradle-to-grave and analyses three separate packaging types for each product. The results are split into stages of Ingredients, Packaging, Processing, Transportation, Use, and End-of-Life. Overall for Hepcat, there is $0.77kgCO_2e/L$ from beer packaged in 30L kegs, $1.14kgCO_2e/L$ from 440ml cans and $1.08kgCO_2e/L$ from 330ml cans. For Trail Pale, the sourcing of low-carbon ingredients means that packaging in 30-litre kegs results in $-0.07kgCO_2e/L$. In 440ml cans, Trail Pales overall GHG emissions are $0.30kgCO_2e/L$ and $0.24kgCO_2e/L$ for 330ml cans. For the Swell Lager, there is $-0.05kgCO_2e/L$ for 30L keg, $0.31kgCO_2e/L$ for 440ml cans and $0.25kgCO_2e/L$ for 330ml cans. The study highlights the importance of regenerative agricultural practices within the brewing section and the significance this can have on overall product GHG emissions.

7 Supplementary Data

To be made available on request

8 References

[1] P. Bhatia, C. Cummis, D. Rich, L. Draucker, H. Lahd, and A. Brown, "Greenhouse gas protocol corporate value chain (scope 3) accounting and reporting standard," 2011.

[2] P. Bhatia, C. Cummis, D. Rich, L. Draucker, H. Lahd, and A. Brown, "A corporate accounting and reporting standard," 2011.

[3] B. P. Weidema, C. Bauer, R. Hischier, C. Mutel, T. Nemecek, J. Reinhard, C. Vadenbo, and G. Wernet, "Overview and methodology," *Data quality guidelines for the ecoinvent database version*, vol. 3, 2013.

[4] o. b. o. B. C. Sphera, "Beverage packaging a comparative life cycle assessment," 2020.

[5] M. Martin, S. Herlaar, A. Jönsson, and D. Lazarevic, "From circular to linear? assessing the life cycle environmental and economic sustainability of steel and plastic beer kegs," *Circular Economy and Sustainability*, pp. 1–24, 2022.

[6] B. Association *et al.*, "Energy usage, ghg reduction, efficiency and load management manual brewers association, june-july 2021.[manual]," *Accessed Dec*, vol. 7, 2016.

[7] N. B. ENV, "Pefcr for beer note the order of sections and their titles shall not be modified," 2018.

[8] NetZeroNow, "Net zero brewery protocol," 2022.