



Brewery
Vivant

The Carbon Footprint of Farm Hand French Style Farmhouse Ale

Report by **Kris Spaulding**, Owner & Sustainability Director
Paul McVeigh, Sustainability Intern



Table of Contents

Introduction.....	2
Definitions of Key Terms.....	4
Units of Measurement & Conversion Factors.....	5
Summary.....	6
Breakdown of Emissions.....	7
Upstream.....	8
Raw Materials.....	8
Recipe Water.....	11
Carbon Dioxide.....	11
Packaging and Non-Consumable Materials.....	12
Brewery Operations.....	16
Energy Usage.....	16
Manufacturing Waste Disposal.....	18
Downstream.....	20
Distribution.....	20
Retail.....	22
Use.....	24
End-of-Life.....	25
Can vs. Draft.....	26
Summary & Conclusions.....	27
References.....	29



Introduction

The background of this report was done in black in hopes you will avoid printing it. Please contact sustainability@breweryvivant.com for a printable version.

This study was conducted by Brewery Vivant for the purpose of assessing the environmental impact of one 16oz can of our Farm Hand French Style Farmhouse Ale, from the farming of the grains and hops, to the end disposal (hopefully recycling!) of the can after consumption. Just as important to us as brewing great beer is being responsible stewards to the world and community we operate in. We feel that this analysis will help increase transparency of our operations and help us in our pursuit of sustainability by setting baseline measurements on which to continuously strive to improve upon.

What Is a Carbon Footprint?

A carbon footprint is an in-depth study of the greenhouse gas emissions associated with every step of a product's life cycle. The scope of what we term a "cradle-to-grave assessment" includes everything from the production and acquisition of raw materials all the way to the end-of-life of the finished product. Such studies generally focus on a single unit (i.e. one 20 oz bottle of soda) or a defined number of units (i.e. one 12-pack of soda cans). In our case, we chose to use one 16 ounce can of our most popular beer, Farm Hand, as the focus of our study.

The purpose of conducting a comprehensive carbon footprint study is to increase transparency of environmental impact, to identify hotspots and opportunities within a company's value chain, and to benchmark baseline impacts to which future progress can be measured. It is important to note that carbon footprints are *not* meant to be used for comparison between different businesses or products. As different standards, emissions factors, assumptions, and boundaries are used in each study, they should be considered unique and unrelated.



Previous Industry Studies

To our knowledge there are only a small handful of environmental impact analyses that have been conducted in the brewing industry. Only one such study, as far as we know, really set out to accurately quantify greenhouse gas (GHG) emissions and environmental impact, from cradle-to-grave, of a functional unit of beer. This 2008 report, conducted by New Belgium Brewing Company, based in Fort Collins, Colorado, was an invaluable guide for us in putting together this report and we would like to thank New Belgium for their contribution not only to us, but to the pursuit of sustainability, especially in the brewing industry. We would also like to thank everyone who contributed to this report, including our suppliers, distributors, retailers, and of course our awesome brewery staff.



Definition of Key Terms

Carbon Dioxide (CO₂) – The primary greenhouse gas associated with human activities, primarily through the burning of fossil fuels.

CO₂ Equivalents (CO₂^e) – Other greenhouse gas emissions, aside from carbon dioxide, are directly associated with human activities. These gases, including methane (CH₄), nitrous oxide (N₂O), and perfluorocarbons, are weighted according to their global warming potential, relative to that of CO₂.

Class 6 Truck – A truck (in this study, used in regional distribution) whose gross vehicle weight is between 19,501 and 26,000 lbs.

Class 8 Truck – A truck (in this study, tractor-trailers used for transportation) whose gross vehicle weight rating exceeds 33,000 lbs.

Climate Change – The effect by which increases in greenhouse gas emissions, from human activities such as deforestation and the burning of hydrocarbons, leads to changes in our natural climate cycle by altering the amount of longwave radiation trapped inside our planet's atmosphere.

Global Warming Potential (GWP) – Emissions numbers are commonly normalized into carbon dioxide equivalent numbers by multiplying them by a weighted GWP number. The EPA reported numbers used in this study were 21 for N₂O and 310 for CH₄. That is to say, one unit of nitrous oxide has the same effect as 21 units of CO₂ and methane has the same effect as 310 units of CO₂.

Greenhouse Gas (GHG) – This refers to the naturally occurring gases in our atmosphere that emit and absorb radiation, greatly affecting our planet's climate. It has been shown that human activities, primarily post-Industrial Revolution, have added significant amounts of these gases to the atmosphere, causing concern that it contributes directly to climate change.

Liquification – the condensing of a gas into a liquid

Submeter – A meter, used in conjunction with main utility meters, to separate out how much usage is going to one particular process or activity.



Units of Measurement & Conversion Factors

Hectare (ha) – 10,000 square feet or 2.47 acres

Kilogram (kg) – 1,000 grams or 2.2 pounds

Kilometer (km) - 0.62 miles

Tonne (Mt) – 1,000 kilograms or 2,204.6 pounds; also written as metric ton

Nautical Miles (NM) – 1.15 miles or 1.85 kilometers

Ton-Mile – A measurement unit equivalent to a ton of freight moved one mile. This is used in our railroad transportation calculations.

Twenty-Foot Equivalent Unit (TEU) – An inexact way of measuring the volume capacity of a cargo container. For purposes of this study, we are accepting the assumption that 1 TEU = 21,600kg.



Summary

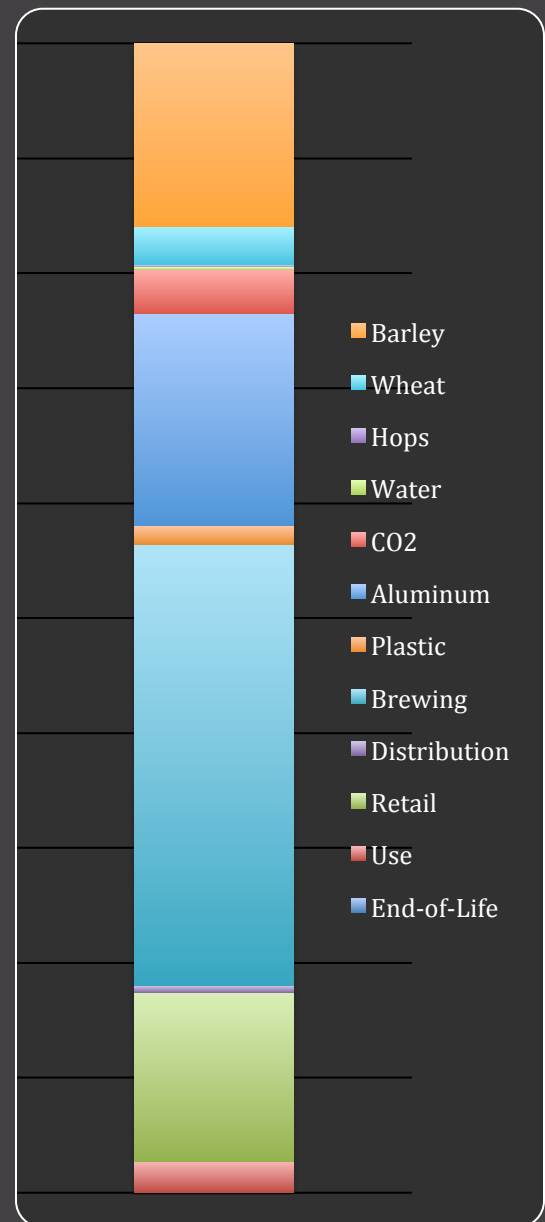
418.97 g CO₂^e

Total Carbon Footprint of Farm Hand

As a comprehensive study of the greenhouse gas emissions that are a direct result of a can of Farm Hand, we took into account everything from the acquisition of the raw materials to the actual brewing process, and all the way to end-of-life.

Through this footprint, we have identified the largest contributors of carbon dioxide and its equivalents to be the electricity and natural gas used in our brewing operations, the refrigeration of the finished beer in distribution and retail locations, and production of aluminum for our cans.

We hope to use this report to benchmark future progress and isolate areas, such as our own energy and water consumption, to improve upon.



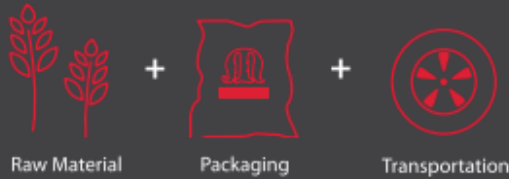


Breakdown of Emissions

Contributor	Category	Emissions
Brewing Natural Gas	Energy	139.54 g
Aluminum Production	Packaging	75.95 g
Barley Agriculture	Agriculture	57.61 g
Retail Utilities	Energy	38.04 g
Retail Refrigeration	Refrigeration	22.32 g
Brewing Electricity	Energy	18.64 g
CO2 Production	Carbon Dioxide	15.78 g
Wheat Agriculture	Agriculture	12.56 g
Home Refrigeration	Refrigeration	11.27 g
Barley Transport	Transportation	8.14 g
Can Storage Utilities	Energy	6.50 g
Plastic Production	Packaging	6.30 g
Transport to Retail	Transportation	2.45 g
Wheat Transport	Transportation	1.12 g
Hops Agriculture	Agriculture	0.67 g
Distributor Refrigeration	Refrigeration	0.61 g
Water (Non-Consumable)	Water Treatment	0.41 g
Transport to Distributor	Transportation	0.30 g
QuadPak Transport	Transportation	0.28 g
Water (Consumable)	Water Treatment	0.19 g
Aluminum Transport	Transportation	0.17 g
Hops Transport	Transportation	0.06 g
Distributor Utilities	Energy	0.04 g
End-of-Life Transport	Transportation	0.02 g
Total		418.97 g



Upstream



Raw Materials (Consumable)

Barley

65.75 g CO₂^e

Agriculture

57.61 g CO₂^e

The planting, irrigation, and harvesting of barley is an extremely energy and water intensive process. A thorough carbon footprint of barley agriculture was published in 2011, which we have used to base our calculations on. The study, conducted in Finland, found greenhouse gas emissions for the conventional tilling of a hectare of barley to be 2,330 kg CO₂^e. This is based on an average yield of 3,380 of barley per hectare (1 hectare = 10,000 meters²) of harvested farmland.ⁱ The 101.07 g of barley that go into making a can of Farm Hand, using the study's finding of 0.57 g CO₂^e per gram of harvested barley, is responsible for 57.61 g of CO₂ equivalents being released into our atmosphere.

Transportation

8.14 g CO₂^e

The malted barley we purchase for Farm Hand is grown in the Beloeil region of Belgium. Without being able to pinpoint an exact international shipping route, we are assuming that the grains are sent via class 8 (or EU equivalent) truck to the Port of Antwerp.ⁱⁱ We are using a Post-Panamax class container ship as the vessel for basing our calculations on (as it does not need to pass through the Panama Canal, it is likely this size ship is used), which emits an average of 1,241 kg CO₂^e per nautical mile.ⁱⁱⁱ The average cargo weight, or deadweight tonnage, for this class of ship is around 100,000 tonnes, of which our barley constitutes a miniscule portion.^{iv} The coefficients used to determine CO₂^e equivalent emissions from trucking are different between domestic and international trucking due to a difference in average trucking fuel efficiency between the United States



and the European Union. The EPA has reported average miles per gallon to be 7.3 mpg in the United States for single-unit commercial trucking,^v while we obtained an estimate of 7.66 mpg for international trucking, by averaging two separate studies.^{vi}

Using our estimated fuel efficiency numbers, along with our EPA-reported carbon emissions factors for diesel which states that for every mile driven, roughly 10.15 kg of CO₂ and equivalents will be emitted,^{vii} we have calculated the shipping of barley from the Beloeil region of Belgium to the shipping port in Antwerp to be responsible for 0.32 g of CO₂^e. Traversing 3269 nautical miles of the Atlantic Ocean, to New York, accounts for an additional 4.10 g CO₂^e. From New York, the grains board a train and are shipped to Union Station in Chicago, Illinois emitting along the way another 2.71 g CO₂^e.^{viii} The last stage of transport involves being shipped the 25 miles to Mid Country Malt in South Holland, Illinois and then the final 166 mile trip to Grand Rapids, Michigan which together account for 1.01 g CO₂^e.

Wheat

13.68 g CO₂^e

Agriculture

12.56 g CO₂^e

There are many contributors to the emission of carbon throughout the farming of wheat including the production of seeds, tillage, fertilization, and harvesting. Using the 2011 study conducted by Rajaniemi, Mikkola, and Ahokas, concerning agricultural contribution of CO₂ and its equivalents, we were able to assess the impact of this facet of production. The study found that the average crop yield is 3,940 kg of harvested wheat per hectare of farmland. From the planting of the seeds to the harvesting of the wheat, this process contributes 2,250 kg CO₂^e per hectare, or 0.59 g CO₂^e per gram of wheat yielded.^{ix} Using this standard, we can allocate 12.56 g CO₂^e to the agriculture of the 21.28 g of wheat used in 16 ounces of Farm Hand.

Transportation

1.12 g CO₂^e

The wheat we use in the beer comes from Gilbertson & Page, and is shipped from the city of Calgary in Canada. As freight train routes were not available, we used passenger railway routes to get an estimate of the distance between Calgary and South Holland, 1607 miles.^x Using our standard emission factor of 25.43 g CO₂^e /ton-mile, the grain allocated for 16oz of Farm Hand account for 0.96 g of CO₂^e that is released into our atmosphere. From South Holland, Illinois the wheat is sent on to Brewery Vivant via tractor-trailer, which emits an additional 0.16 g of CO₂^e.



Hops

0.73 g CO₂^e

Agriculture

0.67 g CO₂^e

Just as with barley, there are many steps in the growing and harvesting of hops in which CO₂ and its equivalents are emitted. As we could not find any reliable data on the growing of hops, we decided to use the agriculture of hemp as a substitute for this portion of the study. Both Cannabis (hemp) and Humulus (hops) are from the genus Cannabaceae and have fairly similar growth and maintenance characteristics.

Agriculture between the two does vary, as Cannabis is an erect plant while hops are a twining plant that is grown vertically. However, we felt this was a good stand-in for reliable secondary data on hops.

From a study conducted in 1996 considering the emissions stemming from the growth and harvesting of cotton and hemp, we found that for every tonne of hemp fields cultivated and harvested, there are 947 kg CO₂^e emitted.^{xi} The hops that go into making one 16oz serving of Farm Hand constitute only 0.000071% of this metric tonne, so we can allocate 0.67 g of CO₂^e and its equivalents to one can.

Transportation

0.06 g CO₂^e

The three types of hops used in Farm Hand come from different locations and involve many stages of transportation before arriving at the brewery. Two of the strains are harvested in Europe, one from Germany and one from the Czech Republic, and require shipment across the Atlantic along with transportation via freight train and trucking. Only 0.71 g of these hops can be allocated to one 16 oz can of beer, so impact is quite minimal.

For the domestic transportation involved, we have calculated emissions using our standards for class 8 trucks and diesel-electric freight trains. Information was limited as to the specific route our hops take while abroad, so we have assumed transport via truck from growing regions in Bohemia, CZ and Bavaria, DE to the Port of Hamburg in Germany.^{xii} As the container ship used to traverse the Atlantic does not need to pass through the Panama Canal or any other narrow passages, we have assumed for our study that it is a Post-Panamax class vessel.

In total, international trucking to the Port of Hamburg accounts for only 0.008 g of CO₂^e being introduced into our atmosphere from the 0.37 g of our European hops. In the 3,524 nautical miles traveled from Hamburg to New York, approximately 0.016 g CO₂^e is emitted.^{xiii} Total domestic railroad transportation, including both routes from a growing area near Yakima, WA to Chicago and also from the shipping port in New York, account for 0.029 g of CO₂^e.^{xiv} All domestic travel via tractor-trailer, the bulk of which is from our distributor in South Holland to Brewery Vivant, accounts for 0.007 g of CO₂^e.



Recipe Water

0.19 g CO₂^e

Amount Used

25.55 oz

The water that ends up in the beer itself is introduced in three separate steps during the brewing process. First, base water is poured into the mash tun before the grains are added, to keep them from sticking to the bottom. Water is again added during the mashing process, more is added during the sparging process, where water is poured through the lauter tun to extract sugars from the grains and again as the beer is filtered. The sparging process is where the majority of the consumable water is introduced. It should be noted that this water does not *all* end up in the beer itself; much is lost during the early stages of the brewing process.

Water Treatment

0.19g CO₂^e

All of our water comes from the Grand Rapids municipal water supply. The source of CO₂^e emissions is the electricity required by the various processes of treating the water, including sedimentation, flocculation, and filtration. To gauge the CO₂^e output directly associated with our beer, we have obtained data from the city of Grand Rapids for ten months of electricity usage from mid 2010 to mid 2011. The average electricity consumption for the treatment facility was 1272.1 kW-h per million gallons (or roughly 0.0013 kW-h per gallon) of clean water produced.^{xv} Using eGRID reported emission numbers for the state of Michigan, this equates to 0.9629 g CO₂^e per gallon of water used in the brewing process, or 0.007523 g CO₂^e per ounce.^{xvi} Thus, for the 25.55 oz of consumable water used in each 20 Bbl batch, 0.19 g of CO₂^e is produced.

Carbon Dioxide

15.78 g CO₂^e

The CO₂ we use to fill our cans and kegs at the brewery comes from Carbonic Systems in Grand Rapids. Unfortunately, with our automated system, we don't have an accurate measure of exactly how much carbon dioxide goes into each can. To get an idea of how much CO₂ is infused into each can of our beer, we looked at New Belgium's *The Carbon Footprint of Fat Tire Amber Ale*, which stated that for every six-pack of 12 ounce bottles, they used 54.5g of CO₂ for carbonation.^{xvii} Using this for a rough estimate of how much carbon dioxide goes into carbonating beer on the commercial level, we figure that roughly 0.757g of CO₂ are used per ounce of finished beer. For our 16oz cans, this comes out to be 12.11g of CO₂.

Processing

15.78 g CO₂^e



Following New Belgium's lead, we used secondary data for the electricity consumption of the liquefying process, using nitrogen processing as a proxy, as we couldn't find any reliable data concerning CO₂ specifically. The different stages and processes of producing commercial-grade CO₂ is much the same as producing N₂, so it should give us a good picture of our CO₂ equivalent emissions from the processing of this input material. A very energy intensive process, liquification alone can consume around 400 kW-h per tonne produced.^{xviii} There are other steps in the process that we are not taking into account, due to lack of reliable information, but liquification is the biggest contributor so we felt we should include it. Going by our electricity emissions factors for the State of Michigan, this comes out to a total of 302.78 kg CO₂^e per tonne. Allocated to one can of Farm Hand, the production of 12.11 g of carbon dioxide used for carbonation is responsible for 3.67 g CO₂^e. The amount of carbon dioxide itself, 12.11 grams, is also included in our total, as it is processed from fossil carbon.



Packaging & Non-Consumables

Aluminum

76.12 g CO₂^e

When Brewery Vivant started up in 2010, we made the choice to can all of our beer, quite unconventional for a craft brewer.^{xix} One of the biggest drivers in our decision to do this was that aluminum cans are significantly lighter to ship and are much easier to reprocess into new products at the end of their life. We also liked that people are more likely to recycle metal than any other material and that the aluminum can is the only package that more than covers its recycling cost, thus helping to finance the collection and recycling of other materials.^{xx} It just made sense.

Our cans come from Ball Corporation, the industry leader in aluminum packaging solutions and a company also focused on sustainability. The 16 oz can that Farm Hand comes in has an empty weight of 17 g and is manufactured using approximately 68% recycled aluminum.^{xxi}



Production

75.95 g CO₂^e

Virgin Content

54.14 g CO₂^e

The virgin inputs in each 16oz can make up approximately 32% of the material, or 5.44 g by weight. As reported by the EPA, the process of manufacturing and transporting virgin aluminum for cans emits 10.97 MT CO₂^e/Short Ton.^{xxii} Attributed to one 17 g can, the emissions from virgin steel inputs come out to 54.14 g CO₂^e.

Recycled Content

21.81 g CO₂^e

Recycled inputs make up roughly 68% of every can, or 11.56 g by weight. The emissions from the processing and transporting of these inputs total 2.08 MT CO₂^e/Short Ton, significantly lower than that of virgin aluminum.^{xxiii} Of this, we can associate 21.81 g of CO₂^e directly to the production of one can of Farm Hand.

Transportation

0.17 g CO₂^e

Empty aluminum cans are transported from Ball's Metal Beverage Packaging Division in Monticello, IN to our warehouse in Walker, Michigan, a distance of 196 miles via I-196N. Using our assumed trucking standards of 10.15 kg CO₂^e per mile, with a full cargo load the trip will emit 272.83 kg CO₂^e into the atmosphere. Considering the 17 g weight of each empty can, 0.16 g CO₂^e can be attributed to a single 16oz can.

The second, much shorter leg of the journey from our warehouse to the brewery is 9.6 miles in length. This trip is responsible for approximately only 0.008 additional grams of CO₂^e per can.

Storage

6.50 g CO₂^e

We are currently warehousing empty cans at a building in Walker, Michigan until we need them for canning at the brewery. On average, we estimate that a can stays at our warehouse for around 6 months before actually being brought to the brewery to be filled and sealed.

Electricity

5.00 g CO₂^e

According to the North Carolina Energy Office, the average electricity consumption for a non-refrigerated warehouse is 4.5 kW-h/ft² per year.^{xxiv} Using



the eGRID emissions factor of 756.96 g CO₂^e per kW-h, this equates to a total of 1,703.16 g CO₂^e per square foot of storage over six months time. As one can takes up 0.047 ft² of vertical space, and are stacked 16 high, it is responsible for 5 g CO₂^e of this.

Natural Gas

1.50 g CO₂^e

The NCEO also gives an estimate of 19.2 kBtu/ft² per year for this type of space. As one therm of natural gas is responsible for 5,319.6 g CO₂^e,^{xxv} 0.192 therms (the equivalent of 19.2 kBtu) are responsible for 1,021.36 g CO₂^e over a year. One can takes up only 0.047 ft², and is in a pallet 16 rows high, so we can attribute 1.5 grams of CO₂^e for the half year sitting in storage.

Plastic

6.58 g CO₂^e

The connectors we use in our four packs of Farm Hand come from PakTech, based out of Eugene, Oregon, and are made out of 96% post-consumer recycled content. PakTech recently put together their own life cycle assessment of their QuadPak connectors, which was extremely helpful to us in pinning down emissions directly attributable to our use of their packaging products. The LCA was conducted on connectors containing 87% PCR material, but we thought it best to use their primary data rather than estimate based on secondary data.

Production

6.30 g CO₂^e

PakTech found the total CO₂^e emissions from conversion and manufacturing of a QuadPak connector to be 25.20 g CO₂^e.^{xxvi} As each connector holds four cans, each can is directly accountable for a quarter of these emissions, or 6.3 g CO₂^e.

Virgin Content

5.72 g CO₂^e

The connectors we purchase are made out of 87% recycled HDPE plastic and 13% virgin material. According to the EPA, processing and manufacturing HDPE from virgin sources emits 10.83 times more CO₂^e emissions than does recycled material. Based on this assumption, we can attribute roughly 5.72 g CO₂^e to the conversion and manufacturing of virgin inputs.

Recycled Content

0.58 g CO₂^e

The remaining emissions come from the processing of recycled plastic, which is significantly less than with virgin material. Using EPA reports on HDPE



production we can attribute around 0.58 g CO₂^e to the 87% of recycled content in each QuadPak connector.

Transportation

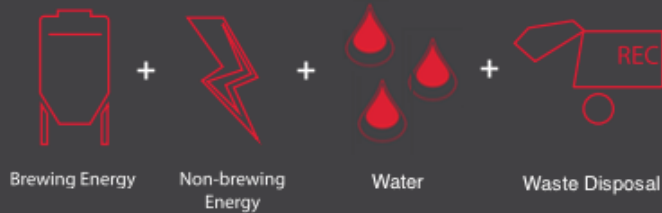
0.28 g CO₂^e

Four-pack connectors are shipped to Brewery Vivant from PakTech via class 8 tractor-trailer. The route, passing through Salt Lake City, UT and Chicago, IL, is approximately 2,400 miles in length and, assuming a fuel efficiency of 7.3 mpg, and consumes around 406.8 gallons of diesel fuel. As reported by the EPA, 10.15 kg CO₂^e is emitted per mile driven in this type of diesel truck, so the trip accounts for approximately 3,340.8 kg CO₂^e. As one connector accounts for only 10g of the assumed maximum 30,000 kg cargo load, we can attribute 1.1 g CO₂ per QuadPak connector. Of this, one quarter is directly associated with one can of Farm Hand, which comes out to be 0.28 g of CO₂^e.





Brewery Operations



Energy & Water

Electricity

18.64 g CO₂^e

Power needed to run our brewing operations, refrigeration, air conditioning, and other equipment comes from Consumers Energy in the form of traditional, coal-fired electricity. Furthermore, taking into account the full carbon emissions from traditional energy sources will serve as additional encouragement to work to adopt on-site renewable energy generation in the future.

In a six-month energy and water study conducted by The Green Brewery Project^{xxvii} in 2013, it was found that the biggest electricity users were the rooftop air handler units (RTUs) that air condition the brewery and the glycol chiller system which are circulated through the fermenting tanks and cold room condensers. These systems account for over half of the electricity used at Brewery Vivant (variable depending on the season). These systems, along with the brewery's lighting, should be the main target for reducing electricity consumption on the brewery operations side of Vivant.

In the future, sub-meters will be installed to differentiate between electricity going directly to brewing operations and electricity going to run our brewpub. In the interim time before this equipment is installed, we chose to estimate this number by taking the emissions from our annual electricity use, and multiplying it by the percentage of revenue represented by one can of Farm Hand.^{xxviii} Our eGRID emissions factor for the State of Michigan holds that 756.96 g of CO₂^e are emitted for every kilowatt-hour of electricity used. Assessing the impact of just one can, we have determined that approximately 18.64 g CO₂ equivalents are released as a result of production.



Natural Gas

139.54 g CO₂^e

Heat in our brewery, used both in the boiling processes during brewing and in climate control comes from DTE Energy in the form of conventional natural gas. Though a great deal of natural gas is used in the brewing process itself, we had to separate out the natural gas used for heating our brewery during our cold Michigan winters. While sub-meters will soon be installed to separate the brewery and brewpub, we found the best option for the purpose of this study was to take the CO₂^e equivalent emissions that come from our total annual gas consumption and multiply it by the percentage of our total annual revenue that comes from one can of Farm Hand.

Using the US Energy Information Administration emissions factors of 5.306 kg CO₂, 0.5 g CH₄, and 0.01 g NO₂ per therm of natural gas,^{xxix} we calculated the CO₂ equivalent based on the appropriate global warming potential (over a 100-year period, methane is 21 times more effective at trapping heat in the atmosphere and NO₂ is 310 times more effective). The CO₂ equivalent emissions from one therm of natural gas are 5,319.6 g CO₂^e. By taking the minute percentage of our annual revenue that one can of Farm Hand contributes, we estimate that a can is attributable to 139.54 g CO₂^e being released into the atmosphere.

Non-Consumable Water

0.41 g CO₂^e

Amount Used

53.97 oz

In The Green Brewery Project's 2013 audit, water use was studied by setting up a series of flow meters at different points in the brewery, measuring the flow of hot and cold water and separating out brewery from brewpub. In the time period from June 10 to July 22, the team measured that 80,196 gallons of water were used in the brewery, during which time 520 Bbl, or 16,120 gallons, of beer was brewed. Through this data, we can approximate that we are getting, on average, a 4.97:1 water-to-beer ratio. Per 16 oz can, this means our total water consumption is roughly 79.52 oz.

By subtracting out the water going into recipe, which we know to be 25.55 oz, we can associate a total of 53.97 oz of non-consumable water to each can of Farm Hand. This includes all water used for the rinsing and cleaning of equipment, as well as spillover from our hot liquor tank, filtering, and other steps in the brewing process.



Water Treatment

0.41 g CO₂^e

We can use the same number from the consumable water portion of our study, taken from our eGRID emissions data, of 0.007523 g CO₂^e per ounce of processed water. For the 91.25 oz of water that goes into brewing Farm Hand, but doesn't end up in the can, we can associate 0.41 g of CO₂^e to the processing and water treatment.



Waste Disposal

As a business that is trying to come as close to zero-waste as possible, we are proud to say that we either recycle or compost all packaging and transport material, including all pallets, grain bags, cardboard, strapping, and plastic wrap. The only landfilled waste we could pinpoint coming out of our brews is sludge left over after the brewing process.

Landfilling

0.00 g CO₂^e

The only waste from our brewing process that isn't diverted from the landfill is the sludge that is taken from the bottom of the kettle after brewing. While all spent grain is given to a local rodeo performer (yes, you read that right) to be used as animal feed, there remains a fair amount of wet sludge, which is not composted due to the large amount of standing water it would introduce into our compost bin.

Recycling

0.00 g CO₂^e

A fantastic perk of being located where we are in East Hills is that we are right down the street from Tree Huggers, a terrific packaging-free organic grocery store that also acts as a recycling hub and “green learning center.”

All polypropylene (PP), low-density polyethylene (LDPE) plastics and other recyclable waste, including the strapping used in the transport of cans, is taken by our friends at Tree Huggers. It is not in the scope of this study to include any emissions after it arrives at Tree Huggers, as it takes on a “new life” by being re-processed and re-sold as a new

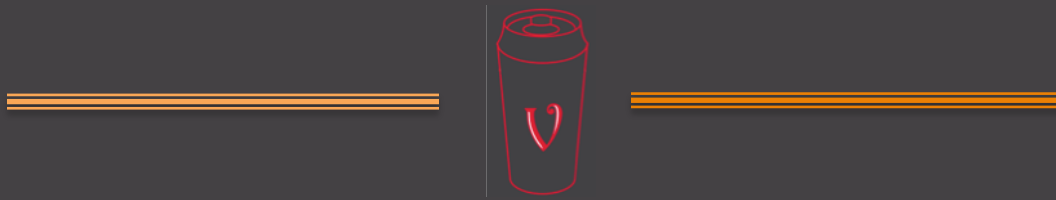


product. Being only 0.4 miles away, the 5 lbs of recyclable waste we have has effectively zero emissions when considering the allocation of emissions to one can.

Composting

0.00 g CO₂e

We have chosen to compost organic waste such as our cardboard shipping boxes, filter pads, and grain bags, as it requires no additional energy to transport and re-process the materials, and mixed with food waste from our kitchen, makes a terrific natural fertilizer. Furthermore, composting leads to an increase in carbon sequestration in the soil, so there is actually a small reduction in CO₂ emissions from this activity. This sequestration, accounting for the organic composted waste associated with one can of Farm Hand, is so small we have chosen to consider it equivalent to zero for the purpose of this study.





Downstream



Distribution

Transportation

2.75 g CO₂^e

To Distributor

0.30 g CO₂^e

Before a can of Farm Hand reaches one of the dozens of retailers who carry our beer, it first takes a trip over to our distributor’s warehouse, Kent Beverage, located on 36th Street in Grand Rapids. This trip is approximately 5.1 miles in distance, via class 6 beverage truck, which the Center for Transportation Analysis has reported to get between 5 and 12 miles per gallon (which we averaged out to be 8.5 mpg).^{xxx} Assuming a cargo load of 10,000 kg (22,046 lb), one full can which weighs 497 g can be associated directly with 0.3 g CO₂^e.

To Retail

2.45 g CO₂^e

While it is easy to calculate emissions between the brewery and the distribution center, it is much trickier to pin down emissions from transit between Kent Beverage and one of our many retail locations, at greatly varying distances, across Michigan. We felt that, rather than skewing the numbers with a close location or a location farther away, we could approximate it with more certainty by taking an average of emissions between a number of locations. We chose four retailers in the Grand Rapids area and four retailers located farther away to base this calculation on. Between these 8 stores, ranging in distance from between 4 miles and 100 miles away from our distributor, we found the CO₂^e emissions from the class 6 transport of a full can to be 2.45 grams.^{xxxi}



Refrigeration & Storage

0.65 g CO₂^e

Refrigeration

0.61 g CO₂^e

When being stored at our distributor's refrigerated warehouse before being sent to one of our retailers, a good deal of electricity is used to power the chilling units, as well as the lighting and other essential systems. A 2010 report, published by the North Carolina Energy Office lists total annual electricity usage per square foot as 28.8 kW-h, respectively.^{xxxii} Using our eGRID numbers, we know that this equates to 21,800.45g CO₂^e annually, per square foot. Per can, which only takes up 0.047 ft² vertically and in a pallet stacked 32 high, this comes out to 32.02g CO₂^e per can, per year.^{xxxiii} Taking into account that a can typically sits in the warehouse for 7 days before being shipped out,^{xxxiv} this comes out to 0.61g CO₂^e per can during the storage stage.

Natural Gas

0.04 g CO₂^e

Calculating natural gas was much the same as electricity for pre-retail storage. The NCEO study cited also lists natural gas usage for these types of facilities, 23.3 kBtu ft²/year, which is the equivalent of 0.233 therms ft² per year. Allocated to one can for the 7 days it will typically sit, this comes to 0.04g of CO₂ and equivalents being emitted due to natural gas.





Retail

Refrigeration & Overhead

60.36 g CO₂^e

Upon arriving at a retail location, the back stock of cans is generally stored at room temperature until it goes into a refrigerated display unit. We feel that by taking into account both the actual electricity needed to power the refrigeration units, and also the overhead of the store as a whole, we are covering all of the bases.

Refrigeration

22.32 g CO₂^e

There is a sizeable difference between emissions from the closed-door, hermetically-sealed refrigeration cabinets generally used in small convenience stores and liquor stores, and the large, open front chillers found in supermarkets and big-box stores. A 2006 study, published by Evans, Scarcelli, and Swain, on the energy performance of retail chilling units was instrumental in pinpointing the emissions from storing Farm Hand at a given retail store. We have split the following refrigeration emissions into both small and large retailers.

Liquor, Convenience, & Specialty Stores

9.09 g CO₂^e

Small stores comprise the majority of our retailers, around 54%.^{xxxv} Speaking to a local retail store, we were able to get a better picture of just how long our beer stays on the shelf and the type of coolers that are used. As shelves in these coolers are dominated by bottles of beer (generally six-packs), and not four-packs of cans, we had to get an estimate of how many a cooler would fit. Together with our retailer contact, Siciliano's Market in Grand Rapids, we concluded that a cooler that normally fits 72 six-packs should fit 108 four-packs, meaning one can constitutes 1/432nd of a commercial closed-front cooler. Siciliano's, who sells our cans both in four-packs and individually, has estimated that a single can will sit in the cooler for one day before being purchased.^{xxxvi}

The type of closed-front refrigerating units typically used by these retailers is reported to use approximately 0.4 kilowatts of electricity per hour of use.^{xxxvii} Over the day our can sits on the shelf, this equates to a total of 9.6 kW-h of electricity being consumed. Using again our eGRID emission data for the State of Michigan, 756.96 g CO₂^e per kW-h of electricity, the emissions from the power consumption of the cooler running for a full week are 7.27 kg of CO₂^e. One can's share of this comes out to be 16.83 g CO₂^e and, as these stores constitute 54% of our retail chain, we can allocate 9.09 g CO₂^e to one can of Farm Hand.



Large Retailers

13.23 g CO₂^e

Many large grocery chains, including Meijer and Spartan Stores, currently carry our beer. These make up the other 46% of our retail store network. We found the most common refrigeration unit to be the Hussman D5X-E merchandiser, typically the 12-foot model, though some stores use the 8-foot and 6-foot models.^{xxxviii} We have chosen to use the 12-foot model, as it was the most commonly found.^{xxxix} According to the Evans study, this type of merchandising display consumes 5.3 kilowatts of electricity, which equates to 127.2 kW-h over the day that our can of beer typically stays on the shelf. Thus, the total daily emissions from powering this type of cooler are 96.29 kg CO₂^e.

A major plus of using cans is that, unlike glass bottles, they can be stacked. Not all retailers stack our cans on display but in observing different stores, we noticed that roughly half have two rows stacked on top of one another. As a typical 12-foot commercial display can fit 372 six-packs, we estimate it can fit 558 four-packs or 1,116 if they are stacked two high. Taking an average between the two, we hold that a single can will take up 1/3,348 of a typical display. Allocating our total emissions from a day's worth of electricity to one can, this comes to 28.76 g CO₂^e and, as these stores are 46% of our total retail chain, we can pro-rate this as 13.23 g CO₂^e.

Utilities

38.04 g CO₂^e

Retail stores, both big and small, cannot operate without electricity and natural gas to keep the store comfortable and essential equipment running. These utilities, of course, account for carbon dioxide and its equivalents being released into our atmosphere.

Liquor, Convenience, & Specialty Stores

32.78 g CO₂^e

As secondary data wasn't readily available concerning typical energy consumption by smaller beverage retail stores, Siciliano's Market in Grand Rapids was a great help in pinpointing these emissions. Through primary energy consumption information provided by Siciliano's, we were able to allocate 0.0035 kW-h of electricity associated with storing a can for the day it will typically sit on a shelf or in a cooler.^{xl} As revenue and other information is proprietary in nature, we cannot disclose publicly how we reached this number. Using again our eGRID emissions data, we can attribute 2.65 g CO₂^e to the electrical consumption used by Siciliano's, pro-rated down to one can's share.

Looking at natural gas in a similar way, we were able to allocate roughly 0.0057 therms of natural gas to the storage and display of one of our cans for a day. Again using our EPA reported emissions factors of 5.306 kg CO₂, 0.5 g CH₄, and 0.01 g NO₂ per therm of natural gas, we calculated emissions to be 30.13 g CO₂^e



per can of Farm Hand.

Large Retailers

5.26 g CO₂^e

Using data from a study conducted by the EPA in 2003 on energy consumption by supermarkets, we know that an estimated 51.3 kW-h of electricity and 0.38 therms of natural gas are used annually, per square foot, in these larger stores.^{xi} Going again to our eGRID emissions factor, we can determine that these stores generate roughly 38.83 kg CO₂^e per square foot of space. As one can takes up 6.786 in² of space, or 0.047 ft², and a can typically only sits for a day, we can attribute 5 g of CO₂^e to the electricity associated with storage. Similarly, the natural gas used in a supermarket, when allocated to a single can, comes out to 0.26 g CO₂^e.



Use

Refrigeration

11.27 g CO₂^e

Home refrigeration units range greatly in size, age, and energy efficiency, which makes it hard to assign an exact CO₂^e number, but we have calculated a good representation of the power it would take to cool our beer for a week (if you can keep it in the fridge that long).

As energy consumption varies widely with the type of fridge, we have found an average of four numbers for different ages and sizes of refrigerators. We have data on maximum kW-h from both a 25 cu ft side-by-side unit with in-door ice, and an 18 cu ft top-mount freezer unit without ice, both from 2001 standards and from 2007 standards. An average of these four numbers gives us our yearly electricity consumption for a residential fridge, 500 kW-h, and from that our weekly consumption of 9.6 kW-h. Using our eGRID data on emissions from our region's electricity production, we can then attribute 7.27 kg CO₂^e per week of refrigeration.

Of course, one can only takes up a fraction of space in any residential fridge. In the top-mount model, a 16oz can accounts for roughly 0.16% of the total capacity (ignoring



freezer space) and around 0.15% of the 15 cu ft of fresh food space in the side-by-side. That's space for a lot of four-packs! So, of the total weekly emissions correlated with running your residential fridge, we can allocate approximately 11.27 g CO₂^e to home refrigeration of a can.



End-of-Life

Landfilling

0.01 g CO₂^e

Aluminum cans have a reported recycle rate of 58.1% nationwide,^{xlii} and even higher in Michigan due to the state's pay-to-recycle system, which is one of the major reasons we decided to can our beer instead of the more traditional glass bottles used in the craft beer industry. As state recycling statistics were not available, we have chosen to use the national average for aluminum can recycling, meaning that 41.9% of cans find their way into a landfill and 58.1% are recycled.

The EPA assumed average for a refuse truck route is 32 kilometers, or 19.88 miles. A class 8 diesel garbage truck driving this route would emit a total of 27,672.96 g CO₂, of which 0.02 grams can be allocated to the transport of one empty can. As 41.9% of total cans will be, on average, landfilled rather than recycled, we took this percentage of the total CO₂^e amount, which comes out to roughly 0.01 grams of CO₂^e for the landfilling of our can.

Recycling

0.01 g CO₂^e

As the recycling process itself is preparing the waste product into an entirely new, repurposed product, it is not in our scope to include actual processing, but rather we have limited our scope to take into account transport to the plant. Using the EPA assumption of an average 19.88 mile truck route to the recycling facility, this will amount to 0.02 grams of CO₂ emissions, based on our EPA garbage truck emissions factors. With 58.1% of this being sent to recycling, rather than landfill, we can allocate 0.01 grams of CO₂ and equivalents to one can of Farm Hand.



Can vs. Draft



In addition to calculating our total footprint per can, we thought it would be cool to see the difference in impact between drinking a can at home and drinking a draft in our brewpub.

Enjoying a pint in our pub cuts out a *huge* portion of the downstream activities associated with the same 16 ounces of beer. Instead of CO₂e intensive aluminum production, diesel fuel emissions, warehouse refrigeration, and all of the other activities that go into that can of Farm Hand sitting on your local retailer's shelf, the only real things that go into a draft pint is some CO₂ for kegging, refrigeration, dishwashing of glasses, and the energy used in keeping our brewpub a comfortable place to be. Kegs and glasses are used over and over and over, so they don't make an impact anywhere close to what a disposable can does.

Can	On Tap
418.97 g CO₂^e	341.78 g CO₂^e

It's no huge surprise that cutting out so much of the beer's life cycle results in much lower GHG emissions. All the more reason to enjoy a pint in our brewpub or grab a growler to go!



Summary & Conclusions

Upon completing our study, we took a step back and thought about what it all meant. A number like 412.1 grams, of gases you can't see or smell, seems quite arbitrary; what does it mean and why is it important?

Our goal in conducting this study was to gain a better and more holistic understanding of how what we do affects the world around us. The more we understand about what we're doing now, the more we can work to improve what we do in the future.

By using the information we have learned from this study about our carbon footprint, we have set a baseline for future progress to be compared against. Furthermore, we have identified some hotspots and key areas we feel need the most attention. There are, of course, many factors we have very little influence over (like the type of refrigerator a beer drinker has in their kitchen) but for those we *do* have direct control over, this report is a valuable tool in assessing what areas we should focus on now and in the coming years. And lastly, as one of our tenets of sustainability, we feel strongly about transparency and being open about our business. Our footprint is a reminder to us that we aren't perfect and there is always room to improve. As some wise person once said, "sustainability is a journey, not a destination."



Among our **key findings**, we learned:

- Our electricity and natural gas usage in the brewing process is by far the largest contributor of greenhouse gases in our beer's life cycle, roughly 38% of the total footprint. We would love to incorporate on-site renewable energy generation in the future and are currently looking into our options.
- Our water-to-beer ratio was higher than we had previously thought. At 4.9:1 water to beer, we have some work to do to get down to our ambitious goal of 3:1.
- In comparing emissions from the production and transport of cans to that of glass bottles, we found that canning cut GHG emissions nearly in half.^{xliii}
- Emissions from transport, at all stages, were much lower than expected, at around 4% of the total footprint.



- Agriculture practices used in the farming of our grains and hops, which are heavily reliant on synthetic fertilizers, are a large contributor of GHG emissions. Using more organic barley, wheat, and hops in our beers would cut down on the emissions from this stage.

If you have any questions, concerns, or suggestions about our carbon footprint or any of our other sustainability reporting or initiatives, we'd love to hear from you at sustainability@breweryvivant.com.

Cheers!

Kris Spaulding, **Owner & Sustainability Director**
Jason Spaulding, **Owner**
Paul McVeigh, **Sustainability Intern**

Brewery Vivant, 2013





References

- ⁱ Data from *Greenhouse Gas Emissions from Oats, Barley, Wheat, and Rye Production*, 2011
<http://agronomy.emu.ee/volo9Spec1/p09s123.pdf>
- ⁱⁱ Port, routing, and distance information obtained from Searates.com
<http://www.searates.com/reference/portdistance/?country1=155&country2=200&fcity1=518&fcity2=16959&speed=24>
- ⁱⁱⁱ Calculated from the EPA's 2008 document *Direct Emissions from Mobile Combustion Sources* and Notteboom and Cariou's document "Fuel Surcharge Practices of Container Shipping Lines: Is it About Cost Recovery or Revenue-making. Proceedings of the International Association of Maritime Economists Conference, Copenhagen" (2009)
- ^{iv} Deadweight tonnage was given as a range between 80,000-109,999 tonnes; we selected 100,000 as it was a nice, round, reasonable number in this range
http://www.aristonshipping.gr/index.php?option=com_content&view=article&id=16&Itemid=21&lang=en
- ^v U. S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2010*
- ^{vi} The two independent reports used to calculate our average were Goodyear's document *Factors affecting truck fuel economy*, which converted to 7.84 mpg (http://www.goodyear.eu/be_fr/images/Fuel_Economy-ENG_tcm59-34637.pdf) and a case study from Glass Transport Partners, who reported the equivalent of 7.47 mpg in their trucking fleet (<http://fleet-fuel-efficiency.eu/en/report/case-studies/glass-transport-partners/>)
- ^{vii} Calculated from the CO₂, N₂O, and CH₄ data from the EPA document *Direct Emissions from Mobile Combustion Sources* (2008) and converted to CO₂ equivalent using EPA "global warming potential" numbers
- ^{viii} As with waterborne and highway transport, rail transport numbers were obtained from the EPA's *Direct Emissions from Mobile Sources* document.
- ^{ix} Calculated using data from *Greenhouse Gas Emissions from Oats, Barley, Wheat, and Rye* (2011) by Rajaniemi, Mikkola, and Ahokas
- ^x Rail mileage courtesy of Amtrak.com and Canadian Pacific Railroads
- ^{xi} Nova Institute, 1996. Das Hanfproduktlinienprojekt. Hürth/Köln, Germany. P172, 386-397
- ^{xii} Distances, via truck, to ports abroad were found by mapping out likely routes using Google Maps
- ^{xiii} Distance between ports was found using Searates.com
<http://www.searates.com/reference/portdistance/?country1=163&country2=200&fcity1=1650&fcity2=16959&speed=24>
- ^{xiv} All domestic railroad transport distances were found using rail distances for Amtrak Empire builder and Lake Shore Limited passenger trains traveling similar routes
- ^{xv} Data from City of Grand Rapids spreadsheet, detailing all annual treatment plant utilities



^{xvi} 2012 State-by-State eGRID emissions from electricity production
http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_GHGOutputrates.pdf

^{xvii} *The Carbon Footprint of Fat Tire Amber Ale*, New Belgium Brewing Company
<http://www.newbelgium.com/Files/the-carbon-footprint-of-fat-tire-amber-ale-2008-public-dist-rfs.pdf>

^{xviii} Frank, K. G. (2006). *Industrial Gas Handbook: Gas Separation and Purification* (p. 180). Boca Raton: CRC Press.

^{xix} Though unconventional, many other craft brewers are beginning to move, at least in part, to cans including New Belgium Brewing, Sierra Nevada, and Arcadia Ales

^{xx} *Why Recycle?* The Aluminum Association
<http://www.aluminum.org/Content/NavigationMenu/TheIndustry/Recycling/Whyrecycle/default.htm>

^{xxi} Average recycled content in aluminum cans was obtained from The Aluminum Association
(<http://www.aluminum.org/AM/Template.cfm?Section=Home&CONTENTID=31569&TEMPLATE=/CM/ContentDisplay.cfm>)

^{xxii} Emissions data for aluminum production from the EPA document *Introduction to WARM and Metals*, detailing the CO₂ equivalent emissions from recycled and virgin aluminum inputs (p. 11)
<http://www.epa.gov/climatechange/waste/downloads/Metals.pdf>

^{xxiii} Data taken from the EPA's *Introduction to WARM and Metals* PDF document (p. 16)
<http://www.epa.gov/climatechange/waste/downloads/Metals.pdf>

^{xxiv} Benchmarks - Ranking Building Energy Intensity (2010, May). Retrieved January 22, 2013, from
http://portal.ncdenr.org/c/document_library/get_file?uuid=cd0f4b36-b013-427f-a72e-2e1ce9058b48&groupId=38322

^{xxv} Calculated using data from the EIA *Voluntary Reporting of Greenhouse Gases Program Fuel Carbon Dioxide Emission Coefficients* <http://www.eia.gov/oiaf/1605/coefficients.html>

^{xxvi} All Paktech information comes from an LCA data spreadsheet provided to us by Laura Mann, Customer Service Account Manager with the company

^{xxvii} "Resource Audit Report," The Green Brewery Project, 2013

^{xxviii} Calculated using year-end Brewery Vivant financial statements

^{xxix} Data from the EIA *Voluntary Reporting of Greenhouse Gases Program Fuel Carbon Dioxide Emission Coefficients* <http://www.eia.gov/oiaf/1605/coefficients.html>

^{xxx} 2012 Vehicle Technologies Market Report." Center for Transportation Analysis, 2012. Web. 20 Apr. 2013. <http://cta.ornl.gov/vtmarketreport/pdf/chapter3_heavy_trucks.pdf>.

^{xxxi} For breakdown of transport emissions, see the *LCA Emissions Calculations* document, compiled by Brewery Vivant

^{xxxii} Benchmarks - Ranking Building Energy Intensity (2010, May). Retrieved January 22, 2013, from
http://portal.ncdenr.org/c/document_library/get_file?uuid=cd0f4b36-b013-427f-a72e-2e1ce9058b48&groupId=38322



xxxiii The body dimension of one of our cans is 2.605 in², meaning it will take up 6.786 in² of space, or 0.047 ft²

xxxiv From correspondence with sales representative from Kent Beverage

xxxv From correspondence with Janet Schleming at Kent Beverage, breaking down distribution to type of retail location for the period 1/1/2012-12/31/2012

xxxvi Correspondence with Sarah Derylo and Steve Siciliano, owner of Siciliano's Market in Grand Rapids

xxxvii Evans, J. A., Scarcelli, S., & Swain, M. V. L. (2007). Temperature and energy performance of refrigerated retail display and commercial catering cabinets under test conditions. *International Journal of Refrigeration*, 30(3), 398-408.

xxxviii Observed at local supermarkets including Meijer, Family Fare, and D&W

xxxix Specifications on the Hussman D5X-E refrigerated merchandiser display
http://www.hussmann.com/Product%20Data%20Sheets/0463856_h_d5x-e.pdf

xl Correspondence with Sarah Derylo and Steve Siciliano, owner of Siciliano's Market in Grand Rapids

xli Sector Collaborative on Energy Efficiency Accomplishments and Next Steps (2008, July). Retrieved January 4, 2013, from http://www.epa.gov/cleanenergy/documents/suca/sector_collaborative.pdf

xlii Data from 2011 article published by The Aluminum Association
<http://www.aluminum.org/AM/Template.cfm?Section=Home&CONTENTID=31569&TEMPLATE=/CM/ContentDisplay.cfm>

xliii While the emissions factor of glass is much lower than that of aluminum, the mass of glass needed for a bottle is *much* higher than that of a can. NBB reported that a six-pack consists of 2.67 lb of glass, so we can assume that a 16 oz container uses 267.62 grams of glass, versus only 17 grams of aluminum for one of our cans. Based on EPA WARM data, we can attribute roughly 160 grams CO₂e to the raw material acquisition, processing and transport of the glass.
<http://www.epa.gov/climatechange/waste/downloads/Glass.pdf>