KERRY

Brewing sustainably

Quantifying the carbon reduction and cost-benefit effectiveness of Kerry brewing solutions

LIFE CYCLE ASSESSMENT TECHNICAL REPORT

Contents

Executive summary

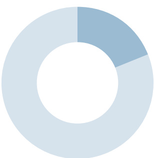
Brewing is well recognised as an energy-intensive process and its environmental impact is regularly assessed. In recent years, the brewing industry has made significant improvements, but, as awareness of climate change grows and consumers continue to demand more sustainably produced products, it is imperative the brewing industry continue on its journey of better environmental stewardship.

To support brewers in this mission, Kerry's Life Cycle Assessment (LCA) study of the brewing process was carried out using the company's range of brewing solutions. The study findings confirmed significant sustainability benefits attainable through the application of Kerry brewing solutions, which, when coupled with impressive commercial and product quality improvements, hold potential to deliver exceptional benefits to forward-thinking brewers.

This LCA analysis focused on raw materials, brewing operations and waste management. Kerry's processing aids and enzymes complement the natural brewing process by reducing the net impact of raw materials; making the individual brewing process stages more efficient; and lowering the volume of waste generated during production.

CUMULATIVE POTENTIAL BENEFITS:

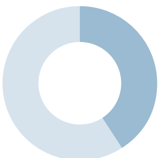
ENERGY



Savings of

19%

CO_2 EMISSIONS



Reduction of

41%

PRODUCTION COST

Savings of up to

€1.70/hl

Key Impacts:

- FermCap™ prevents excessive foaming during production by lowering surface tension. In the LCA study, FermCap™ delivered energy savings of 8% and a CO_2 emissions reduction of 19%. Numerous commercial trials have also confirmed that cost savings of up to €0.09 per hectolitre can be achieved through the use of FermCap™.
- Biofine™ is used to flocculate yeast at the end of fermentation. In the LCA study, Biofine™ delivered a 14% reduction in maturation time, a doubling of filtration cycles, and a drop of 50% in filter aid consumption. Other benefits included a 1% reduction in beer loss, a 5% CIP reduction, 8% lower energy use, and a 17% reduction in CO_2 emissions. Commercial trials have also confirmed cost savings potential of up to €0.19 per hectolitre through the use of Biofine™.

The extensive LCA study also examined the impact of a wide range of other Kerry brewing solutions. The available cumulative benefits include energy savings of 19%, a CO_2 emissions reduction of 41%, and production cost savings of up to €1.70/hl.

As the LCA study on the brewing process illustrates, Kerry's targeted solutions provide brewers with a suite of options to improve sustainability within their production processes while simultaneously decreasing production costs.

With sustainability never before as important as it is today, the findings of this LCA will appeal to brewers seeking to enhance their sustainability efforts and reduce their carbon footprints.

Improve sustainability during the production process while simultaneously decreasing production costs.

Preface: Toward sustainable brewing

While the global brewing industry has greatly refined the efficiency of beer production processes over the centuries, it is still an extremely resource-intensive business — one that uses an enormous amount of water and energy while generating a considerable volume of waste. As a result, there is both significant scope and motivation to further improve efficiencies by adopting more sustainable practices. Kerry's brewing process LCA study was designed to quantify the sustainability improvements available through the application of processing aids and enzymes. These improvements and process efficiencies can translate into significant cost savings for breweries, further escalating their benefits.

Significant cost savings are available through the use of processing aids and enzymes, further escalating the benefits for breweries.

Increasing consumer purchase preference for sustainable products

Kerry's surveys of consumer attitudes consistently show majority support for corporate social responsibility. In short, consumers benefit from a "feel good" factor when they support sustainable products, support that shows no signs of abating. Innova Market Insights found in 2019 that 89% of global consumers expect companies to invest in sustainability; this is a large increase from the 65% reported in 2018. Additionally, while we knew consumer concern about climate change was rising pre-COVID, evidence suggests the pandemic has ultimately strengthened and further elevated this awareness.

Another study, conducted by Indiana University, revealed that almost 60% of respondents would pay an extra $1.30 per six-pack for sustainably produced beer. And, as seen in Kerry's *Future of Food* study, over 40% of surveyed consumers (and 52% of millennials) stated that they strive to purchase from ethical brands. Quite simply, consumers want to do something for the environment that supports the fight against global warming.

89% **of global consumers expect companies to invest in sustainability**

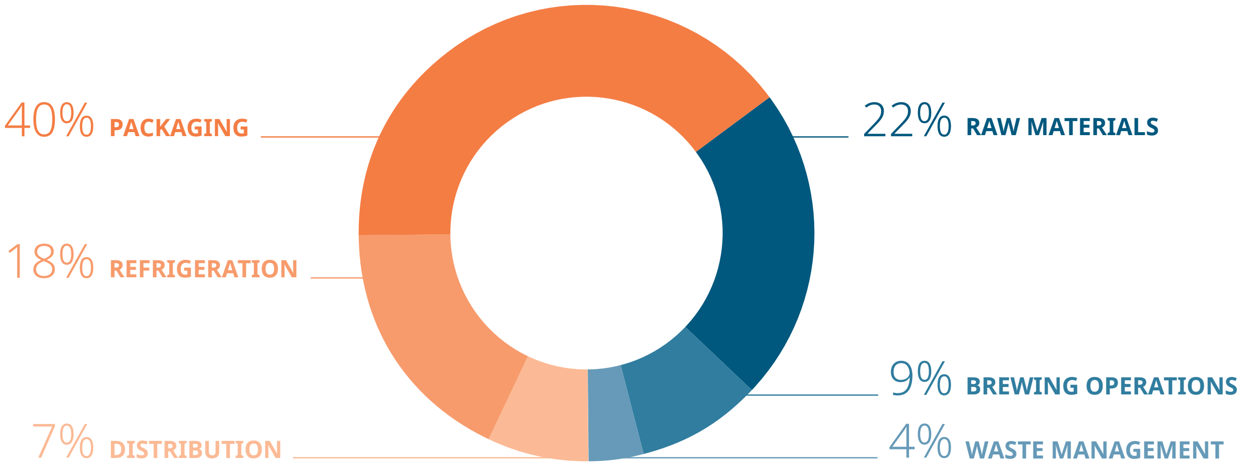
Download the *Future of Food* white paper here

Introduction

It has become increasingly evident that a strong focus on sustainability has the capacity to be a key differentiator for brewers in today's ultra-competitive environment. However, how do you evaluate and implement sustainable brewing practices that not only resonate with environmentally concerned consumers but also make sound business sense, both in the boardroom and in the brewery?

To fully appreciate, understand and control the carbon footprint of beer as it relates to specific stages in the brewing process, we need to consider the full LCA of the product. To do this, we must first analyse the many energy inputs involved: crop production; transport of relevant crops from the field to the brewery; processing; packaging; delivery to warehouses; distribution; and refrigeration prior to consumption. Figure 1 gives a breakdown of the key contributors to beer's carbon footprint.

FIGURE 1: BEER LIFE CYCLE ANALYSIS



Source: Center for Sustainable Systems, University of Michigan - 2017[1]

At 40%, packaging is the single largest contributor, followed by raw materials at 22%; however, both refrigeration (18%) and brewing operations (9%*) also contribute heavily

*This value can vary from a low of 4.3 to a high of 19.6 kg/hl depending on the size of production unit and the engineering efficiencies already implemented[2].

Introduction *continued*

Global brewery energy and emissions ratios declined over the period 2013–17, moving, respectively, from 1.25 MJ/L to 1.14 (-9%) and from 111.72 gCO_2E/L to 90.46 (-19%)[3]. These reductions have come from three key advances: process automation and optimisation in fermentation and malting; packaging improvements and recycling; and efficiencies gained by increasing brewery size. However, brewers will be encouraged by the news that even further reductions can be achieved through the addition of processing aids and enzymes into the beer production process.

The carbon footprint attributed to beer production represents both a challenge and an opportunity for brewers to significantly reduce plant emissions by measuring and controlling the output of individual steps within their processes.

At Kerry, we have developed a broad portfolio of brewing solutions that can help lower the net impact of raw materials, individual brewing process stages and waste production/disposal. Working with the sustainability division of global engineering firm Jacobs, we completed an LCA on our brewing solutions portfolio and, by applying details from commercial-scale brewing operations, constructed a model based on the average dose rates and average benefits (extract yield, fermentation, maturation, process optimisation and filtration).

The model system was a standard high-gravity (18°P) lager brew using a 100% malt base produced in a medium- to large-sized brewery (one million hectolitres per annum).

3 KEY ADVANCES IN BEER PRODUCTION:

- Process automation and optimisation in fermentation and malting
- Packaging improvements and recycling
- Efficiencies gained by increasing brewery size

Materials and methods

LCA is a technique used to assess environmental impacts associated with all stages of a product's life cycle. Application of product footprint standards, such as the PAS 2050:2011, requires assessments of the greenhouse gases (GHG) of products using LCA techniques specified in BS EN ISO 14067 and ISO 14044 (British Standards Institute, 2011).

This study compared five variants, as referenced in table 1 (based on process aid inputs), of a standard high-gravity (18°P) brewing process that uses 100% malt.

The model is driven by a true/false statement that indicates whether a particular process aid has been utilised. Based on data accumulated from numerous brewing production processes, key assumptions on extract recovery/yields in the brewhouse — e.g., hop utilisation, fermentation and maturation times, and changes in filtration cycles and CIP cleaning cycles — were applied to the model. Using these outcomes, impacts on energy utilisation and CO_2 production were calculated.

TABLE 1*: ENERGY CONSUMPTION BREAKDOWN — LCA MODEL

Ratio & Balance	MJ/year	%
Wort Boiling	30,000,000	20%
Fermentation	7,050,000	5%
CIP for Fermentation	20,520,000	14%
Filtration	15,000,000	10%
CIP for Filtration	13,680,000	9%
Other Processes Outside of Scope	28,750,000	42%
Entire Brewing Process	**115,000,000**	**100%**

*Based on a standard model 1Mhl p.a. brewery 115MJ/hl, 25% electricity/75% natural gas

LCA baseline assumptions:

- Medium- to-large-sized brewery: 1M hectolitres per annum
- Standard lager from 100% malt
- High-gravity brewing copper out cold wort, 475hl at 18°P
- Dual-tank process utilising separate tanks for fermentation and maturation
- Filtration through standard plate frame filters using kieselguhr/diatomaceous aid as precoat and body feed
- Average brewhouse emissions per hl beer is 7.02kg of CO_2 equivalent[4]
- Energy source: 75% electricity, 75% natural gas (see table 1 for energy consumption breakdown)

Scope and definitions

TABLE 2

Term	Definition
Scope 1 Emissions	Direct emissions from owned or controlled sources, e.g., onsite fuel consumption, company vehicles
Scope 2 Emissions	Indirect emissions from the generation of purchased electricity, e.g., steam, heating and cooling consumed by the reporting company
Scope 3 Emissions	All other indirect emissions that occur in the company's value chain, e.g., manufacture of ingredients

Source: https://www.carbontrust.com/resources/faqs/services/scope-3-indirect-carbon-emissions/[5]

Excluded from LCA scope: carbon emissions from packaging, distribution and refrigeration (retail/home)

Impact of Kerry brewing solutions

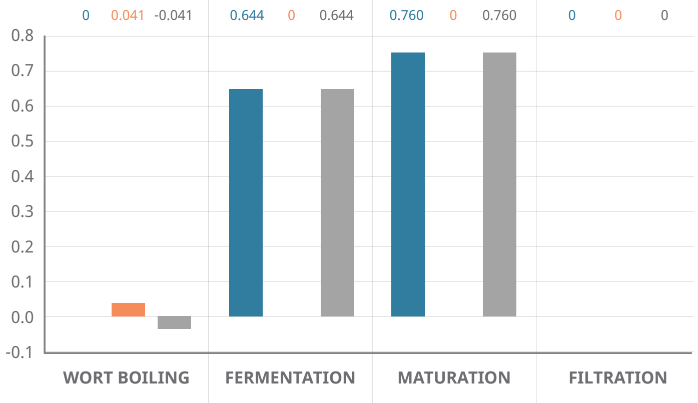
FermCap™: Antifoaming agent that delivers increased fermentation capacity and improved hop utilisation

FermCap™ is Kerry's proprietary antifoaming agent. It is an extremely effective surface-active agent that prevents excessive foaming during production by reducing surface tension. A dose rate of 6 g/hl was used for this LCA model, added at the start of fermentation.

Results:

Figure 2 provides a breakdown of the impact of FermCap™ during individual brewing process steps, as well as overall net CO_2 reduction per hl due to the efficiencies generated. As shown, the main effect is measured in fermentation, maturation and filtration, and occurs as a result of increased tank utilisation.

FIGURE 2: NET IMPACT OF FERMCAP™ ON BREWING PROCESS CO_2 EMISSIONS



Decrease in Scope 1 emissions (kg CO_2e/hl)
Increase in Scope 3 emissions (kg CO_2e/hl)
Net carbon emissions savings (kg CO_2e/hl)

FermCap™ Impact:

- Delivers 8% energy savings and 19% reduction in CO_2 emissions (figure 2)
- Increases fermentation capacity by 10%, resulting in improved tank utilisation
- Improves hop (alpha acid) utilisation
- Improves final beer foam stability
- Reduces expensive wort losses, unhygienic spillages and cleaning/ effluent costs in brewhouse
- Reduces CIP cycles and CIP agent consumption by 10%
- Maximises CO_2 recovery

The Kerry savings analytical calculator was applied to this product. When added to a standard brewing production process,

FermCap™ has been shown to enable cost savings of up to €0.09 per hectolitre.

FermCap™ delivers an 8% energy savings and 19% reduction in CO_2 emissions equivalent to ~1,362 mtCO_2e per annum.

Biofine™: Yeast flocculant utilisation optimises maturation time and improves filter throughput

Biofine™ is Kerry's range of proprietary processing (fining) aids used to flocculate yeast at the end of fermentation. The typical dose rate is in the range of 1.5–10 g/hl. A dose rate of 10 g/hl was used for this LCA model, added at the end of fermentation.

Biofine™ Impact:

- Delivers 8% energy savings and 17% reduction in CO_2 emissions (figure 3)
- Reduces storage time
- Reduces maturation time by 14% (144 hours versus standard maturation time of 168 hours)
- Increases filtration efficiency
- Doubles filtration cycles and reduces filter aid consumption by 50%
- Reduces beer loss by 1%
- Reduces CIP by 5%

In addition, the cost-saving impact of Biofine™ is considerable, as summarised in table 3.

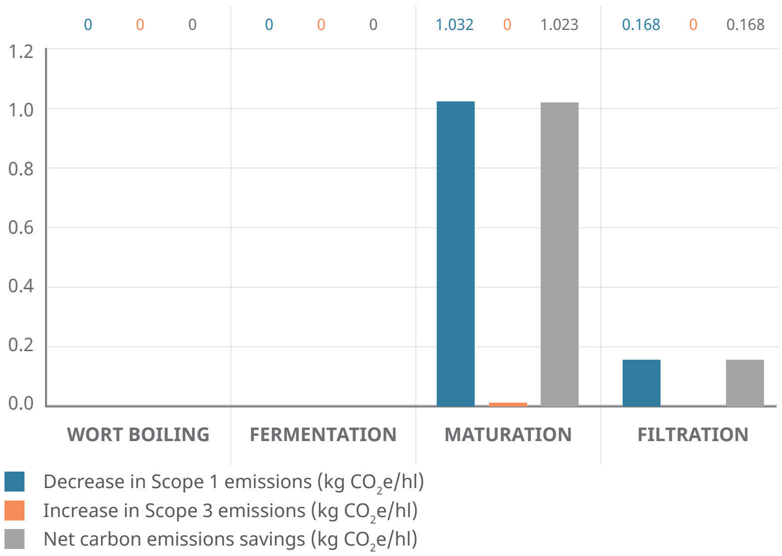
In this commercial trial, Biofine™ delivered an estimated saving of €0.19/hl.

TABLE 3: COST-SAVING IMPACT OF YEAST FLOCCULANT UTILISATION (COMMERCIAL TRIAL)

	Dose rate (g/hl)	EBC haze (after 36 hours)	Yeast cell count (10^6/ml)	Filter aid (g/hl)	Filter cycle (hl)	Estimated savings (€/hl)
Control	0	23.1	3.2	180	11,600	—
Biofine™	1.2	1.9	0.4	55	3,500	0.19

Results:

FIGURE 3: NET IMPACT OF BIOFINE™ ON BREWING PROCESS CO_2 EMISSIONS



The cumulative Biofine™ benefit encompasses primarily a reduction in refrigeration holding times during maturation, with additional benefits accruing due to increased filtration run times and related efficiencies.

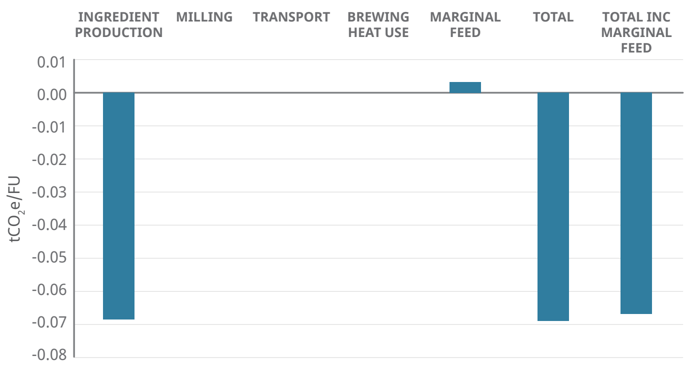
Biofine™ delivers an 8% reduction in energy usage and 17% reduction in CO_2 emissions equivalent to ~1,191 mtCO_2e per annum.

Bioglucanase™ enzyme delivers improved filtration performance, reduced filter aid consumption and disposal, and lower production costs

Bioglucanase™ enzyme can lower wort and beer viscosities and reduce the loading of solids on filters. This will significantly increase filter run lengths and capacity while reducing the quantity of filter aid used per hectolitre of beer filtered. Bioglucanase™ was dosed at 0.1 kg/tonne malt for this LCA model.

Results:

FIGURE 4: NET IMPACT OF BIOGLUCANASE™ ON BREWHOUSE PERFORMANCE



Relative Difference Scenario 1 (Malt) vs. Scenario 2 (Malt + Bioglucanase™)

FU = Functional unit (500hl wort at 18°P)

Bioglucanase™ delivers a 1% energy savings and 1% reduction in CO_2 emissions equivalent to ~81 mtCO_2e per annum.

Additionally, enzyme technologies can have significant benefits when increasing the percentage of unmalted grains and adjuncts used in the brewing process, and Kerry has a specific LCA model to deal with high-adjunct brewing.

Visit https://www.kerry.com/insights/case-studies/brewing-efficiencies-and-carbon-footprint-improved-with-bioglucanase-xf to learn more.

Bioglucanase™ Impact:

- Delivers 1% energy savings and 1% reduction in CO_2 emissions (figure 4)
- Reduces energy consumption by 1% and creates a more efficient beer production process
- Reduces lautering time by 12% (table 4)
- Reduces filter run rate by 8.5% (table 4)
- Increases yield by 1% in a 100% barley malt process (figure 4)

In addition,

Bioglucanase™ can deliver cost savings in the region of €0.03/hl.

Bioglucanase™ assumptions for LCA model:

- Added to a 100% malted barley recipe for a commercial brewery
- Only savings due to increased extract yield are considered, and as such can be seen as an overall reduction in the quantity of malt required to produce the same amount of wort at target gravity
- In this case, any positive impact on process turnaround times or mash/beer filtration cycle optimisation have not been included in the energy savings or CO_2 emissions reduction calculations

TABLE 4: REDUCTION IN LAUTERING TIME AND MAXIMISATION OF FILTRATION RATES (COMMERCIAL TRIAL)

Brewhouse	Malt (tonnes)	Wort (hl)	Lautering time (hrs:mins)	Extract (°P)
Control	10	750	2:45	15
+Bioglucanase™ GB*	10	764	2:15	15

Filtration plant	Filter type	Filtered beer (hl) one pre-coat	Filter run length (hrs)	Filter aid (g/hl)
Control	candle	5,000	2:35	165
+Bioglucanase™ GB	candle	11,400	2:15	79

*Dosed at 0.05 kg/tonne malt in brewhouse only

Whirlfloc™: Copper fining agent that increases wort recovery and extends filter run lengths

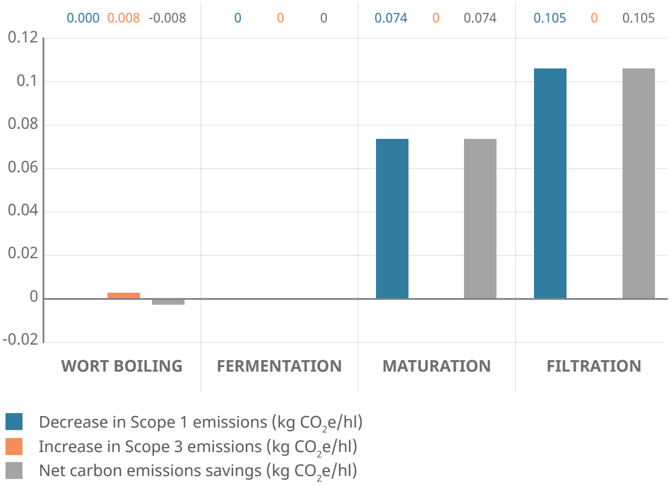
Whirlfloc™ is a purified form of high-molecular-weight carrageenan extracted from red marine algae (*Rhodophycae*). Whirlfloc™ is insoluble in cold water and soluble in hot water and wort above 60°C. It is available in powder, granular or tablet format, and is typically applied 10–15 minutes before copper casting at a dose rate of 3–5 g/hl wort. A dose rate of 4 g/hl was used for this LCA model.

Whirlfloc™ accelerates the formation of dense and compact hot and cold trub, saving time in the brewhouse and increasing wort recovery. This results in considerably brighter worts, with the added benefit of greatly reduced solids loading on filters (facilitating extended filter run lengths).

Results:

Figure 5 provides a breakdown of the impact of Whirfloc™ during individual brewing process steps, as well as overall net CO_2 reduction per hl. As shown, the main impact is measured in both maturation and filtration, and occurs as a result of improved efficiencies and increased volume throughput.

FIGURE 5: NET IMPACT OF WHIRFLOC™ ON BREWING PROCESS CO_2 EMISSIONS



Whirlfloc™ Impact:

- Delivers 1% energy savings and 3% reduction in CO_2 emissions (figure 5)
- Improves trub compaction
- Increases extract yield/reduces yield losses
- Reduces wort losses by 1% with brighter/cleaner worts
- Increases beer volume by 1% in maturation tank
- Increases filter run length by 50% and reduces filter aid consumption by 50%
- Reduces CIP by 10%
- Reduces filter pressure

Whirlfloc™ delivers a 1% reduction in energy usage and 3% reduction in CO_2 emissions equivalent to ~172 mtCO_2e per annum.

Yeastex™: Fermentation nutrients reduce fermentation time and increase yields

Yeastex™ is Kerry's unique line of products formulated to meet the diverse nutritional requirements of brewer's yeast. These customized products are effective in both malt-based and high-adjunct (barley, wheat, sorghum, maize, cassava, rice and others) brewing and distilling fermentation processes.

Key nutrients (including sugars, amino acids, nitrogen compounds, vitamins, essential co-factors and minerals) control the development and growth rate of yeast cells in the brewing process.

In situations in which some of these nutrients and cofactors are missing or limited, Kerry's Yeastex™ formulations work by compensating for the deficiencies. They also assist yeast in commencing a vigorous fermentation, thereby inhibiting the growth of contaminating organisms.

These products, available in powder form, are easy to handle and can be added at the end of the boil or into the whirlpool. A dose rate of 12 g/hl was used for this LCA model, added to cold wort.

Yeastex™ Impact:

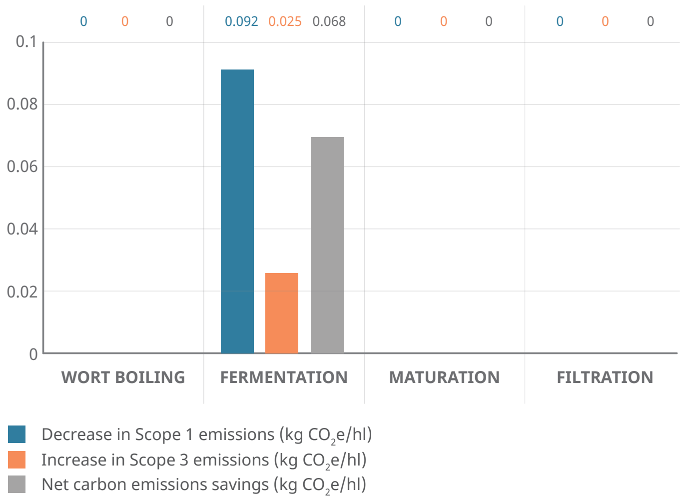
- Delivers 1% energy savings and 1% reduction in CO_2 emissions (figure 6)
- Reduces fermentation by 24 hours (144 hours versus a standard fermentation of 168 hours)
- Enables higher alcohol yield and attenuation
- Provides higher yeast viability and metabolic activity over generations
- Reduces off-flavour development
- Lowers cell count at end of fermentation and facilitates filtration

When added to a high-adjunct (>40%) brewing production process,

Yeastex™ has been shown to enable cost savings of up to €0.08 per hectolitre.

Results:

FIGURE 6: NET IMPACT OF YEASTEX™ ON BREWING PROCESS CO_2 EMISSIONS



Yeastex™ delivers a 1% reduction in energy usage and 1% reduction in CO_2 emissions equivalent to ~68 mtCO_2e per annum.

Impact summary

Utilisation of processing aids and enzymes: Improves the sustainability of beer production by reducing energy consumption and CO_2 emissions, in addition to reducing plant costs.

Plant cost reductions:

When processing aids and enzymes are applied effectively during the brewing process, they can collectively deliver cost benefits of up to €1.70/hl beer (figure 7). In addition, by increasing fermentation capacity and filter throughput (table 5), capital expenditures associated with additional fermenters or beer filtration kits may not be required.

Reduced energy consumption and CO_2 emissions:

Processing aids and enzymes also deliver a significant reduction in energy consumption and CO_2 emissions. Table 5 summarises the potential energy savings and CO_2 emission reductions obtainable through using processing aids and enzymes at different stages in the brewing process.

TABLE 5: INCREASE IN FERMENTATION CAPACITY AND FILTER THROUGHPUT (LCA MODEL)

Technology	Application benefit	Energy savings (%)*	CO_2 emission reduction (%)**
Bioglucanase™ enzyme	Improved wort/beer filtration	1%	1%
Whirlfloc™	Wort clarification/beer filtration	1%	3%
FermCap™	Antifoam increased fermentation capacity	8%	19%
Yeastex™	Yeast nutrient — reduced fermentation time and/or increased alcohol yield	1%	1%
Biofine™	Beer clarification, maturation, filtration	8%	17%
Total Potential Reductions		**19%**	**41%**

*Based on a standard model 1Mhl p.a. brewery 115MJ/hl, 25% electricity/75% natural gas (see page 5 for LCA baseline assumptions)

**Based on emissions from brewing operations only

FIGURE 7: TOTAL POTENTIAL CARBON EMISSION REDUCTIONS AND COST SAVINGS

REDUCED CARBON FOOTPRINT

SAVE UP TO **~2,981 mtCO_2e** per annum

41% **CO_2 reduction** /hl beer

19% **energy reduction** /hl beer

IMPROVED COST OPTIMISATION

SAVE UP TO **€1.70/hl beer** in production costs

RAW MATERIALS: +25% UNMALTED ADJUNCT -20% HOPS

BREWING OPERATIONS: -5% PLANT COSTS

WASTE MANAGEMENT: -50% FILTER AID

Conclusions

The brewing industry has made significant strides in reducing its carbon emissions in recent years, yet further improvements continue to be both available and attainable. All breweries, both large and small alike, are keenly aware of this fact, and are working diligently to implement sustainability programmes that encompass their entire supply chain and production regimes. Although the industry is being further challenged by a dramatic reduction in beer production and consumption around the world due to the COVID-19 pandemic, there is evidence that the current difficulties will ultimately work to strengthen and propel the industry in its adoption of more sustainable brewing production methods.
This LCA study confirms that Kerry's brewing solutions provide a suite of options to improve sustainability within production processes while simultaneously decreasing production costs. The competitive positions of breweries and their brands all around the globe are sure to be enhanced by these important advances.

Authors: Eoin Lalor, BSc, Global R&D Director, Alcoholic Beverage Applications; Jonathan Doyle, PhD, Business Development Director, Brewing; Liz Lalor, MSc, Global Assistant Marketing Manager, Brewing, Kerry Group, Ireland. For further information, contact eoin.lalor@kerry.com or jonathan.doyle@kerry.com.

About Kerry Taste & Nutrition

Kerry, the Taste & Nutrition company, offers solutions that nourish lives all over the world. From humble beginnings as an Irish dairy co-operative, Kerry has grown into a large international food industry leader, with offices in 32 countries, 151 manufacturing facilities and more than 26,000 employees globally, including over 1,000 food scientists. We bring to the table our strong food heritage, coupled with over 40 years of experience, global insights and market knowledge, culinary and applications expertise, as well as a range of unique solutions that anticipate and address our customers' needs. For more information, visit Kerry.com.

151 **manufacturing facilities**

1,000+ **food scientists**

26,000+ **employees**

About Jacobs Sustainability Services

Jacobs Engineering Group Inc. provides a broad range of technical, professional and construction services to numerous global industrial, commercial and governmental clients. Jacobs works with clients at the programme, project or scheme level to develop, roll out and monitor project-specific sustainability plans. This includes working with design and delivery teams to challenge approaches and advise on and/or assess potential opportunities to both reduce impact and optimise the value of solutions.

Jacobs complete LCAs for its many clients, Kerry among them. As an independent technical consultant, Jacobs provide Kerry with third-party perspectives, practitioners with a range of experience in different products and assessment types, and access to world-leading LCA software. Jacobs has a global presence with LCA practitioners in the UK, USA and Australia, allowing its experts to work in close conjunction with its clients and around the clock. This key service and expertise help Jacobs' clients manage their value-chain impacts and drive their sustainability priorities.

Jacobs delivers LCA studies in alignment with relevant standards, e.g.,

ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification

ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines

GHG Protocol — Product life cycle accounting and reporting standard

PAS 2050:2011 — Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

About Product Life Cycle Assessments

An LCA provides valuable information when exploring the environmental impacts associated with each life cycle stage of a product, i.e., from cradle to grave. An LCA is often used to compare two different products or processes in order to identify the most sustainable path. An LCA provides many other benefits, e.g.,

- Understanding of the life cycle impacts of a product beyond a company's manufacturing site (including through the supply chain and at customers' sites)
- Ability to forecast savings in raw material use, energy use and costs
- Insights into possible improvements across the supply chain
- Identification of benchmarks by which improvements can be measured
- Support for sustainability targets
- Competitive advantage through sustainable product creation
- Improved site and company credibility

Brewing Model Quality Assurance

The LCA model designed by the Kerry Brewing team in collaboration with Jacobs was created in MS Excel to replicate the relevant modules of the brewing process. Calculation modules were set up to analyse the life cycle impacts of the changes in input product mix, manufacturing yield and site energy consumption, in alignment with relevant life cycle standards (ISO 14067, ISO 14044 and PAS 2050:2011) and using best professional judgement and industry standard practice. Impact calculations were based on empirical evidence from the effects of the addition of brewing additives. The model complies with Jacobs' internal Quality Assurance process.

For more information on life cycle analysis, visit https://www.jacobs.com/about/sustainability.

References

1. Food Product Environmental Footprint Literature Summary: Beer.
   A report by: Center for Sustainable Systems, University of Michigan (2017).
2. Research on the Carbon Footprint of Beer (Beverage Industry Environmental Roundtable, June 2012) https://www.bieroundtable.com/publication/beer/.
3. Beverage Industry Continues to Drive Improvement in Water, Energy, and Emissions Efficiency 2018 Benchmarking Study. Trends & Observations — January 2019 https://www.bieroundtable.com/publication/2018-water-and-energy-use-benchmarking-study/.
4. Brewing Green 2019. The British Beer & Pub Association (BBPA). http://beerandpub.com/wp-content/uploads/2019/08/Brewing-Green-2019-2.pdf. Cited in The Drinks Business — August 2019 https://www.thedrinksbusiness.com/2019/08/uk-brewers-reduce-carbon-emissions-by-42.
5. What are Scope 3 emissions? https://www.carbontrust.com/resources/faqs/services/scope-3-indirect-carbon-emissions/.