

Resource Efficiency Guidance for the Irish Microbrewing Sector

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- Kelly's Mountain Brew
- The Independent Craft Brewers of Ireland (ICBI)



Foreword

The craft brewing industry in Ireland has only begun to blossom in recent years as the global trend for craft beer is changing the market for beer. The major changes are the offering of unique artisan local and varied beer products. This market is very much at its early developmental stage as new entrepreneurs enter the market to create viable business models. The entry points on a manufacturing scale are from the very basic home brewing type operations extending into small / medium size processes with various operational capacities and vessel sizes, degrees of capability and with many forms of business operations.

As of early 2016 there are about 63 craft breweries operating in Ireland. Many individual breweries are very small, with over 50% currently producing less than 1000 hl per year. The industry is well engaged in food and drink tourism through craft food and beverage fairs, domestic and export markets and it is expanding exponentially. Product output has grown from 26,000hl in 2011 and is predicted to rise to 241,000hl in 2016.

Against this background, the need to look at resource efficiency has not yet been viewed as a priority by many craft brewers. This is not due to a lack of interest in sustainable production, but mainly due to the pressures faced by a developing industry. The ethos of craft brewing is to use local, natural ingredients and develop brews that have individuality and connection with the community. This local involvement is also an important aspect of the international brand development of craft beers as unique products. There is a natural culture for the craft brewer to be environmentally friendly and they will endeavour to minimise their impact — but the added outlay for specialised equipment and staff required to effectively manage resources will counter this intuitive position.

As the sector matures, international good practice examples and case studies that are available to the Irish craft brewing companies will be very useful. This EPA funded resource efficiency guide provides comprehensive assistance to the craft brewing sector, as it sets out practical actions that can be taken at each process step, to facilitate efficient raw material sourcing, water and energy minimisation, and good waste management practices.

The benefit of engagement in sustainability for a craft brewer is in the bottom line, - realising cost savings, increasing profit margins, and gaining competitive advantage in the market place.



*Brewing Consultant
Ex Guinness Master Brewer*

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1. Introduction

This manual provides guidance for effective raw material and resource efficiency for the Irish microbrewing Sector. The project was commissioned by The Environmental Protection Agency under the GreenBusiness programme and was completed by Flannery Nagel Environmental Ltd.

The term craft brewery refers to breweries that are involved in small-scale production of beer (< 30,000 hectolitres). In the context of this report craft brewing is referred to as microbrewing.

In essence, these are breweries that concentrate on the handcraft that is involved in brewing beers and developing speciality brews which are unique to their particular brewery.

In this guidance the resource efficiency examples, good practice and case studies are organised by brewery process. The intention of the guidance is to promote awareness of more sustainable brewing practices throughout the microbrewing industry in Ireland.

As the microbrewing sector is a relatively new industry to Ireland, there are few Irish resource efficiency case studies available and associated benchmarking data, this will come with time as the industry grows and expands.

Beer can be broadly divided into three categories: **ales, lagers and stouts**. The primary difference between ales and lagers is in the fermentation process. Ales undergo fermentation at room temperature with the yeast at the top of the fermentation tank, while lager is fermented for a longer period at lower temperatures with the yeast at the bottom of the fermentation tank. Ales are consumed a short time after production while lagers require conditioning by chilled storage for some weeks before sale. Stout is a dark beer made by top fermentation of yeast, using roasted malt or roasted barley.

1.2 Method

This study was undertaken in four key steps.

Interviews with representative organisations - This phase of data-gathering involved interviews with relevant trade associations. These included Bord Bia, the Independent Craft Brewers of Ireland (ICBI), and a sector expert (Fergal Murray).

Bord Bia Engagement -Bord Bia were engaged to gather aggregated information on sustainability measures implemented by microbreweries under the Origin Green Programme. The ICBI representative and specialists were invited to suggest suitable companies for site visits and questioned on where knowledge gaps pose a barrier to robust understanding of resource efficiency.

Company interviews and site visits - The data-gathering process involved site visits and interviews with brewers at Carlow Brewing, Kellys Mountain Brew, Jack Cody's and Rye River.

Literature review – This involved assessing available International literature on benchmark data, process efficiency and best practice that could be deployed to microbreweries in Ireland.

1.3 About the Craft Brewing Industry in Ireland

The Independent Craft Brewers of Ireland (ICBI) and The Irish Brewers Association (ABFI) represent the interests of the microbreweries in Ireland. In late 2014 ICBI commissioned a report on the economic impact of the Irish microbrewery market in Ireland, this was launched by the Minister for Agriculture, Food and the Marine in November 2014.

The report highlighted that the output of the microbrewing industry is doubling every two years with “craft beer tourism” on the increase. In 2014 there were approximately 33 microbreweries operating in Ireland with a further 17 at development stage.

The budget in 2014 lifted the ceiling for **excise relief** on microbrewery production by 50pc, meaning the brewers will get a 50pc rebate of excise paid on 30,000hl of production rather than on 20,000hl. The current tax rebate is withdrawn once breweries reach 30,000hl in annual production, this is a barrier to expansion of the sector in Ireland as around Europe there is a tapered rebate up to the EU mandated limit of 200,00hl.

A further report produced for ICBI in 2015 detailed the extent of the market growth and production output in 2015. (Feeney, 2015). In 2015 the **number of microbreweries** had risen to 63, 48 of which are producing beer on their own premises, with the remainder marketing and selling products produced on their behalf by other breweries.

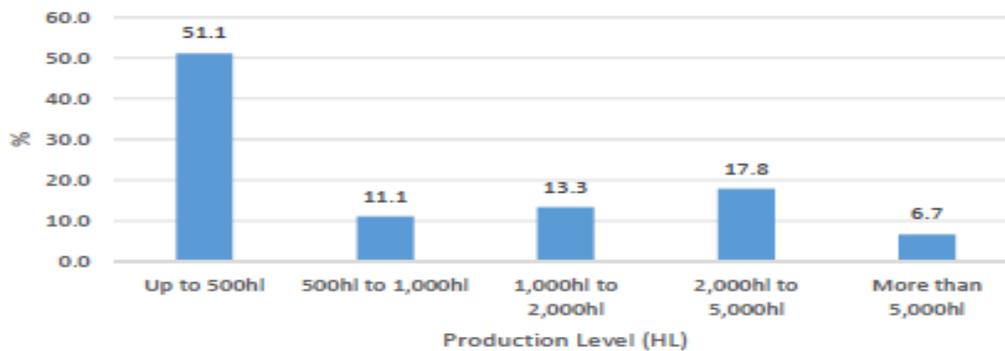
Microbreweries in operation in 2015 were **employing** 259 persons on a full time equivalent (FTE) basis. Employment in craft brewing has more than quadrupled since 2011.

The industry sources over half of its **brewing ingredients** by value domestically. For example, in 2014, almost 90% of microbreweries sourced supplies of malted barley from within the Republic of Ireland, typically amounting to 80% to 90% of all their malted barley inputs. Distribution is another source of local spin-off activity.

In 2014, 41% of the output of the sector was channelled through wholesalers/distributors. Thus, there are significant downstream benefits for the agricultural and other sectors in Ireland.

Product output has grown from 26,000hl in 2011 and is predicted to rise to 145,000hl in 2015. Production forecasts provided by ICBI suggests a further 64% increase in output to 241,000hl in 2016. Of the 44 breweries in production during 2014, over 50% produced 500hl of beer or less in that year. The large number of microbreweries with very low level of production is due to the large number of new entrants that were in production for only part of the year. In 2014, 11 microbreweries had production in excess of 2,000hl. The Figure below shows the % distribution of production outputs based on 2014 production levels.

Figure 4: Distribution of Production Microbreweries by Production Level, 2014 (%)



Source: *Craft Beer and Microbreweries in Ireland, 2015 (A Report for the Independent Craft Brewers of Ireland), August 2015. Author: Bernard Feeney, Economic Consultant.*

The domestic and **export market** is growing for Irish craft beers, with 21,400HL beer being exported to 25 countries in 2014 (40% of microbreweries are export oriented).

The drinks sector is targeted for growth under the Governments Food Wise 2025 programme. There are significant opportunities, but challenges also as the industry needs a strong base of grain growers to supply the required inputs. (DAFM (Department of Agriculture, 2015).

The challenge to the industry is the ability to achieve full utilisation of plant capacities while maximising efficiencies. Regarding sustainability,

the industry is encouraged to join the voluntary sustainability programme, Origin Green operated by Bord Bia.¹ Under this programme food and beverage companies develop sustainability plans, identifying targets in areas of raw materials, manufacturing process efficiency and social sustainability. These plans are then independently verified. Difficulties in developing such plans are experienced as staff and time resources are stretched in the sector. It is hoped that this guidance will provide assistance to the microbrew sector in identifying resource efficiency measures.

There are huge opportunities for growth in the whiskey and craft beer sector with plans to double whiskey exports and increase the number of microbreweries to 100. Emerging markets in Asia and the explosion of the craft alcohol market in the United States provide Irish companies with enormous potential to expand.

FoodWise 2025

¹ Origin Green is the only sustainability programme in the world that operates on a national scale, uniting government, the private sector and food producers through Bord Bia, the Irish Food Board. <http://www.origingreen.ie/about/origin-green-promise/>

2. Regulatory and Non-Regulatory Drivers

2.1 Regulatory Drivers

The microbrewing sector in Ireland is governed by legislation which covers aspects such as waste management, packaging, waste water discharge, air emissions and by-products management. Facilities in the microbrewing sector **do not** fall within the Environmental Protection Agency licensing regime, as these licences commence at product output thresholds above 250,000hl per year, and microbreweries are performing at less than 30,000hl per year.

The EPA Act 1992-2013 Schedule 1 sets the following licensing thresholds

*7.3.1 IPC Licence applicable to Brewing (including cider and perry production) in installations where the production capacity **exceeds** 25 million litres (250,000HL) per year*

Waste water

Premises where food and drink manufacturing takes place are required to operate under a **Trade Effluent Discharge to Sewer Licence**.

Trade effluent is any liquid waste (other than domestic wastewater and storm water) that is discharged from a business premises to the public sewers. Trade effluent may contain materials such as fats, oils and grease, chemicals, detergents, heavy metal rinses or food waste.

Since January 2014 the Water Services (No. 2) Act 2013 was enacted. Irish Water is now responsible for Water Services, including the issuing of licences under Section 16 of the Local Government (Water Pollution) Acts 1977 to 2007. A licence is required from Irish Water for any trade effluent discharged to a sewer controlled by Irish Water.

Trade Effluent Discharge to Sewer Licences set out conditions that must be complied with. These may include:

- The nature, composition and volume of the trade effluent discharge;
- The method of treatment, the location of discharge and the periods during which discharge may be made;
- The taking and analysis of trade effluent samples and the trade effluent records that must be kept; and
- Applicable charges for discharging trade effluent.

Animal Feedstuffs

By-products of the food and beverage industry and surplus food are a significant source of animal feed in Ireland. Controls are carried by the Department of Agriculture Food and the Marine (DAFM), as the competent authority for animal feed, to ensure the

manufacture and supply of these feeds are in accordance with the feeding stuffs legislation.² and to ensure the safety of the feed.

By-products from breweries such as brewer's grains are a valuable source of animal feed. Breweries who are **feed business operators (FBO's)** are classified as "Suppliers of Feed Materials". The DAFM requires that any operator producing or supplying feed materials from food or industrial processing must be registered and comply with their obligation as **feed business operators (FBO's)**. To register FBO's must complete an application form³, Sections B and C must be completed by the "Supplier of Feed Materials".

In order to register, the FBO must ensure that their HACCP is amended to indicate that by-products or surplus food stuffs are not a waste but a by-product under Article 27 of the Waste Management Acts and designated as animal feedstuffs. Decisions made by an FBO under Article 27 must be notified to the Environmental Protection Agency (EPA) using their online system.⁴

Packaging

The European Union (Packaging) Regulations 2014 promote the recovery of specified packaging waste. The Regulations impose obligations on all **producers**, including manufacturers, importers, distributors, wholesalers and retailers, who supply packaging to the Irish market. A producer is required to segregate waste on-site for recycling or recovery purposes, or return the used packaging to the supplier, if applicable.

The Regulations place obligations on "producers" and "major producers" of packaging.

A company is a "major producer" of packaging if it had a turnover of more than €1m in the preceding calendar year, based on audited accounts, and supplies more than 10 tonnes of packaging on the Irish market per annum. Additional obligations are placed on major producers. **A major producer must either register with their relevant local authority or with the compliance scheme Repak.**

2.2 Non-Regulatory Drivers

The ethos of craft brewing focusses on the individuality of ingredients, brewing methods and local customer support. Craft brewers are generally strongly linked to the community they are located in. Breweries utilise local supply chains and ingredients and can express their commitment to sustainability by supporting their communities in terms of employment or social funding, thereby building trust among customers and the community. This local involvement is also an important aspect of the international brand

² **Food and Feed Hygiene legislation S.I. 432 of 2009**

³ <http://www.agriculture.gov.ie/agri-foodindustry/feedingstuffs/formsguidancedocuments/>

⁴ **For further information details can be viewed at**
<http://www.epa.ie/waste/wastereg/byprod/#.Vcm6YHFViko>

development of craft beers as unique products. Several support programmes and initiatives can assist breweries to become more sustainable and to use resources better, which in turn provides financial and marketing benefits to the company, these include:

Origin Green - The Bord Bia **Origin Green Programme** encourages all food and drink producers in Ireland to take part in the verified sustainability programme. All participants of Origin Green identify site specific targets which lead to more sustainable production across a three to five year period. The targets include sustainable raw material supply, waste, water and energy resource management, biodiversity measures and social commitments. Once a company has achieved Origin Green certification, focused marketing and branding support is provided to the company by Bord Bia to promote the sustainable product on the international market. Under Origin Green Programme there are currently (May 2016) 27 microbreweries engaged in the programme with 4 verified members, 8 actively working on sustainability plans and 15 registered and preparing plans.

Enterprise Ireland provides financial support to companies that are setting up or expanding with a focus on job creation and export markets. As part of this support companies are encouraged to take part in resource efficiency and environmental management programmes under the **Enterprise Ireland Lean and Green initiatives**. The Lean Business Offer helps companies to increase performance and competitiveness, while the Green Offer provides assistance and training to improve resource efficiency and increase access to international customers who are demanding more environmentally friendly products and services.

GreenBusiness, as part of the EPA funded Be Green programme, provides free site assessments to organisations that wish to access advice on resource efficiency at their facilities. The Greenbusiness advisors provide recommendations on how companies can implement environmental improvements, focusing on energy, water and waste minimisation measures which can demonstrate significant cost savings to a company.



3. Environmental Pressures and Resource Use of Microbreweries

The main environmental pressures of the microbrewing sector are water and energy use, effluent management, by-products management, waste minimisation and packaging. These will be similar to the larger breweries, although larger breweries benefit from greater economies of scale.

Manpower presents a key challenge to an organised, systematic effort to improve overall efficiencies.

Energy

Microbreweries can consume twice as much energy per hectolitre of finished product than large microbreweries, as they do not benefit from the efficiencies of scale. However typically microbreweries have narrow profit margins, so energy-efficiency measures can be a particularly effective way to save money and thereby increase profits. There is more awareness amongst microbrewers of energy consumption compared with water use.

The exact mix of electrical and thermal energy used in brewing processes will vary depending on such factors as the equipment in use, the packaging employed, and the size, age and layout of the brewery. However, most electricity generally goes toward packaging and refrigeration, whereas most thermal energy (from natural gas or gasoil/ coal) goes toward the actual brewing process. For the production of 1 hectolitre of beer, an efficient brewery should consume 8-12 kWh of electricity and 150 MJ of thermal energy, whereas microbreweries typically use 20 – 25 kWh/hl electricity and 50 – 75 kWh/hl (220 MJ) of thermal energy. (EnergieAgentur NRW.de)

The efficiency of electricity in brewing will be affected by the phase that can supply the energy — very few breweries move to the three phase solution due to cost of set up. Energy savings would be made immediately if the equipment and supply could be synergised to best practice, however installation and investment costs are frequently prohibitive for startup microbrewers.

Water

Water is another significant resource use in the brewing sector. Only a small portion of the incoming water is used in the final product, with about a third of incoming water used in cleaning and cooling. The chemical characteristics of the water can influence not only the taste but also the brewing efficiency and additional treatments are often necessary.

For the production of one litre of beer, the water consumption in an efficient brewery should range from 4 to 7 litres. Some proactive breweries in the United States even aim for 2-3 litres for one litre of beer. The volume of water used per hectolitre of beer produced is an important indicator of environmental performance for this sector, , but is the least considered in Irish microbreweries, partially due to the perceived low cost of water. One industry source stated that microbreweries in Ireland use roughly 10 times the amount of water to 1 litre of beer produced, so if a brewery has a product output of 2,000hl of beer, they will use between 15,000-20,000hl of water.

Monitoring of water use is minimal with the sector in Ireland, with many only availing of the public mains input meters. Understanding water intake through sub-metering in a few strategic places can help to measure water use in different zones and thus direct water conservation or reuse measures according to areas of biggest demand, such as cleaning water.

Water use is affected by cleaning methods but also the type of packaging used. For instance single trip plastic kegs require no washing and single-trip bottles also require less water usage. These are popular with some Irish craft brewers, but result in larger waste volumes at the customer end. Reusable kegs require a significant amount of water for washing which is often done manually in microbreweries. Reduced water volume CIP (Cleaning -in-Place) systems are advantageous, as are water reuse/ recycling systems where feasible.

Wastewater generated in the brewery is characterised by large variations in their physicochemical parameters. In particular, the chemical characteristics and volumes of the waste water streams generated from the fermentation and filtering processes account for 3% of the total waste water generated, but 97% of the biochemical oxygen demand (BOD)⁵ (organic matter) load. (Brewers Association (US))

Brewery wastewater has a high **chemical oxygen demand (COD)**⁶ in the average range 2,000-6,000mg/l (though it can be much higher) with a BOD/COD ratio around 0.5-0.74. This is largely due to easily biodegradable organic compounds such as sugars, ethanol and soluble starch, making biological treatment (anaerobic and aerobic) an attractive option; yet much of the industry still discharges untreated waste water to the mains sewer. The cost of this can be compounded due to limitations on discharge content. It is common practice for companies in general to dilute the organic content of wastewater with potable water direct from the mains – effectively running water down the drain.

Other effluent parameters include suspended solids (discharge of by-products, label pulp from the bottle cleaner), nitrogen (detergents, malt and from additives), phosphorus (cleaning agents) and pH (variable depending on the use of acid for the cleaning process of equipment/infrastructure and returnable bottles).

Most microbreweries do not operate a waste water treatment plant and discharge trade effluent to the public sewer.

⁵ **Biochemical oxygen demand (BOD)** is the amount of dissolved oxygen needed by aerobic biological organisms (e.g., aerobic bacteria) to break down organic material present in water at certain temperature over a specific time period. It is expressed in milligrams per liter (mg/l).

⁶ **Chemical oxygen demand (COD)** is a measure of the capacity of water to consume oxygen during the decomposition of organic **matter** and the oxidation of inorganic chemicals such as ammonia and nitrite. It is expressed in milligrams per litre (mg/l).

By-products

Organic by-products like spent brewery grains and yeast surplus can be used for animal feed. Most breweries provide spent grain for free as animal feed to local farmers. Surplus beer is also produced from unavoidable beer losses throughout the brewing process. This may be used to enhance animal feed.

Due to their energetic value, spent grains can also be considered suitable for biofuel combustion (or co-combustion) or as substrate for biogas production. This study has not identified any facilities in Ireland that utilise microbrewery by-products as biofuel for steam or heat generation, although one renewable energy company has been investigating the viability of a biomass burner for the brewery sector, based on American technology. The examples of breweries in Europe using their spent grain in biomass boilers relate to large breweries which directly utilise the generated heat for steam in production. The current viability of this technology is limited by the need to dewater and dry the spent grains to below 60% moisture, or mix it with a dry biofuel such as sawdust, so sustain combustion. (Environment and Technology Magazine, 2008)

Idea: A group of microbrewers in close proximity could combine their spent grain to generate sufficient material for a biomass combined heat and power (CHP) burner. Logistics of this arrangement would need to be determined.

Waste

Diatomaceous earth (DE) is an inert silica matrix with a high organic solids content and a high moisture content. Also known as **kieselguhr**, it is a filtration media traditionally used in the final clarification of beer. The kieselguhr filtration takes place via a frame, candle or mesh filter. The kieselguhr represents one of the biggest environmental problems in the beer industry, both from a raw material standpoint (use of a finite quarried natural resource) and due to the waste management considerations. The disposal of wet kieselguhr sludge is expensive, and when dried kieselguhr can generate very fine dust (crystalline silica) particles which are classified as hazardous waste in some countries. The **2008 EPA BAT Guidance** states that diatomaceous earth can be used in the cement industry. (Environmental Protection Agency, 2008).

In Ireland most microbreweries do not use kieselguhr filters, instead alternative reusable membrane filters have proven to be easier to set up and use and dispose for the Irish microbrewing sector.

Air emissions

Several air emissions are generated in the brewing process. These include exhaust gases generated by fossil fuel combustion (SO_x, NO_x, CO₂, CO, particulates) and biogenic CO₂ generated during fermentation. . The largest source of specific odour emissions is the hops liquor evaporation from wort boiling. Dust mainly arises from milling, for larger milling operations a dust extraction system may be required.

4. Resource Efficiency Measures in Irish microbreweries

Microbreweries in Ireland are increasingly interested in operating more efficiently and more sustainably. Under the Bord Bia Origin Green Programme there are currently (May 2016) 27 microbreweries engaged in the programme. Many are at the stage of gathering resource use data for water and energy (electrical and thermal) and are installing meters at various points throughout the brew process to compile more detailed usage data. This will enable the companies to establish key performance indicators to measure performance of their own operations, including current and targeted water use in litres of water per litre of product, and kWh of electricity use per litre of product output.

Resource efficiency and sustainability measures implemented by a number of microbreweries over the past 2 years and efficiency measures they seek to introduce over the next 5 years are summarised in Tables 1 and 2 below.

Table 1. Resource efficiency and Sustainability measures already implemented

Raw materials	Sourcing increasing quantities of Irish malt.
Brew Scheduling	Scheduling of brewing runs according to orders from customers using a planning management system, to ensure best efficiency of the brewing processes.
Energy	Heat recovery at wort boiling stage by using a plate heat-exchanger to cool down the wort liquid while heating up the brewing liquor to be used for the subsequent brew.
	Only keeping brewing liquor at high temperatures when needed for brewing in the immediate future, rather than keeping the hot liquor tank permanently full and at temperatures over 70 degrees C. Heating elements are only turned on when required through use of an electrical timer.
	Installation of fully automated cooling systems for refrigeration which turn on/off as required.
	Upgrades on Boilers and Heat exchangers.
	Variable Speed Drive (VSD) on pumps & fans
	Installation of Energy Efficient Lighting in brew house.
	Install a capacitor to prevent incurring surcharges.
	Audit of all electrical equipment with a view to improving efficiencies.
	Measure electrical energy usage and produce a key performance indicator – kwh/hl finished beer.

Table 2. Resource efficiency and Sustainability measures to be implemented over next five years

Raw materials	Increasing the amount of Raw Materials from Irish sources such as malt, malted cereal products
	Source Ale and Distillers Malt from companies with Irish Grain Assurance Scheme (IGAS) certification and Origin Green Verification.
Energy	Install a capacitor to prevent incurring Surge Charges.
	Carry out an audit of all electrical equipment with a view to improving efficiencies.
	Recover water and heat from the bottling process

	Install a Data Logger to record water usage on an hourly basis and use information to make improvements and set a baseline.
	Measure electrical energy usage and produce a key performance indicator – kwh/hl finished beer.
Optimise steel/recyclable keg fleets	Detailed investigation into use of recyclable one-way kegs, and their potential environmental impact in different use cases
By-product use	Provision of spent grain to local farmers for free
Water minimisation	Install a CIP plant in order to recover water and chemical from cleaning.

5. Benchmark Data

Benchmark data for resource usage for the microbrewing sector is not currently available in Ireland. International data was reviewed for brew sector facilities, and conversions of metrics from source were carried out as applicable to standardise units to hectolitres.

Benchmark Projects and Sources

FEVIA, the Belgian Food and Drink Federation, measures and benchmarks energy efficiency in the Flemish brewery sector. Poor performance in energy use and beer production is measured. Based on this, energy-specialists audit the least performing breweries to identify possible measures for energy efficiency improvements. (Food Drink Europe, 2012)

The **Deutscher Brauer-Bund** (German Brewers Association) has provided several publications to its members on minimising environmental impact of water use. One publication involved a national survey which benchmarked water use and costs throughout Germany. Such benchmarking enables breweries to compare their performance with others and identify areas for improvement.

The **Bavarian Brewers Association' Bayrische Brauerbund'** completed a survey of water costs and water use in 2009 across the Bavarian brewing sector, in which 93 breweries took part. According to the survey the breweries spend on average € 1.12 / m³ of fresh water, and water usage on average was 4.5litres of water for each litre of beer produced. This has reduced from 6 litres of water per litre of beer 15 years ago, due to innovations and efficiencies in the brewing process. These efficiencies include steam recovery and water recirculation. (The Bavarian Brewers Association "Bayrische Brauerbund", 2010).

The **German Energy Agency of North Rhein Westphalia, EnergieAgentur NRW** carried out a study of 14 breweries in 2014 to ascertain benchmark figures for energy usage within the brewing sector. This study established that on average 26% of energy requirement in breweries is provided by electricity, and 74% is heat energy. The study showed a five-fold increase in energy efficiency in facilities producing more than 500,000 hl compared to facilities producing less than 50,000 hl. This is mainly due to the ability to operate on a longer batch runs, minimising downtime and startup energy.

100 litres = 1 hectolitre

1million litres = 10,000 hectolitre

1 barrel (UK) = 1.64 hectolitre

1 barrel (US) = 1.2 hectolitre

22 gallon (UK) = 1 hectolitre

26.4 gallon (US) = 1 hectolitre

Table 3. Key Performance Indicators established by EnergieAgentur NRW.de

Production Output		
<50,000 hl/a	<500,000 hl/a	>500,000 hl/a
Electricity Demand		
25 kWh/hl	15kWh/hl	8 kWh/hl
Heat Energy Demand		
75 kWh/hl	39 kWh/hl	18 kWh/hl
Combined average Energy Demand		
50 kWh/hl	27 kWh/hl	13 kWh/hl

A study commissioned by **The Brewers of Europe**⁷ in 2012 provided key performance indicators of the European brewing sector over a time period of 2008-2010. (The Brewers of Europe, May 2012). A table from the report is reproduced below for 2009-2010 with comparisons provided with the data from EnergieAgentur NRW.

Table 4 Key Performance Indicators of the European Brewing Sector 2009-2010

	Units	2009	2010
Total production in EU-27 + 3	Million hl	401	399
Production represented (including other beverages)	%	64.8	64.8
Production represented which is not beer ***	%	2.8	2.6
Specific water consumption	hl/hl**	4.4	4.2
Waste water production	hl/hl**	2.8	2.7
Total direct energy	MJ/hl** (kWh/hl)	119.5 33.2	116.8 32.4
Compare to EnergieAgentur NRW KPI	kWh/hl	27 -50	
Renewable energy	%	4.8	5.3
Carbon emissions from brewery (Scope One)	Kg/hl**	4.7	4.6
Carbon emissions electricity usage (Scope Two)	Kg/hl**	3.3	3.2
Total carbon emissions (Scopes One and Two)	Kg/hl**	8.0	7.8
Secondary products: Animal feed	Kg/hl**	15.2	15.5
Secondary products: Biogas production	M3/1,000hl**	83	92

** Per hectolitre of beer produced

*** In some production facilities beer is not the only beverage that is being produced. Data which were gathered represented production of all beverages.

The **Waste Resource Action Programme (WRAP)** produced a series of 'resource maps' in 2012 date for 12 key product groups within the UK drinks sector, detailing product and

⁷ The Brewers of Europe is the trade confederation for the brewing sector in Europe and its voice in the European institutions and international organisations.

packaging waste and water consumption and losses arising in the UK. The summary and overview report provides a summary of the major resource streams for the 12 drinks sectors which includes the microbrewing sector, the data presents total resources used for total production in the microbrew sector, this data has been converted for this report to usage or arisings per hectolitre below.

Table 5 Summary of Major Resource Stream – Beer (Micro)-with conversions to allow comparisons

Product Category	Total Production	Total in-process raw material losses	Total Water Consumed	Total Water Discharged	Total Organic Arisings from extraction	Total Packaging Waste
Beer (Micro)	210 MLitres	4 MLitres	19,935 MLitres	15,282 MLitres	47,950 T	87 T
Conversions	2,100,000 hl)	40,000 hl	190,935,000hl	152,820,000 hl		
Usage hl/hl		0.002	94.9 hl/hl	72.7 hl/hl	0.023 t/hl	0.00004 t/hl

Key Performance Indicators

A performance indicator or key performance indicator (KPI) is a type of performance measurement to evaluate the success of a company or of a particular activity in which it engages. In the case of breweries this would relate the success of a resource consumption reduction programme covering energy, water and waste. Other aspects for which KPI's can be developed can relate to raw material inputs and yields, such as malt, hops, yeast and even packaging.

In the case of energy and water usage and by-product generation, the KPI's are defined as a usage per product output, e.g., water use (hl) per beer produced (hl), or by-product (spent brewers grain) kg per beer produced (hl).

KPI's can be established facility wide or process specific. To establish KPI's that are process specific sub-meters or automated measurements systems for inputs would be required.

Good Practice

In most cases the microbreweries in Ireland only have one energy meter and water input and output meters. It is still **good practice** to monitor and log inputs and outputs during peak and off-peak times, weekdays and weekends to establish a trend and understanding of energy and water inputs. Direct and frequent logging of data from meters is also good practice, as opposed to gathering data from utility bills, as this can be performed when certain processes are active or inactive and can help with understanding peaks and troughs of energy and water usage during different production cycles.

Meter reading and logging of data (unless automated) can be scheduled to coincide with the start to end of the brew process.

To establish a baseline of performance, usage could initially be determined from a previous year's utility bills, or measurements can be taken over a current year period,

gathered over weekly / monthly meter readings, for more accurate usage data and to improve understanding of energy and water use intensity on a monthly basis.

Table 6. KPI's for the brewing sector

Aspect	Facility Wide	Process Area
Energy	Electrical kWh/hl	Brewhouse kWh/hl brewed
	Thermal kWh/hl	Kegging/bottling kWh/hl packed
	Other, gas, oil litres/hl	Refrigeration kWh/hl final product
	Total Energy kWh*	Steam system kWh/hl final product
		Compressed air kWh/hl final product
Water	Total water in m ³ /per month or year Convert to hl if KPI is water use per hl beer produced	Water use at canteen/toilets m ³ /per month or year
	Total water out (wastewater) in m ³	Water use for cleaning, heated process water, rinsing, cooling m ³ /per month or year/hl
	Total water use per hectolitre of product output hl/ hl	
Waste/by-products	Total waste arisings by type and management method, e.g., general waste to landfill -tonnes, recycled-tonnes, recovered-tonnes, compostable waste-tonnes, hazardous waste-tonnes.	By-products-total tonnes/year and per brew
	By-products total tonnes as feed/year	Packaging waste (bottles/cans)/brew and total per year.

* As other fuel sources may be reported in litres; these should be converted to kWh to provide total energy in kWh. Conversion factors should be applied for other energy sources. These are available from The Sustainable Energy Authority of Ireland at;

http://www.seai.ie/Your_Business/Public_Sector/FAQ/Calculating_Savings_Tracking_Progress/What_are_the_conversion_factors_used_to_calculate_TPER.html

6. Beer Production Process and Good Practice Measures

6.1 Raw Materials Inputs

Type of Inputs

The main inputs to beer production are water, malts, hops, yeast and carbon dioxide.

WATER is typically supplied from a mains public supply and in some breweries is pre-treated to reach the required quality to achieve homogeneity of microbiological, chemical and organoleptic elements. Depending on treatment, this increases the energy or resource requirements.

MALT The majority of malt used by Irish breweries is produced from barley grown in Ireland and processed in Irish maltings. Maltings provide the malt pre crushed or whole. Some microbrewers prefer to mill the malt on site to ensure high flavour, however, greater energy efficiencies can be achieved by purchasing malt premilled. Malt is usually delivered in 25kgs bags, but can also be delivered in bulk to a silo.

HOPS are available as whole hops, hop pellets or hop extract. While hop extract may modify the flavour of beer, its' use saves space, reduces boiling time and eliminates the hops separation process, it is however expensive to procure these higher value products. Other benefits of using hops extract is less trub is generated compared with pellets.

Most microbrewers in Ireland use hops pellets. Hops are not grown commercially in Ireland, although there are some Irish breweries trialling hops production. The majority of the worlds' hops production is concentrated in Germany, United States and Ethiopia. Hops production is also carried out in the United Kingdom with the principal production centres in Kent which produces Kent Golding Hops.

YEAST There are two main strains of yeast, the lager yeast and the ale yeast, with many unique strains developed from these for specific beers. Yeast can be supplied as dried yeast or in starter packs. The larger microbrewers state a preference to propagated their own yeast from wort on site. It is recommended that a microbiologist is employed for this task. Brewers with laboratories will culture yeast cells on plates and slants and keep them refrigerated until a new starter is required.

CARBON DIOXIDE is required for the product packaging process when it is used to purge bottles to remove air and protect the taste against oxidation. CO₂ can be recovered from the fermentation process as it is a by-product of brewing, although this is an expensive process for microbreweries.

PACKAGING Most microbreweries bottle their beer with some also engaged in kegging using either steel or aluminium multi way kegs or single trip plastic kegs. Some of the larger microbreweries are canning beer. Other packaging inputs will also include labels and bottle tops.

6.2 Brew Scheduling

Consistent sales forecasting is important for efficient production and brew scheduling. Detailed scheduling will ensure optimisation of brew batches, such as brewing batches back to back where possible. Start up and clean-down use the highest amount of water and energy in the brew process. By brewing multiple batches back to back, instead of spreading the process out over several days, energy and water can be minimised, as the tanks are reused while still warm and do not requiring full clean downs.

Brew scheduling can allow high energy processes to be moved off peak times, to allow the use of cheaper electricity for energy intensive processes (like wort boiling). Because breweries are typically charged higher electricity rates during times of peak load and may be penalised for having excess power factor, it is possible to reduce bills by as much as 20% through load shifting, load shedding, and power factor correction.

Companies should contact their utility provider to learn more about the energy rate and find out how to reduce peak demand surcharges.

Ensuring client orders are scheduled well in advance also minimises inefficiencies regarding batch sizes and brew length, such as avoiding the use of a 10hl vessel for a 5hl batch order. Consistency of batch size also streamlines efficiencies and allows better benchmarking. If a brewery is using 100kg of barley malt the aim is to get about 90% as extract, this is the detail acquired by Excise. But this is very dependent on equipment brew type and various other production challenges (Industry source).

There are a range of brew scheduling and beer production software packages that will deliver savings and reduce resource inputs, however most microbreweries will rely on manual planning.

Guidance: Good Practice Measure Brew Scheduling

- The detailed brew scheduling should enable energy efficiencies by back-to-back brewing (reducing cleaning and start-up processes)
- Move high energy operation to off-peak hours for lower electricity costs
- Discuss potential load shifting, load shedding and power factor correction with your electricity provider
- Avail of pilot plants to produce smaller batches ordered by customers

Case Study: Pilot or nano brew plants

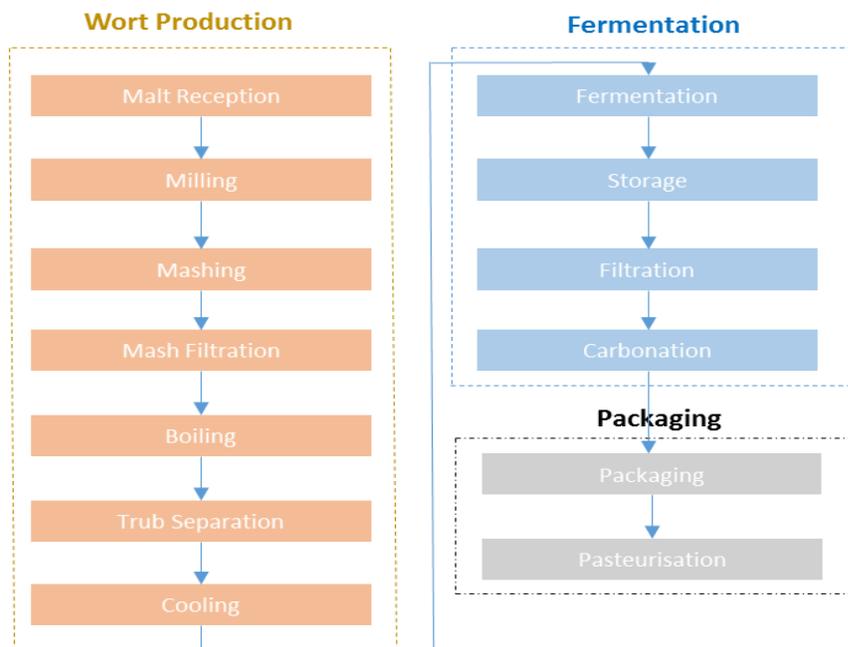
A number of the Irish larger microbreweries have mobile pilot brew plants that can produce between 5-10hl in one brew. These plants are particularly useful for running a smaller batch to order instead of utilising larger vessels. These are often used to trial a new product or produce a new product for festivals or events. One industry source commented that these pilot plants could be shared between smaller operators to reduce costs in producing smaller batches.

6.3 The Process and Resource Efficiency Opportunities

The main beer processing phases are presented below.

The phases occur in three main stages;

1. Wort production
2. Fermentation
3. Packaging



Not all microbreweries perform milling as the malt can be purchased pre-milled reducing the need for a roller mill. Most microbreweries perform their own packaging and labelling, although some of the larger microbreweries may bottle off site.

Stage 1 Hot Processes- Brew House

1. Rolling Barley Malt (or milling)

Malt needs to be thoroughly prepared for the milling operation. Although it is screened by the maltster prior to delivery, it is normal to repeat this at the brewery to remove any unwanted material.

The main objective of this stage is to reduce and control the particle size by producing the grist (cereal flour). The finer the flour produced, the larger the surface area available for enzymatic attack and better sugar extract efficiency.

The malted barley (or other malted/unmalted cereals) is rolled using a **roller mill**, usually powered by 3 phase electricity. This is similar to a rolling pin and exposes the starch in the malt, making it available for conversion to sugar.

Various types of rolling mills are used in microbreweries, two or four-roll mills are most common. The choice of mill depends on facility size, financial and product specific considerations.

The milled grist size makes a significant difference in the efficiency at the mash and sparge stages. Grains should be finely milled, but the milling should leave the hulls largely intact to act as a filter bed. A dual roller mill can achieve this. If the grains are crushed too finely they will plug up the filter bed resulting in a “stuck mash” and the wort will stop flowing.

In most microbreweries the malt is measured by the bag (25kg bags) and poured into the mill. Losses can occur when malt falls to the floor or is not weighed accurately.

Pre-milled Malt

The purchase of pre-milled malt is a cost effective method for achieving a standard spec of milled malt, this can improve the efficiency rate and consistency of malt input and extract. Malt can cost approximately €600 per tonne. Pre-milled malt can cost €1 extra for every 25kg bag. Pre-milled will have a shorter shelf life than unmilled, approximately 3 months, compared with unmilled malt which can last up to one year. By purchasing pre-milled malt, the brewers’ energy use is lowered as the milling stage is bypassed.

Good Practice Measures- Milling

- Buying pre-milled malt reduces **energy** at the facility, and avoids barley losses in the handling and milling operation
- Storage and labelling of un-milled malt bags is very important to ensure correct remaining weight and malt type is identified on the bag
- Mill close to the mash vessel. Milling should be placed in line with the sequence of brewing, by ensuring it is scheduled in advance of set brew times. Ideally the

night before the brew process commences, rather than starting the day with milling

- Dust extraction systems may be required if large volumes of malt are milled, dust extraction systems should be fitted with variable speed drives to reduce energy costs
- Mill rollers should be inspected and re-grooved regularly. This should be part of general maintenance schedule

2. Mashing

The rolled malted barley/other cereals (grist) are mixed with warm water which is heated in an insulated vessel, the **mash-tun** to between c. 71-82 deg C. to create a liquor called **wort**, like a malted porridge. This is let sit for up to 1 hour. During this time the starch in the malt is converted to sugar. Usually the tanks have a mixing paddle to ensure the mix of water and malt is constantly agitated during mashing. The mashing temperature is dictated by wort heating using coils or jackets.

Steam jackets are generally on the outside of tanks to heat the mash in stages. Hand mixing with a paddle is inefficient as more energy is required to maintain the constant temperate as the door to the mash tun is left open.

Good Practice Measures-Mashing

- Insulate the mash tun and internal mechanical agitation to minimise heat loss
- Capture waste heat from the mash tun or from the hot water tank to use in other processes. A hot water tank of roughly 25°C can be used to inject the water into mashing operations. This tank has an overflow stream that can be used during pasteurisation to heat the water to 72°C. If more heat is needed, steam or hot water can be blended to make water at the temperature needed. Steam at a temperature of 75°C is used to heat the mash vessel. However, hot water of 35°C generated from heat recovery can be used to partially heat the mash thereby reducing steam or hot water generation requirements
- The mash tun needs to be refitted with a heat transfer area to recover this waste heat
- Payback >3 years depending on volume of output

3. Lautering

To separate out the liquid wort (unfermented beer) from the grist in the mash tun, the mash is either sent through a **lauter tun** or a **mash filter**.

A **lauter tun** is a large vessel up to several meters wide and tall which has a slotted bottom (like a giant sieve) or screens, which allows the liquid wort to filter through while retaining

the spent grain grist (husk) behind. To extract any remaining available sugars, fresh water is sprayed onto the mash after the initial wort has drained through the slotted base (sparging). There should be just above a trickle flow out from the mash tun. Sparging too fast leaves insufficient time for the hot water to extract the sugars in the grain bed.

A **mash filter** is comprised of a series of plates where the mash is compressed to remove as much wort as possible. Alternatively, the wort is filtered through filter cloths on a shallow bed made of husk. The insoluble remains (spent grains) are removed for cattle feed. The remaining solid mash in the mash filter is washed through with fresh process water (sparged) but less water is needed as the mash filter provides a larger cross section of mash with less depth to penetrate than in a lauter tun.

In some cases, the lauter tun is combined with the mash tun to form a **mash vessel**. In this case, the wort run off is directed through a series of slotted plates at the bottom of the tun. The mash floats on top of the wort. This tends to be the slowest wort separation system although it is the lowest cost in terms of capital outlay.

By-products from this process includes weak wort and brewers spent grains. **Waste water** is generated through rinsing and is characterised by cellulose, sugars and amino acids.

Good Practice Measures-Lautering

- **Water**- Avoid overfilling, fill liquor in mash tun up to correct level, train staff to add the correct amount, this may require a meter to measure amount of water
- **Water**-Save make-up water - Lauter tun drainage can be stored for use as make up water for the subsequent brew. These liquids must be pre-treated by sedimentation, centrifugation, or activated carbon, but their use results in a reduction in water costs, elimination of effluent charges, and a reduction in energy use. This process is only feasible where brews are done back to back
- **Water**-Fit a float-operated valve at low level to the hot liquor tank to minimise hot liquor overflow to drain, and minimise need to top up. Requires minor pipe modifications, but payback time on saved water and effluent charges estimated less than 1 year.
- **By-product Reuse**-Weak wort liquid can be reused back into sparging. First worts filtered from the mash are cloudy. Subsequent weak wort can be collected in a tank equipped with heating jackets and a slow-speed agitator and used for mashing in the next brew. Recovery of this wort will reduce the overall water use, reduce the load of biological contaminants in the wastewater and increase yield
- **Brewers Spent Grains Removal** -Use dry methods to remove BSG using a brush or rake, no need to flush out with water
- **Brewers Spent Grains Reuse**-BSG cannot be repurposed in the brewing process, however they are still rich in protein, fibre and other nutrients and

can be reused in many areas. BSG comprises 85% of by-products generated. Animal feed is the most popular way in Ireland that spent grains are reused. Internationally some larger breweries are using spent grains as biomass for heating boilers. This requires drying of the material, and mixing with wood or saw dust.

4. Wort Boiling (Brew kettle)

Boiling the wort liquid is the single most energy-intensive step in brewing, and fuels for boilers alone can account for 45% of a brewery's overall energy bill.

The sweet wort is transferred to a **kettle** (or wort copper) where it is boiled between 60 and 90 minutes depending on the beer. This ensures the wort is sterile. During the boiling period hops and other ingredients are added to give the wort flavour, aroma and bitterness. Wort boiling results in the evaporation of water and odours (volatile organic components).

Good Practice Measures-Boiling

- **Energy**-Identify steam and condensate leaks, which directly result in energy loss, but are generally straightforward to detect and seal
- **Energy**-Insulate effectively. Steam and condensate return lines and components are often poorly insulated
- **Energy**-Adjust steam pressure. Higher pressures than necessary can result in leakage and steam losses, whereas pressures that are too low can yield significant heat loss during distribution and end use. Check steam pressure regularly to ensure that it's just high enough to meet the maximum equipment requirements
- **Energy**-Evaporation reduction- reduction by as little as 2% can be achieved without hazard to flavour or other qualities
- **Energy**-High-grade heat may be recovered from kettle vapours using either vapour recompressions, spray condensers or heat exchangers. The heat from the vapour can be used to pre-heat the incoming wort, while the heat from the vapour condensate can be used to produce hot water for cleaning, space heating, keg washing or other applications in the brewery
- **Energy**-A system can be installed in which the wort vapour is mixed with the steam from the heating coils. The mixture is fed to a condenser and the condensation heat is used to heat a water circuit, which provides heat to the wort pre-heaters as well as other areas
- **Energy**-Install energy efficient, low nitrogen oxide (NOx) boilers with stack economisers that reclaim heat from the flue gas to preheat feed water to the boiler

5. Wort Clarification

In order to remove the trub, the boiled wort is clarified through skimming protein flocs off the top in the kettle (hot break), and after boiling by sedimentation, filtration, centrifugation or whirlpool (being passed through a whirlpool tank).

Whirlpool vessels are most common in Irish microbreweries. In the whirlpool the wort is agitated for 20-40 minutes. As the whirling action slows down any remaining flocculants gather on top of the liquid, and the trub, which is heavier than beer, forms a conical deposit at the centre of the tank bottom. The clarified wort is siphoned off the side of the tank, often at several siphon points to minimise turbulence, and transferred to the cooling stage. The precipitated trub is then removed through a valve at the bottom of the whirlpool, and generally discharged to drain.

Good Practice Measures- Wort Clarification

- **Effluent Management** -A fine mesh filter should be inserted between the whirlpool discharge and the entry of the effluent to drain, as high yeast and protein concentrations will significantly raise the BOD/ COD and suspended solids of the effluent.
- **Effluent Management** -Fine mesh filters / baskets should also be inserted above floor drains, to capture and divert the trub and grain particles to the animal feed stream rather than release into effluent.

6. Wort Cooling

The boiled wort is cooled via a **plate heat exchanger** during transfer from the **brew kettle/whirlpool** to the **fermentation vessel**. This is followed by pitching or adding of **brewers yeast** to the cooled wort.

Pitching temperatures vary depending on the type of beer being produced. Pitching temperature for lagers run between 6-15°C, whilst for ales are higher at 12-25°C. Certain brewers aerate the wort before cooling to drive off undesirable protein odours (volatile organic compounds). A secondary cold clarification step is used in some breweries to settle out remaining trub.

Good Practice Measures- Wort Cooling

- **Energy**- Heat recovery can be significant energy saving measure, where efforts are made to recover as much hot water as possible from the cooling system. Wort is usually cooled through plate heat exchangers. Heat exchangers are of two types: single-stage (chilled water only) or multiple-stage (ambient water and glycol). Wort enters the heat exchanger at approximately 96-99°C and exits cooled to pitching temperature 5-9°C for bottom fermented beers and 15-18°C for top fermented beers. (Brewers Association (US). (n.d))

- **Water-spent** cooling water at about 85°C (185°F) can be reused as process water for the next mash. The input energy requirement is less with two-stage cooling than with one-stage cooling system.
- **By- Products**-Do not leave residual wort mixed with surplus yeast, as the mixture will start fermenting, reducing the value of both by products.
- **By-Product Reuse**-Washing yeast to reuse it in another batch. Only part of the yeast can be reused as new production yeast. Yeast washing is a simple process used to separate the live yeast from the underlying trub (protein, hops and spent grains) left at the bottom of the fermenter.
- **Yeast Disposal** Avoid disposing of yeast to drain because it has a very high COD level and its propensity to form organic acids. Use fine mesh baskets over floor drains to keep grain out of the drainage system

Stage 2 Fermentation

7. Fermentation and Conditioning

The cooled wort is transferred to a fermentation vessel. While being transferred the wort is mixed with oxygen. In the fermentation vessel yeast is added to catalyze the chemical conversion of sugars from wort into carbon dioxide and alcohol. Lagers are fermented at between 10°C and 12°C and Ales are fermented at between 22°C and 24°C. The process generates significant heat that must be dissipated in order to avoid damaging the yeast.

Fermenters are cooled by coils or cooling jackets. Fermentation time will vary from a few days for ales to about 10 days for lagers. The rate is dependent on the yeast strain, fermentation parameters and the taste profile that the brewer is targeting.

During fermentation CO₂ is produced, CO₂ can be recovered from the top of the fermentation tank, the maturation vessels and the bright beer tanks. CO₂ can be scrubbed, purified and compressed for storage and later used for carbonation and bottling. CO₂ must be scrubbed and purified as it contains various impurities. The process to recover CO₂ does have a high energy demand and is more applicable to breweries with higher product outputs. For every hectolitre of beer 4kg CO₂ is produced, 2kg can be recovered which is the amount required for use. There are a range of CO₂ recovery systems available that can be sized to brewers demands, single unit systems can be provided to microbreweries and multiple units can be integrated as brewery production increases. The recovered CO₂ can be delivered to the existing CO₂ storage for reuse.

After fermentation, brewers yeast is separated and stored in tanks to be used generally as animal feed or re-used in the fermentation process. The material can also be used for pharmaceutical purposes or sent to AD for biogas production or disposed of as waste.

Effluent from fermentation and filtering are high in BOD but account for 3% of the total waste water generated, but 97% of the biochemical oxygen demand (BOD) (organic matter) load. (Brewers Association (US)).

After fermentation the beer is conditioned by separating the yeast and transferred to conditioning tanks. These tanks are placed in refrigeration and the beer is brought down to c. 4 degs C over about 5 to 6 days. The beer is conditioned between 1 and 2 weeks or longer – some lagers can be conditioned up to 4 weeks.

Good Practice Measures- Fermentation and Conditioning

- **By product Reuse-** Recovered Yeasts can also be used in the pharmaceutical or animal feed industry
- **By-product-**Avoid disposing the yeast slurry from the bottom of fermentation tanks to drain, as it contains very high BOD and SS. Collect and dispose of it as animal feed.
- **Reduce Product Loss** -Use a capacitance level switch in the fermentation tank to identify the separation layer of beer from dead yeast cells, to avoid loss of product. (See case study below).
- **CO2 Recovery** Single unit CO2 recovery systems are available to microbreweries and multiple units can be integrated as brewery production increases. The recovered CO2 can be delivered to the existing CO2 storage for reuse.
- **Water-**Reuse the final rinse of the gauging, fermentation, and storage tanks for the next cleaning in place wash.
- **Water** Make sure the pump size is adequate to cope with the maximum flow of cooling water when all fermenters are in use.
- **Water** Prevent overflow by setting the top-up level in the chilled water tank so that it is not topped-up until the reception tank is full.
- **Water** Install frequency controllers on the pump to fine-tune the water flow based on cooling needs. This will help to minimise the water flow as well as reduce energy use.
- **Water** Ensure procedures are in place to stop the cooling water supply when the fermentation process comes to an end. (Brewers Association (US))

Case Study: Recovery of Yeast after fermentation EU BREF Note 4.7.9.3

An example brewery recognised that it was losing beer worth more than GBP 1 million/year in its waste water. A waste minimisation audit showed that 80 % of all beer losses were from a vessel that separated the beer from the brewers' yeast cells. Clear beer was run off from the vessel using a fixed standpipe, before the bottom phase containing the yeast cells, was discharged to the drain. The position of the interface between the two phases depended on the type of beer, and any beer below the level of the standpipe was lost to drain. The process was modified so that the yeast phase was drained off first, until a **capacitance level switch** at a low level in the vessel detected the interface. The beer was then run off to storage.

Guidance: Best Practice Measure**Yeast Reuse****White Labs Yeast Reuse Best Practices (Brewers Association (US))**

- Collect yeast shortly after fermentation is complete, and keep it at 10 – 15 degrees Fahrenheit below beer temperature.
- Although many brewers use conical bottom fermenters, higher quality yeast is collected from top cropping. This prevents good yeast from mixing with bacteria, waste product and dead yeast at the bottom of the fermenter.
- Store yeast in an airtight container – many brewers use stainless steel soda-type kegs or high-quality food-grade plastic containers or buckets.
- Avoid pressure and carbon dioxide build up –shake and vent pressure at least once a day.
- Use storage containers only for yeast to prevent cross-contamination of other components and bacteria.
- Use reused yeast ideally within 1 – 3 days of harvest in order to preserve viability. Any amount of time beyond two weeks significantly increases the risk of losing yeast viability.
- Test yeast regularly for issues with viability and purity before adding to a brew.
- Once the yeast tests clean, add some wort prior to its use.

Case Study: ECO2Brew project

An EU part funded project with partners: Union Engineering and Carlsberg Danmark commenced in 2011 and was completed in 2013. The project objective was to recover CO₂ using no water and reduced energy consumption. The project budget was €1,466,248 (EU contribution 50%).

The technology developed allows CO₂ produced during brewing to be captured and prepared for re-use, creating a circular process that minimises waste. This is not new, but until now the process has been water- and energy-intensive. The Union Engineering CO₂ recovery plant, known as **ECO2Brew**, uses no water and operates at reduced levels of energy consumption compared to conventional plants. It also results in purer scrubbed CO₂ that exceeds industry standards. The scrubbed CO₂ can be returned to the brewing process, or used in the production of other carbonated drinks.

The full-scale demonstration of the technology as part of the ECO2Brew eco-innovation project took place at the Carlsberg brewery in Fredericia, Denmark. Because of the size of the Carlsberg brewery in Fredericia, the potential water saving was 12.9 million litres annually.

Carlsberg rated the results of the demonstration project as “extremely positive,” and subsequently awarded Union Engineering a contract to install a plant at a brewery in Finland, where the recovered CO₂ is to be used in soft drink production.

Website: <http://eco2brew.com/>

Stage 3 Filtration

8. Filtering

The beer undergoes final filtration and clarification before entering the Bright Beer Tank (BBT) prior to packaging, to remove any remaining organic matter and yeast. Traditionally Diatomaceous Earth (DE) filtration was mainly used, but are less commonly used in the microbreweries in Ireland, where reusable cellulose, low-DE and perlite plate and frame filters are preferred as they are easiest to use, and generates less solid waste to dispose of. Main areas of wastewater generation are with cleaning, start-up, end of filtration and leaks during filtration. Often the waste water will have a high content of suspended solids and a high BOD.

The bright beer may be infused with carbon dioxide, which may be captured and purified carbon dioxide from the fermentation tank.

9. Bottling ,kegging, Packaging and Labelling

This process involves the final filling and packing of product, which includes washing and pasteurisation of various mediums used. The packaging process varies significantly between microbreweries and has significant implications for energy and water use.

Beer that is destined for bottles or cans is sent to the fillers where a vacuum or counter pressure filler will be used to fill the bottles or cans. Other beer will go to the flash pasteuriser and be filled at a later stage in, casks, kegs (for real ale the beer is not pasteurised as this would kill the yeast). Most microbreweries bottle (50cl or 33cl) and keg beer, some are looking to provide canned beer and beer in plastic bottles.

The beer must be cleaned of spoiling bacteria to lengthen its shelf life. For beer that is expected to have a long shelf life, **pasteurisation** is carried out, where the beer is heated to 75°C to destroy biological contaminants. Different pasteurisation techniques are tunnel or flash pasteurisation:

Flash pasteurisation involves the beer being heated for a short amount of time and then being brought down in temperature in a heat exchanger prior to filling.

In-pack (or tunnel) pasteurisation is the pasteurisation of beer that has already been packed in bottles or cans, by bringing the whole packed beer container up to temperature by heating with hot water. This is typically done in a tunnel pasteuriser.

Kegging

Reusable kegs have to be cleaned, sterilised and refilled. Typical keg cleaning requires two rinse stages as well as detergent wash, steam purge and pressurisation which can use up to 40litre per 50litre keg. The filling cycle requires steam heating, sterile air/carbon dioxide purge, sterile air pressurisation and then beer fill. In most microbrewers kegs are washed by hand as large capital investment is required for an automated cleaning and filling system. This can be a time consuming process, involving not just washing, but extraction of the valve and spear assembly from the kegs, which allows the keg to be inspected and the valve washed. This is usually required in a brewpub, where kegs are used on-site.

The cleaning process is crucial as infection in the keg can ruin the product.

Good Practice Measures- Kegging (for brewpubs)

- Invest in a valve-extraction toolkit (c.€200-€300) instead of using alternative tools.
- Remove all keg valves as soon as possible after use to prevent bacterial growth, which reduces washing time.

Good Practice Measures- Keg Washing (Steel or aluminium)

- Common problems that hinder effectiveness of washing-are pressure, temperature and concentration.
- Ensure rinse water is a correct pressure- install pressure gauge on water supply, water scale can build up in tubing and can lead to pressure problems, acid cleaning prevents this problem.
- Rinse water should be 52-72 C as caustic cleaners work best at higher temperatures, but not too high as it can bake dirt into kegs. If temperature is not maintained, often rinsing is repeated as keg is not properly cleaned.
- Proper concentration of caustic concentration is important, it should be about 2% and acids 1.5%, if solutions are too weak, the cleaning is not effective. Checking the pH on final rinse water can verify whether rinsing is complete.
- Brewers should work with their cleaning agent supplier to understand the temperatures and concentrations that allow their chemicals to perform effectively based on the beer type, water source and cleaning system.

Bottling and Filling

Washing procedures differ greatly between returnable and non-returnable bottles. For non-returnable bottles and cans, the washing consists of a simple flushing with water. In contrast, returnable bottles are subject to a 30 minute sequence in which they are successively soaked, jetted and drained.

Following washing, the bottles are moved on conveyor belts to the filling machine where they are filled under pressure according to the quantity of dissolved carbon dioxide in the beer. It is important to prevent oxygen coming into contact with the beer at this stage. After filling the bottles are sent to the crowning machine which fits them with top and then to the tunnel pasteuriser.

Good Practice Measures- Bottling

- **Product loss**-Reduce overfilling of bottles by using in line check weighers or knowledgeable filling operator.
- **Energy**-Optimise packaging line efficiency
- **Energy**-Opportunities exist to recover heat in the bottle washing and keg washing processes where 2nd or 3rd rinse water is reused as the first wash medium, and prior to its use, the water is passed through a heat exchanger, where heat is captured to pre-heat incoming wash water.
- **Water**-Bottle rinse water can also be used as a source for virtually any cleaning-in-place rinse in the brewery.
- **Water**- Water flowing out of the pasteuriser can be used as an initial rinse in the bottle washer section, or it is possible to collect and reuse for other Clean in place systems (CIP)-rinse, where CIP is used.

Packaging Types

The larger of the microbreweries tend to have their own bottling and kegging lines, while the smaller microbreweries fill and label bottles by hand, or outsource the bottling. Only 30litres or 50litres steel or aluminium kegs are used on the Irish market, these are generally rented from a UK based rental company.

Plastic kegs made from HDPE or PET are now widely used, these can weigh 50% less than steel kegs and are recyclable. These kegs are typically only used for single trip and are used for export mainly to rest of Europe and US. One benefit of plastic kegs is that they remove demand for water use as they do not need to be washed, unlike steel kegs. However, they cost around €12. Per keg as opposed to c.10c rental per month for steel kegs.

Plastic kegs do not stack well during transportation and can only be stacked 2 pallets high during transportation.

Some of the microbrewers in Ireland share the rental of kegs and this is now common practice across the UK.

Good Practice Measures- Packaging Efficiencies

- Packaging materials can be selected to minimise the environmental impact. The weight and volume of each material, together with its recycled content, should be considered to prevent waste, as well as the potential for re-use, recycling and disposal of the packaging. Often one material can replace the need for another, e.g. recyclable shrink-wrap could replace the need for cardboard trays and shrink-wrap.
- Try not to use composite plastics or plastic/ foil composite materials as these generally cannot be recycled in Ireland.
- Reduce cross-contamination of materials, e.g. paper labels on plastic sleeves. This requires collaboration between the packaging manufacturer or supplier and, in most cases, the downstream customer, especially if they are a retailer. A caterer may more readily accept bulk deliveries with reused packaging and not require eye catching packaging.

Get agreement from customers to use reusable pallets for deliveries, either wood or plastic pallets that can be returned and used again.

Case Study- UK Craft Brewers- Sharing kegs helps craft brewers slash carbon emissions

A group of 200 craft brewers in the United Kingdom have reduced their collective carbon footprint by over 300,000 tonnes of CO₂e in 2013 by sharing a pool of kegs rather than owning their own.

These findings are the findings of a study by John Heckman, PhD with PE International and commissioned by MicroStar Logistics – a provider of keg management and logistics services to the US craft beer industry.

Raw Material Packaging

A lot of packaging is received particularly with bottles, containing cardboard and plastic wrap. Most microbreweries report that this is recycled, with some being reused for separating plastic kegs during transport.

Case Study: ReBox Recycling Ltd

ReBox Recycling Ltd provides a range of cardboard box sizes to the microbrewing sector. The company receives flat packed cardboard from distilleries and large breweries and uses these to remanufacture cardboard boxes of varying sizes for microbreweries for product distribution.

The benefits include; lower cost to the microbreweries as small volumes can be made to order and a more sustainable sourcing of packaging as the products are made from post consumer cardboard.

Kelly's Mountain Brew in Clane, Co. Kildare avail of this service and have found it very cost effective and order about 12,000 boxes per annum. The added benefit is that on delivery of the order to Kelly's, ReBox will collect clean cardboard (usually flat sheet inserts from glass bottle deliveries) and remanufacture boxes for Kelly's from the material collected.

For more details on the service contact:

Re-Box Recycling Limited

Unit 2B, Kylemore Industrial Estate,

Killen Road, Ballyfermot, Dublin 10.

Tel: 01 626 77 58

Email: info@re-box.ie

<http://www.re-box.ie/>

10. Cleaning and Rinsing

Cleaning and rinsing is dealt with here as a separate aspect of operations as nearly all equipment in the brewery, including the brewery floor, will contain product residue that requires rinsing or cleaning between batches or at routine intervals in continuous operations. All aspects of cleaning and rinsing will generate waste water which will have different characteristics depending on the stage of the process and the cleaning agents used

Process/Area	Operations
Mash Tun/Lauter Tun	Rinsing
Spent Grain	Washing
Whirlpool	Rinsing spent hops and trub
Fermenters	Rinsing
Storage Tanks	Rinsing
Filtration	Cleaning
Bottle washer	Cleaning
Keg washer	Cleaning
Floor washing	Cleaning

Most of the smaller microbreweries do not have cleaning-in-place systems (CIP) and rely on manual cleaning using soft-bristle brushes, non-abrasive pads, cloths and handheld hoses for cleaning. This method is more labour intensive and uses more water and cleaning agents.

A CIP system is a means by process equipment, machines, vessels, fittings and pipework can be cleaned without dismantling. CIP can be automatic, semi-automatic or manual. These systems are generally engineered to a plants specification and can be portable or stationary; single-tank, two-tank or multi-tank; single-use, re-use or once-through; as well as designed for multi-circuit capabilities. Simple systems use the vessel to be cleaned as a detergent reservoir and are more common amongst microbreweries after manual cleaning.

Water minimisation for cleaning operations can be achieved through better management and recycling of water. CIP systems can be complex, especially if multiple systems are in place. It is sensible to have a CIP engineer visit the site, to ensure current systems are working at their optimum, before investing in retrofitting newer systems where unnecessary. Several other CIP improvements are available across the sector, with improved monitoring again linked to better practice.

Where a CIP system is not in place, they can be retrofitted, but this can be more costly than including it at the design stage.

CIP systems although more expensive, depending on type of system and if it has been retrofitted, have advantages over manual cleaning including;

- Less manual labour
- Higher hygiene results due to temperatures used and detergents
- Less use of water, energy and detergents/chemicals (depending on level of automation).
- Opportunities to reuse cleaning and rinsing water.

Good Practice Measures- Water efficiency measures- Housekeeping, no or low cost

- Review water use patterns and examine where it can be reduced or reused, e.g examine if any hot water goes to drain or quantities of usable water being dumped
- Examine project scheduling and vessel and equipment cleaning practice, where economies in water consumption can be obtained easily
- Review equipment for leaks
- Removing product and gross soiling prior to cleaning
- Dry cleaning floor of solids to prevent wash down of solids or excess use of water to dilute solids
- Use cold manual or CIP in refrigerated rooms whenever possible, this may require an alternative cleaning agent
- Ensure water supply for processes stops during idle periods, e.g., last rinses in bottle washer
- Reduce evaporation from tanks by installing or ensuring covers are closed
- Incorporating the internal recycling of water and chemicals

- Ensuring the caustic tank is of large enough volume (to avoid unnecessary refill and loss when the system is running)
- Setting operating programmes which coincide with the real cleaning requirements of the process
- Minimising detergent loss to drain
- Check water pressure settings and apply high pressure low flow nozzles to hoses
- Water use for cleaning of fermenters can be significant as the process results in yeasts and tannins sticking to the side walls of the fermenter. A foam detergent can be used, instead of high powered hot water washing, the foam breaks down the deposits and a small amount of water is needed to rinse the foam deposit.
- Detergents used to clean the fermenter can be stored and transferred to the mash tun, these can then be used to clean the kettle. Detergents or caustic solution can be recovered several times, saving on cost of cleaning materials. pH measurements will be required to determine the strength of the solutions; this can be done through an automated CIP system or through a handheld pH meter.
- Install a water tank for final rinse water to be reused in the pre-rinse stage, the tank should be sized to accommodate the required amount of water.

7. Programmes and Social Enterprises that reuse surplus materials

There are a number of programmes in Ireland that can facilitate the reuse of clean surplus materials. Typical materials arising that would be of interest to these programmes include;

- Marketing/promotional packaging such as boxes, beer mats;
- Flat pack cardboard (from glass bottle deliveries)
- Bottle tops
- Bottles
- Kegs.

Details of these programmes are provided below.

SMILE Resource Exchange (Turning Waste into a Resource)

SMILE provides a FREE platform for businesses nationwide to connect and identify synergies where a waste in one business can be a resource in another. The programme is part funded by The Environmental Protection Agency, Local Enterprise Office and some local authorities.

Potential synergies are identified through an online exchange platform www.smileexchange.ie or through **facilitated technical support**. Businesses can request or offer reusable materials, by-products or surplus stock that could potentially be a raw material in another business.

To register

Businesses from all sectors from large multinationals to SME's and social enterprises can register for free at www.smileexchange.ie

Contact

SMILE Resource Exchange,
Macroom E Enterprise Center,
Macroom Environmental Industrial Park,
Bowl Rd,
Macroom,
CO. Cork
Tel: 026 20520
Email: info@smileexchange.ie

ReCreate (Creativity Through Reuse)

ReCreate is a national social enterprise that takes end of line and surplus stock from businesses and reuses them as arts materials. ReCreate collects and redistributes discarded materials as low-cost supplies for art, education and social services from their Creative Resource Centre in Ballymount, Dublin.

Materials required include;

- Cardboard and Paper
- Tubes and spools
- Foils, lids, bottle tops
- Fabrics
- Foam, trays, beads
- The SMILE Resource Exchange actively seeks to engage with business to supply materials to ReCreate.

Contact

Dara Connolly, Executive Director
Recreate Ireland
Unit 8, Block K
Ballymount Drive
Dublin 12
Tel: 0868209844
Email: dconnolly@recreate.ie
www.recreate.ie
www.facebook.com/recreateireland
<https://twitter.com/ReCreateIreland>



Appendix 1: Case Studies

Water-[New Belgium](#) is a [sustainably minded brewer](#) that has a goal of reducing water in its production process to a 3.5-to-1 ratio. Producing the "hoppier" beers and the demand for more bottles than kegs were contributing to a decrease in its water efficiency in the past few years, but it recently added **sub-meters** throughout its facilities to address any wasted water efficiency opportunities.

Water-[Full Sail Brewing Company](#) in Oregon, US processes have been known for consuming a relatively lower percentage of water used to beer produced. The company installed a [Meura](#) mash filter that improved its water efficiency and achieved a 2.5-to-1 water to beer production ratio. *We compress our work week into four 10-hour shifts, reducing power consumption and water use by 20%.*

Energy-The US [Craft Brew Alliance](#), with brands such as Widmer Brothers, Redhook, Kona Brewing Company and Omission Beer is a continually searching for efficiency opportunities around energy and water, realizing that this can translate into big money savings. They found that even simple, quick fixes can result in significant energy savings. They targeted **compressed air leaks** as well as fan cycling in refrigerated spaces and have saved an estimated \$20,000 a year in energy costs.

Energy-[Sierra Nevada](#) beer based in Chico, California, prides itself on owning one of the [largest private solar arrays](#) in the country. The company's 10,573 panels on its brewery roof and parking lot, at the on-site daycare and at its private rail spur produce two megawatts of DC power and provide the brewery with nearly 20 percent of its energy needs. In addition, Sierra Nevada is the only brewery in the US to house its own hydrogen fuel cells. The fuel cells produce one megawatt of power. Together, on a clear and sunny summer day, the two supply about 90 percent of the brewery's energy, according to the [dashboard](#) on the company's website.

Energy-Refrigeration accounts for about 35 percent of a brewery's electricity bill. Inadequate insulation of cold storage areas and pipes carrying steam or cold fluids, air infiltration, open cooler doors and other energy wasters can have a big influence on energy costs. Using an infrared camera at [Fort George Brewery](#) in Astoria, discovered inefficiencies from heat loss on uninsulated steam pipes and a small compression tank, and from the surface of the hot tank, especially the uninsulated door. They found cold losses from refrigerant lines and cold storage areas, especially around doors. Insulation was specified for the pipes, and a high-speed insulated roll-up door was recommended for cold storage.

Waste- The [Alaskan Brewing Co.](#) in Juneau installed a unique boiler system that burns the grain waste and turns it into steam that powers a majority of the brewery's operations. Some brewers are developing unique products. Waste brew grains are going into everything from pizza crusts to lip balms.

Composting is one way to dispose of the waste. In response to the lack of composting facilities available to it, Sierra Nevada developed what it calls its "HotRot" composting system. The in-vessel system composts wastes from the brewing process along with food service remains, filter remains and waste paper from its operations and concert venues. The compost is used to enrich the hop fields and restaurant and employee gardens.

Eco label for beer-Washington-based organisation [Institute for Environmental Education and Research](#) has developed an eco-label program that allows brewers to display their impacts to the environment on their labels. It looks similar to the nutrition labels on foods. The label reports impacts on carbon, energy and water. In Oregon, [Hopworks Urban Brewing](#) and Fort George Brewery have adopted the labels.

Beer from Bread Waste

Brussels Beer Project is a collective that uses crowd sourcing methods to decide what type of beer they will brew. So far they have created 4 beers this way, including [Grosse Bertha](#) and [Delta](#). Now their fifth beer called "Baby Lone" is a "bread bitter" which uses white bread as one of its ingredients. The researchers



working for Brussels Beer Project developed a recipe for beer using course bread, as well as several types of malt and new variants of hops.

A non-profit organisation in Brussels has brought together several players to organise the creation of this beer. The Delhaize supermarket provides the bread which wasn't sold in their shops as one of the ingredients for this brew. Another organisation collects the bread from the shops and grinds it in to a powder. All the beers of the Brussels Beer Project are brewed by the Anders Brewery. [Brussels Beer Project](#) also receives support of the Belgian government for their sustainable development efforts. Talented brewing specialists were able to reduce the amount of barley used in the brewing process and replace it with bread sourced from local supermarkets, a move which sees an average of 500kg worth of unused loaves find their way into 4000l of amber ale.

Appendix 2

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