Resource efficiency in the UK brewing sector

Reducing water, material and packaging use in the brewing sector
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We work with businesses, individuals and communities to help them reap the benefits of reducing waste, developing sustainable products and using resources in an efficient way.

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Summary Review

The UK beer industry is comprised of over 700 breweries\(^1\), the majority of which are micro-breweries. Processes undertaken vary substantially between large breweries, craft and cask ale breweries, with different resource efficiency opportunities available to each.

Three resource maps have been produced covering micro-breweries, packaged and draught beer with each showing key inputs, production processes and the waste and loss streams that result. These are included at the end of this review. This review highlights some of the hotspots of resource consumption, and provides guidance for improving resource efficiency.

Key Opportunities

- 660 million litres of water worth over £2m could be saved annually with just a 10% improvement from the much larger available opportunity
- £1.45 million could be saved annually from the more efficient use of stretch-wrap
- Waste water, which is mostly discharged to sewer, could be used to generate energy in AD plants

Product loss avoidance

Almost 300,000 hectolitres of beer are lost each year through filling inefficiency, in particular through ‘individual serving’ filling lines (cans/bottles etc). Incorrectly filled cans are difficult to rework and reclaim product, as the ends are typically sealed before the point of quality check. Both under and over-fills can be caused by numerous factors, though they are mostly linked to inherent process variability.

It is good practice to run trials of process variability (ensuring first that the check-weigher is accurate and not responsible for incorrect

\(^1\) BBPA (2010) Statistical Handbook 2010
measuring). If variance is acceptable, the likely reason for inaccuracies may be human error, and staff training may be beneficial. If variance is high, a more technical reason may be apparent, and a more detailed, technical review required which is best done by contacting the original equipment manufacturer (OEMs).

Another reason for loss of product within the brewing sector is the short shelf-life associated with cask ales. Breweries could tackle this by ensuring supply does not exceed demand and using effective forecasting done in collaboration with their customers. This can also be a problem for the end retailers, such as pubs and restaurants and again, effective, collaborative forecasting will minimise unnecessary wastage.

There are innovative packaging formats which will extend product life, but currently these are only available in single-trip kegs, potentially negating the benefit of resource saved in product. However, single trip kegs, which extend shelf-life, do offer benefits in some circumstances and are discussed further below.
Packaging

Light-weighting of glass bottles and aluminium cans has seen much focus in recent years and best in class packaging formats have achieved significant savings. Glass bottle mass varies across the sector, however, and further improvement is possible by rolling out best practice to all.

Bottle design can have an indirect impact on product loss due to difficulties associated with filling, for example. Tall, narrow necks create difficulties during filling, with beer more likely to suffer from fobbing (too much gas for pouring), potentially resulting in more rejects.

One of the key innovations in packaging beer in recent years is the development of plastic kegs made from HDPE or PET and which can weigh up to 50% less than steel kegs. Typically these kegs are designed for single trips only and offer some environmental benefit in terms of resource consumption when compared with standard kegs if used for single trips such as events or for export. Cask ale producers could benefit because these kegs also extend product life as well as potentially opening up new markets outside the UK.

If plastic kegs are transported over long distances or if the customer is unlikely to return the kegs, then the reduced overall material in the keg itself, in addition to life extension properties of the product, may indicate that single-trip kegs could be more efficient. The majority of kegs in use
are returned and it is not clear whether plastic kegs are more resource efficient when compared to a steel keg that will be used more than once.

A full life cycle assessment would need to be carried out that took into account the washing of steel kegs which is less carbon intensive than the production of PET single-trip kegs (1.7kg CO₂ per hl for a 30l one way keg, compared to 1.4kg CO₂ per hl for keg cleaning), balanced against savings in fuel efficiency over long distances (because of the lighter weight of plastic kegs), including any backhaul associated with the steel kegs return.

For packaged beer there are saving potential from the more efficient use of stretch-wrap which is used to stabilise loads. This review estimates that there is a savings opportunity of 1,001 tonnes which at current values equates to £1.45 million (for more details see the review of packaging).
Water use

The brewing industry has taken big steps towards water efficiency, though not all producers are operating at best practice. Average water use per pint of product is 4.4 pints, a significant achievement over the 1990 figure of 6.7 pints. Best practice achieves levels of around 3 pints per pint, and should the whole industry reduce consumption by just 10% of the available opportunity, water savings would be above 660 million litres – saving the sector £2 million per year.

The British Beer and Pub Association (BBPA) benchmarking data on beer shows a significant number of companies have water intensity close to current best practice, i.e. the distribution of companies in terms of water intensity shows a positive skew. This typically indicates a need for innovation to push current best practice forward.

Monitoring of water use is minimal, with many breweries using input and output meters only, offering no indication of high water use areas, or leak detection. A small leak, such as a single leaking float valve in a cooling tower, could cost £3.50 per hour in wasted water; unmonitored, this could be unobserved for weeks or months, costing a brewery around £2,500 per month until replaced. The only effective way to manage water use is to understand where and why it is being used and then target improvement.

There are very detailed guidance documents\(^2\) to help understand some of the common opportunities to conserve water within breweries.

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\(^2\) Industry estimates, 2011
Hidden benefits from good water management

Aside from direct savings achieved through lower water and discharge bills, benefits can be seen in numerous other areas, especially if water is lost at a late stage in processing. Listed below are just some of the potential savings to be made:

- energy
  - for pumping water;
  - for heating and cooling water;
  - for effluent pumping;
- water treatments/chemicals;
- reduced maintenance of equipment;
- lower effluent treatment costs; and
- potential energy production or income from organic by-product.

Analysis of water use within the best performing companies shows that cleaning is the most significant water using operation. Practices in keg and cask washing vary substantially across the sector. Water use can be as high as 45 litres per litre of product packaged, yet optimal ullage recovery (for AD or animal feed), use of detergent, and effective wash systems can reduce this significantly. One-way kegs remove this water demand entirely, but can lead to higher resource consumption in packaging, therefore a whole-life assessment of product should be considered, ensuring all aspects of impacts are considered when making decisions.
Clean in Place (CIP)

CIP is another critical use of water. The Carbon Trust’s brewing sector guide\(^3\) estimates that the UK brewing sector could save 4,600 tCO\(_2\) or 1% of total sector carbon through the implementation of real time cleaning verification alone. In addition to these, several other CIP improvements are available across the sector, with improved monitoring again linked to better practice. Other areas to review include:

- optimising plant process design;
- 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);
- staff training;
- carefully setting operating programmes which coincide with the real cleaning requirements of the process;
- minimising detergent loss to drain;
- using water efficient spray devices; and
- removing product and gross soiling prior to cleaning.

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.

Waste water

Brewery wastewater has a high COD in the average range 2,000-6,000mg/l (though it can be much higher) with a BOD/COD ratio around 0.5-0.7\(^4\). 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; several

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\(^4\) Industry estimates, 2011
companies that were reviewed were diluting the organic content of wastewater with potable water direct from the mains – effectively running water down the drain.

**Organic resource**

Brewers’ grain is the most significant organic arising produced during the brewing process and this by-product has historically been used for animal feed, though alternative options are being developed. There were no examples found where brewers’ grain is sent to landfill. As a by-product brewers’ grain is not considered a waste arising.

Other organic arisings include brewers’ yeast and hops. Yeast is not suitable for ruminants in large volumes, but has a high value (nutritional and financial) for monogastric animals such as pigs. There is also value in human food production, with Marmite being the most recognised brand using brewers’ yeast.

Yeast spoils quickly and has to be denatured before consumption is possible. With large scale production, there are benefits from drying the yeast (and brewers grain) on-site, thus reducing transportation requirements and potentially lengthening shelf life.

*Figure 4: Adnams BioEnergy AD plant* Brewery waste and local food waste are converted into biogas and digestate at this Suffolk anaerobic digestion plant.
Brewers’ hops have a bitter flavour, and are generally unpalatable to livestock, offering little value to farmers, unless blended with grain. Approximately 10,000 tonnes of residual hops arise per year with different opportunities for recovery after use depending on the variety of hop.

Cask ales and micro-breweries generally require hops in a natural, plant form which present difficulties for recovery, whereas larger producers may use pellet hops and these can be recovered alongside brewers’ grain. Natural hops are more traditional, yet offer fewer opportunities for resource efficiency; however they are selected for specific flavour preferences. The challenge is to develop end uses for these hops. Composting for use as a soil improver, or for fertiliser, offers potential solutions.

Alternative treatments are available for organic resources and new technologies and innovations offer expanding opportunities. Bioenergy facilities, such as biomass and AD plants, can convert organic matter into renewable energy, and brewers’ grain offers a high calorific value (20.7–21.9 MJ/kg)\(^5\). When used for energy production, resources are diverted from animal feed. While alternative animal feed sources are readily available establishing the environmental and economic impacts may be more problematic. Ullage and effluent have lower value from bioenergy, but additional solid-based organic matter is needed to feed the plant sufficiently.

Anaerobic digestion is a growing alternative to animal feed, but currently this is not used on a large scale. Gate-fees are often prohibitive, and distances for transportation to facilities can be a barrier, but the industry is seeing substantial growth, and the benefits to large breweries of creating facilities on site are worthy of investigation. This is even more apparent when considering ullage and effluent, where nutritional value to animals is low (as is the price paid by farmers).

\(^5\) Animal Feed Resources Information Systems (2011) Food and Agricultural Organisation of the UN
Conclusions

There are several focal points for maximising resource efficiency within the brewing sector in the UK, and these are listed below.

- **Improve monitoring.** The brewing sector has achieved some excellent steps towards resource efficiency, but improved monitoring for water use and CIP would offer greater awareness of where inefficiencies lay.
- **Improved CIP.** Frequent reviewing and improving on CIP is essential, as developments and improvements are available. Ensure staff are trained on the details of the system, and ‘cleaning’ is understood in order that systems are running at maximum efficiency.
- **Monitor filling efficiencies.** and review reasons for loss. Equipment maintenance and proper handling can reduce some inefficiencies, though technical reviews should be carried out at frequent intervals.
- **Effective wastewater management.** The practice of diluting effluent to acceptable levels of COD and pH, using fresh water should be avoided. Consider effluent separation to recover value in the organic content of effluent, for example, utilising for AD or alongside Brewers’ grain for animal feed. If space is limited, ensure recovery at point of arising is maximised, for example, recovery of ullage from returned kegs rather than rinsing to drain.
- **Secondary packaging.** Consider most efficient usage of stretch wrap and other secondary packaging materials; focus on recycling has overshadowed excessive use of resources.

**Beer Resource Maps**

![Beer Resource Maps Diagram](image-url)
Resource efficiency in the UK brewing sector

Microbrewery beer resource map

Key inputs
- Malted barley (31.8 kt)
- Water (1.1 M ML)
- Hops (60 t)
- Yeast (1.24 Mt)
- Casks, glass bottles (17.5 t), cans, beer, labels, glue

Process stage
- Create grid
- Washing and lautering
- Boiling, whirlpool separation
- Fermentation, maturation, filtration
- Packaging
- Storage
- Retail
- Home/On trade

Key non-product outputs
- Brewers' grains (91.6 kt) and trub
- Brewers' hops (50 t)
- Brewers' yeast (6.3 kt)
- Spent grains; filter cakes
- Washwater with suspended solids
- Product loss from filling estimated 1.5%
- (21,000 hl) maximum
- Few 'typical' retail routes; little knowledge in this area
- Few 'typical' retail routes; little knowledge in this area
Draught beer resource map

Key inputs | Process stage | Key non-product outputs
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Malted barley (200t) | Create grist | Brewed grain (265.8t) and wastewater
Water (12,246 Ml) | Mashing and lauterating | Brewed hops (400t) and trub
Hops (560t) | Boiling, whirlpool separation | Brewed yeast (95.7t)
Malt: 13.1lt and CO₂, sugar | Fermentation, maturation, filtration | Spent fined yeast (11.9lt) and wastewater with suspended solids
Kegs | Keg filling | Upto 1.2% product loss at fill; not typically reported to fill gin
Storage | On trade | More data needed on product loss at point of dispensing