Circular Economy, Resource Efficiency and Waste Reduction for Distilling

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Significant focus on Circular Economy, Resource Efficiency and Waste Reduction is delivering, or has the potential to deliver, major cost and carbon savings. Over the past two years Pale Blue Dot have complete projects in each of the three areas which present proven and innovative opportunities for the distilling sector. In this paper:

- **Circular Economy** focuses on CO₂ Utilisation and looks briefly at the reuse of draff;
- **Resource Efficiency** touches on both energy audits and water audits;
- **Waste Reduction** covers the reuse of waste heat and insights on two coproduct liquid solid separation trials.

In 2016, Scottish Enterprise commissioned a study (Wilson et al, 2016) to identify the “Actions required to develop a roadmap towards a Carbon Dioxide Utilisation Strategy for Scotland”. The report presents numerous findings and recommendations but the two key findings relevant to the distilling sector are that:

1. High purity sources of biogenic CO₂ from bioenergy plants and fermentation presented the best opportunity for creating value from CO₂ Utilisation.
2. Two commercially ready, profit generating, technologies were identified. One technology from CCm Research, converts CO₂ and a mix of raw materials including a fibre based material (digestate / draff) into an inorganic fertilizer. The other from Carbon8 also mineralises CO₂ in to a carbonate which can be incorporated within building materials.

Pale Blue Dot have completed several Carbon Capture & Utilisation (CCU) projects. As said, biomethane and grain distillery operations are good candidates for CCU.

1. At a Scottish biomethane operation agricultural waste feeds anaerobic digesters. The resulting biogas runs through a gas purification unit to produce biomethane which is then injected into the gas grid. The purification unit emits 8000 tonnes per annum of 98% pure CO₂. Several CO₂ utilisation options were assessed including the production and sale of liquid CO₂ and/or dry ice and the conversion of the CO₂ into building aggregate or fertiliser. All options bar mineralisation were shown to have an attractive return. In all cases, finding local customers for the CCU product is key to success.

2. At Glen Turner’s Starlaw grain distillery in the Scottish Central Belt, the CO₂ vent lines on all the fermenters are hard piped to a single point of emission. The same CO₂ utilisation options were assessed for the 20,000 tonnes of CO₂ available. All CCU options, bar Carbon8, were economically modelled and have potentially attractive returns. Again, finding local customers for the CCU product will be key to success.

Both case studies have shown that bioenergy and fermentation can provide capture ready streams of CO₂ that present easy low cost access from which to bolt on value generating CCU technology. The Circular Economy potential is exciting. For example, barley absorbs CO₂ from the atmosphere as it grows, the CO₂ is released during fermentation, but is then captured and converted into fertiliser which is applied back onto the fields to grow the next crop of barley.
The distilling sector is well versed with circular economy with several well established routes for extracting value from the reuse of draff most of which goes for:

- Draff sold direct to farm for cattle feed
- Products such as Supergrains, Vitagold etc. that gave an enhanced protein offering through the inclusion of residual yeast
- The combination of pressed draff with pot ale syrup in large centralised plant to produce high value Distillers Dark Grain Pellets for sale as animal feed
- Conversion into compost
- Conversion into bioenergy through anaerobic digestion and direct combustion

Recent years have seen significant volumes of draff/grains being used in several large bioenergy projects. As shown in Figure 1, in respect of full cycle carbon impact, this is a less preferred option versus redistribution as animal feed from a Food and Drink Waste Hierarchy perspective. However, both the lack of demand for and recognised value in draff/grains still results in volume travelling from the North of Scotland into England. So, whilst investment in bioenergy plants continues, several other options aimed at extracting higher commercial value from draff could result in some volume moving up the Hierarchy.

For example, West Brewery and Regrained are converting small volumes of brewers grains into human food, i.e. bread, flapjacks and supergrain bars. Plant Chicago are successfully growing mushrooms for human consumption using spend grains as the growing medium. Biscuits are also being baked for animals by Doggie Beer Bones and Brewscuit. The above are all relatively low volume and low value offerings.

Higher volume and value options continue to be developed by FDT Consulting and Celtic Renewables. A useful summary of both is within a Circular Economy study published by Zero Waste Scotland (Arnison et al, 2015) “Sector Study on Beer, Whisky and Fish”. FDT’s PUREOPE process seeks to extract high value polyphenols, a type of antioxidant, for use in food and drink products, pharmaceutical applications and increasingly as a preservative in bio-based products. FDT have estimated the polyphenols available from Scottish distillery co-products to have a market value of >£50million per year. Celtic Renewables, secured £9m in Scottish Government funding in May 2017 to commercialise a process that produces bio-based fuels and chemicals from industrial coproducts. Celtic Renewables will use their ABE microbial fermentation process to make biofuels and commodity chemicals. A handful of regionally based, large scale biorefineries could potentially treat all of Scotland’s spent grains as well as a significant proportion of pot ale.

The CCm Research process for CCU mentioned earlier could also enhance the value of draff through inclusion within a fertiliser product.
In Figure 1, the top of the Waste Hierarchy was Prevention. The author’s experience has seen a tendency to accept coproduct and wastes as they are. But, significant opportunities can be achieved by looking within the operation and challenging existing practices and process to minimise both volume and impact first and then review the subsequent implications on the “end of pipe” solutions later.

Most UK based distillers are required to complete Energy Saving Opportunity Scheme (ESOS) audits. The focus of these audits is energy efficiency but a comprehensive end to end assessment in one area can also yield other resource savings and reduce the impact associated with managing coproducts.

Pale Blue Dot completed an ESOS audit for a large distillery during which 19 improvement projects were identified with the potential to reduce annual energy spend by 37% or circa £1m. But in addition, wins were identified to extract and reuse heat from waste water to assist the site to meet their discharge consent temperature and another project identified the extraction and reuse of heat from Pot Ale Syrup to address issues with cattle scalding.

Pale Blue Dot also completed ESOS audits across three Glen Turner operations with over 30 improvement projects identified with the potential to reduce annual energy spend by 45% or circa £300k at one location and 51% or circa £2m at the main location. The latter housed the Starlaw Grain Distillery where several opportunities associated with coproducts were identified. Most involved the reuse of waste heat for preheating process streams. One opportunity involved a modification to the existing Distillers Dark Grains Plant. Other opportunities involved reducing the volume of influent to the onsite waste water treatment plant through both elimination and recycling. The water treatment plant was running above design capacity and the actions if implemented presented the site with an option for incremental production resulting from removing the treatment plant pinch point.

The latter is reminiscent of an excellent case study completed at a Monsanto site in the UK over 20 years ago, (Environmental Technology Best Practice Programme, (1997), where a water pinch study led to resource efficiency cost savings of £845k but more importantly an £8m capital cost saving on a new effluent treatment plant.

Inspired in part by the above Case Study, Mabbett Associates and Pale Blue Dot completed comprehensive water audits for a Client across ten UK sites in 2016. The aims of the audits were to a) advise the Client on improvements to their Water KPI Reporting process, and b) identify
opportunities to reduce water usage. Reports for each location summarised the current and future Water KPI’s. Water savings, some significant, were identified at all operations across the ten locations. Irregularities in water volume accounting and KPI reporting were identified and corrections qualified and quantified. Overall, an average potential KPI improvement of 16% was identified, including true water savings. A total of 179 Recommendations were made which were a mix of capital and continuous improvement projects with benefits within the operation and also on the downstream processes. The potential cost savings, including caustic and energy, exceeded £1m with an average project payback of 0.6 years. Potential carbon savings were estimated at 2,000 tonnes per annum.

Now audits are meaningless if there is subsequently no follow through. The “Identification” of opportunities is only the first step as shown in Pale Blue Dot’s approach to Resource Efficiency Implementation, Figure 2. Audits help to identify where to apply focus via assessment and benchmarking. Decision support activity is then required to further Qualify and quantify savings, costs, etc. Resource Efficiency Improvement Projects should then be prioritised based on facts. Only fully qualified projects that meet investment criteria should then be Delivered. During the Delivery phase, regular review and tracking is essential to create and sustain momentum.

As in the case of Glen Turner’s ESOS Audit, the Qualification stage may involve the completion of further audits. The main recommendation from the ESOS audit was the installation of a Combined Heat and Power (CHP) engine. To ensure that the reuse of heat from the CHP engine was optimised alongside the large quantities of waste process heat already available, a Waste Heat Study, funded by Resource Efficiency Scotland, was completed by Mabbutt Associates and Pale Blue Dot. The study identified that the grain distillery produces over 18 MW of heat. Over 17 MW of waste heat sources were identified and represented within a Sankey diagram, Figure 3, from which the potential for waste heat recovery of over 15 MW exists. Eight specific reduction and reuse opportunities both on-site and offsite were identified valued at £750,000 and 5700 tonnes of CO₂ per annum.
Figure 3 Heat and Waste Sankey Diagram for Glen Turner's Starlaw Distillery
A major environmental impact associated with distillation coproducts is transportation. Most draff and pot ale across the Scottish distilling sector is transported from the distillery, either direct to farm or for handling / processing at a centralised location. If the volume of coproduct can be reduced at site the full cycle environmental impact could be reduced. Ian Macleod Distillers’ Tamdhu Distillery on Speyside are endeavouring to do this and completed two trials in the first quarter of 2017. Although the aim for neither was achieved, useful insights were gained and further work is in progress.

The first trial aimed to separate out solids from pot ale. The removed solids would be added to draff with the residual liquid evaluated for a simpler intermediate treatment step which would enable the residual liquid to be processed by the onsite aerobic plant. Tamdhu’s pot ale is currently handled offsite. The trial involved the evaluation of two low capex and opex liquid solid separation units with a range of tests completed utilising 40-200 micron filters. Figure 4, shows the PeelTech unit top left and the Russell Finex 17450 unit top right. The image of the bottom of Figure 4 shows the pot ale solids profile across a Wash Still discharge. The profile varies significantly with a peak of solids at the start of the run, reducing to minimal solids mid discharge and a spike at the end. The wide variation in profile had a significant impact on trial unit performance with the Russell Finex unit more suited to a consistent profile. Despite the PeelTech unit having been designed to remove potato starch solids from waste water the unit’s current design configuration was unable to separate any of the pot ale solids. Although the Russell Finex unit did achieve partial separation the performance was below expectation. Jar tests completed on pot ale samples pre-trail indicated that 125 micro filter screens would be sufficient. However, during the full-scale trials, it was found that the majority of organic solid particles were broken down further and pushed through even the 40 micron filter. A review of options is continuing.

Figure 4 Tamdhu Distillery Pot Ale Solid Separation Trial
The second Tamdhu trial aimed to separate out draff bree for recovery into the Hot Liquor Tank. Recycling draff moisture back into the process would result in smaller volumes of drier higher value draff being transported from site. The aim is to move draff moisture as measured ex-hopper from 78% down to 65%. It was decided to trial the low capex and opex Russell Finex 17450 liquid solid unit, Figure 5, which had previously been proven on grain distillery stillage. Various trials completed with a 200 micron filter were partially successful. Although most trials were curtailed because of draff bridging the unit inlet, clear separation was achieved once material was in the unit. However, to get draff into the unit the feed had to be converted into a slurry with recycled bree. So, although clear liquid solid separation occurred within the unit there was little difference in the moisture content of the final draff versus the samples of draff taken from within the mashtun. A review of options is continuing.

In conclusion, the opportunities for Circular Economy, Resource Efficiency and Waste Prevention for distilleries are there for the taking. The value creation opportunities can be significant in both monetary and carbon terms. The identification of improvement opportunities is the easy part. The subsequent qualification and delivery of improvement projects is the hard part.
References


