Dalby Bio-refinery Ltd.

Sustainable Manufacturing in Action

- 80% of the plant's water is met using Class A+ recycled water
- World's best practice drying of process residue to produce valuable stock feed.

United Petroleum's bio-refinery in Dalby (DBRL), is one of three commercial bio-refineries currently operating in Queensland and is Australia's first grain-to-ethanol facility.

First commissioned in 2008, the plant converts red sorghum grain into fuel-grade ethanol and high value animal feed products.

The Darling Downs is Australia's largest sorghum growing region. Historically the sorghum was predominantly sold as animal feed for cattle feedlots, piggeries and dairies. The establishment of the ethanol plant however has allowed an additional step in the supply chain. DBRL now purchase 200,000 tonnes of sorghum grain from local growers to produce around 76 million litres of fuel-grade ethanol annually. Remarkably this advanced manufacturing process enables every 1ooo kg of sorghum grain purchased by DBRL to be converted to 400 litres of ethanol whist returning 99% of the original protein back into the animal feed supply chain.

Whilst the plant is inherently sustainable in that it produces a renewable fuel to replace petroleum DBRL is also committed to ensuring its day to day operations are sustainable, clean and cost effective.

Water Efficiency

The ethanol plant consumes around 1.2 ML of water each day primarily for cooling, and a small quantity is also retained in the animal feed co-products.

Alternate Water Supply

In 2010, due to water supply concerns in the region, DBRL switched from using mains potable water to Class A+ recycled water. The Dalby township's wastewater treatment plant was upgraded to supply this water in a project jointly funded by the state government, the council, and the bio-refinery. The plant now receives around 1ML of recycled water daily. This has enabled 20% of Dalby's potable water supply to be returned to town's residents to help it deal with future growth and extended drought periods.

Zero Discharge

No water is discharged from DBRL to the sewer. Incoming recycled water is treated on site using reverse osmosis (RO) filtration. Brine from the RO process is evaporated in a lined pond. Wastewater from the ethanol process flows to a facultative pond for biological treatment and is then irrigated on site.

Water Efficiency

Water losses in the ethanol treatment process occur due to evaporation and blowdown from the plant's cooling towers and boilers when the water becomes to concentrated with salts and must be flushed from the system. A number of water saving initiatives have been implemented on site.

Queensland Government

These initiatives include:

- Full condensate recovery to return water and chemicals to the boiler
- Optimising cycles of concentration of cooling towers or boilers
- The plant is currently reviewing ways to reuse water from its cooling tower to further reduce water use

Energy Efficiency

DBRL consumes around 1.2 terajoules (TJ) of energy per day as the production of ethanol is a complex and energy intensive process. Energy is predominately used for the production of steam needed for the starch conversion process, distillation and evaporation and drying.

While the carbon footprint of a modern ethanol plant is around 40% lower than that of a traditional petroleum plant, DBRL actively seeks to optimise its energy consumption for both environmental and financial gains.

Process Optimisation

As the process is complex and the plant operates 365 days a year, 24 hours a day process optimization is essential. A Siemens advanced process control system monitors over 2000 control points and provides real time feedback on all the plant's operations. This allows staff to follow up on abnormalities in the process as quickly as possible. It also enables DBRL to investigate ways to optimise the process by understanding the impacts of small changes to the process. This type of monitoring typically results in 5% energy savings with the added benefit of process efficiency in improvement in yield, reduced down time and less bottlenecks in the process.[i]

Efficient Drying

After the ethanol has been distilled the remaining residue is called stillage. The stillage is centrifuged to separate the grain solids (wetcake) and liquid solubles (syrup). As the proteins, fats, fibres, vitamins and minerals in wetcake are concentrated it makes a valuable animal feed source. The storage life of the wet cake however is only 5-7 days. Drying the wetcake to Dried Distillers Grain (DDG) extends the shelf life the product to over 2 years

The drying process is however energy intensive, with drying in a traditional rotary drum dryer typically making up around 40% of all the thermal, and 30% of all electrical energy, consumed by a plant.[i] The rotary drum dryer mixes hot air with the wetcake to evaporate the water and a thermal oxidizer destroys the dryer's odours and pollutant emissions.

In 2015, the DBRL installed a world's best practice Swiss Combi's ecodry™ drying system.

World's best practice SWISS Combi's ecodry™ drying system

Features of the technology are:

- The ability to dry with superheated steam reducing primary energy consumption by up to 11% while still achieving the same amount of product output. Superheated steam also provides a gentler drying process thereby retaining more of the feed's nutritional value, in particular the proteins.
- Drying can be undertaken at a lower temperature because semi-dried product is recirculated back to the initial heat zone for additional drying and dispersion. The recycling of a portion of the stillage improves drying efficiency and reduces variations in feed quality.
- Energy savings by recovering heat from the furnace's flue gases (outlet gases) to heat steam.
- Energy savings by eliminating the need for a separate thermal oxidiser to destroy air pollutants and odour which are instead introduced into the furnace as combustion secondary air.

Typical emission reductions from Ecodry compared to conventional drum dryers [ii]	
Flue gas	48% lower
Nitrous oxides (NO_X)	14% lower
Total Organic Carbon (TOC)	100% lower (almost 0)
Particulate matter	100% lower (almost 0)
Carbon monoxide (CO)	86% lower

Heat Recovery

Plate and shell heat exchangers are used throughout the plant to maximise the recovery of heat.

The plant also uses triple-effect evaporators to distil water from the ethanol. The series of three evaporators saves energy as only the first evaporator is heated. The subsequent evaporators are held at a lower pressure. Because the boiling temperature of liquid decreases as pressure decreases the vapor boiled off in one evaporator can be used to heat the next.

In triple-effect evaporators, 1kg of steam produced in the first evaporator can be turned into 1.8kg of steam in the second evaporator (effect) and 2.6kg in the third evaporator for the same amount of heating energy.[ii] [iii]

To remove any remaining water after distillation the ethanol is passed through a bed of molecular sieve beads (zeolites). As the liquid passes through the bed, the water molecules are adsorbed onto the beads. Molecular sieves can offer significant energy savings (up to 40%)[iv] compared to distillation when a very dry result is required. Furthermore, heat can be recovered sieve and used by the triple effect evaporators.

Steam System Optimization

Generating steam is an energy intensive activity. To optimise steam production DBRL

- Recover all condensate to return water and any residual heat and chemicals to the boiler
- Regular monitoring and maintenance for leaks and steam traps
- Insulate all steam pipe work.

This case study has been prepared by The Ecoefficiency Group Pty Ltd for the Queensland Department of State Development in 2017.

[i] Minnesota Technical Assistance Program, 2008, Ethanol Benchmarking and Best Practices - The Production Process and Potential For Improvement.
[ii] SWISS COMBI, 2017, Detailed information of SWISS COMBI ecoDry system
[iii] Jatindra Kumar Sahu, 2014, Introduction to Advanced Food Process Engineering, CRC Press
[iv] Wintex, 2017 Molecular Sieve Dehydration Units (MSDU)
]