ENERGY RECOVERY – E5

Eco-efficiency resources for the food processing industry

Energy within the process

Waste produced in food processing can sometimes be converted to forms of energy for use in the factory. This fact sheet provides information on some methods of harnessing this energy.

Bioenergy

Most food waste has a useful content of energy and/or nutrients. In Australia, such organic waste is disposed as landfill, used in horticultural and agricultural sectors as compost and liquid fertiliser, or applied in the generation of renewable energy.

These sources of energy can sometimes be relatively easy to store and control to provide a consistent energy source when required, however, odour nuisance and space issues can prevent this.

In the food industry, sources of organic waste include the by-products of food processing and wastewater treatment systems providing benefits from reduced solid waste and tradewaste disposal costs.

There are two main types of bioenergy conversion processes: biochemical conversion and thermoconversion.

Biochemical conversion

Biochemical conversion involves the breakdown of (usually) high-moisture organics by microorganisms to produce gaseous or liquid fuels. The processes commonly used are fermentation, composting and anaerobic digestion.

Fermentation is not currently a viable option for most food processing plants as the waste stream requires sugar concentrations of over 20 per cent to produce even 10 per cent alcohol, but molasses utilisation for ethanol is a good example of biochemical conversion. Research is being undertaken on advanced fermentation systems to further develop this field.

Anaerobic digestion

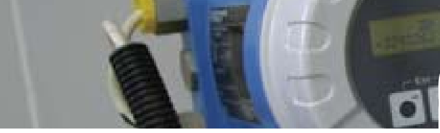
Anaerobic digestion and biogas recovery is best suited to large food processing plants with high-strength wastewater, such as dairy processing plants or breweries.

Anaerobic digestion is the transformation of organic material to biogas, in a controlled environment and in the absence of oxygen. Biogas is made up of methane, carbon dioxide and other components such as hydrogen sulphide (H_2S) and moisture.

The methane content in the biogas depends on the composition of the waste stream and the digester used[1] and is generally between 60-80 per cent.[2]

[1] Dairy Industry Sustainability Consortium, 2005, Closing the Loop, www.diaa.asn.au/resources/8/default.aspx

[2] Biogas Association of New Zealand, Biogas, 2007, www.bioenergy.org.nz/biogas.asp



Natural gas has a heating value of 40MJ/m³, however biogas is typically lower between 18 and 26 MJ/m³ due to the carbon dioxide content.[3] The moisture and H_2S content of biogas can lead to corrosion in boilers. However, this can be alleviated by using a condensation trap and scrubber containing iron filings or other methods.

Biogas produced can be suitable for use in boilers, gas-turbines, co-generation plants or as process heating.

Table 1 outlines the biogas yield from an anaerobic process in an ice-cream factory.

Table 1: Energy yields from biogas digestion in an ice-cream factory, NSW

	Low-rate digestion of effluent (lagoon digester)
Material available for digestion	3,060 kg COD/day
Organic load available	0.34 kg COD/m³/day
Methane conversion rate	0.352 m³/kg COD removed
Organic removal rate	70 per cent
Methane yield	754 m_3 CH_4/day
Energy yield	27,000 MJ/day
Equivalent natural gas cost	$324/day @ $12/GJ

The Resource recovery from wastewater fact sheet (W8) provides more information on anaerobic digestion.

The following calculation can be used to estimate energy and methane yield and potential savings.[4]
Maximum yield (m_3/day) = Load of COD to digester (kg/day) x COD removal rate (%) x0.352 m³ CH4/kg COD removed

Energy available (MJ/day) = quantity of methane (m_3/day) x heating value of methane (35.8 MJ/m³)

Biogas collector at Foster's Australia.

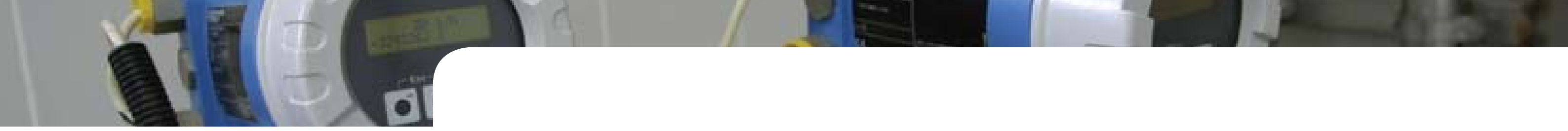
WASTEWATER BY-PRODUCT SAVES ENERGY AND MONEY

A brewery, Foster's Australia, installed upflow anaerobic sludge blanket (UASB) units as part of their wastewater treatment process. Biogas is extracted from this process into a flexible container which expands and contracts to maintain a constant pressure depending on the generation and use of the biogas. Biogas is burnt in the boilers and contributes approximately 20 per cent of the energy use on site saving approximately $750,000 per year. The biogas unit cost approximately $220,000 to install in 1995 and had a payback period of less than one year.

OUTSOURCING WASTE FOR ENERGY GENERATION[5]

A commercial scale anaerobic digestor developed by EarthPower Technologies in Sydney processes organic waste from sources such as food processing plants, commercial kitchens, markets and supermarkets for much lower fees than landfill. Processing up to 82,000 tonnes of biomass every year, biogas is being produced to operate a co-generation plant (see section below) with an electricity generating capacity of 3 MW. The by-products are high-grade liquid and solid fertilisers sold to the agriculture and horticulture market.

[3] Biogas Association of New Zealand, Biogas, 2007, www.bioenergy.org.nz/biogas.asp
[4] Prasad, P., 2004, Eco-efficiency for Australian dairy processors – Fact sheet 5: Biogas, www.gpa.uq.edu.au/CleanProd/toolkits/toolkits.htm#Dairy_Processing
[5] Australian Department of the Environment, Water, Heritage and the Arts, 2008, Biomass: Food Biomass to Green Energy. www.environment.gov.au/settlements/renewable/recp/biomass; Earth Power Technologies, 2008, www.earthpower.com.au



Thermochemical conversion

Thermochemical conversion uses high temperatures or combustion to break down biomass and is useful for organic waste with low moisture content. Methods include direct combustion, pyrolysis and gasification. Where a waste stream (such as macadamia shells and bagasse) can be sourced as a fuel, savings can also be made on waste disposal.

Direct combustion is the simplest method of burning organic waste to produce steam, electricity or heat. Many food processing plants use this method to supplement energy requirements and dispose of their organic waste. For example, many sugar mills produce more than their energy requirements through burning bagasse, a sugar cane by-product, and then sell excess energy to the power grid.

Pyrolysis is another combustion method, which under a high temperature and low oxygen environment turns organic waste into pyrolysis oils, combustible gases, solid carbon and ash.[6]

Gasification produces syngas by heating wastes in the presence of air.[7] This gas has approximately 20 per cent of the heating value of natural gas and can supplement energy requirements.

At the moment it appears that the cost of gasification and pyrolysis facilities is relatively high and the throughput required is greater than that generated from most individual food processing plants. Therefore, to be economically viable, such a facility would need to process organic waste from numerous food processing plants as well as additional sources.

Cogeneration

Cogeneration (cogen) or combined heat and power (CHP) systems use a single source of fuel to produce both electrical and thermal energy more efficiently providing cost benefits and reduced emissions.

The efficiency of a cogeneration plant can be as high as 80 per cent, because energy is being extracted from the system in the form of both heat and power.[8]

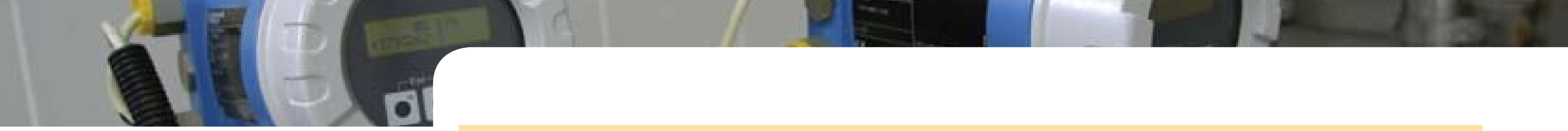
By contrast, conventional coal fired power stations have a conversion efficiency of approximately 30 per cent with further losses (approximately 10 per cent) occurring during the transportation of electricity along the distribution network from the station to the user.[9]

Cogen provides two fold environmental benefits by increasing efficiency therefore reducing resource consumption through lower fossil fuel use and reducing greenhouse gas production.

Cogeneration plants can last for up to 15 years and tend to be cost effective only if they are operated for at least 12 hours a day, seven days a week.[10] The payback period for a cogeneration plant is typically between one to four years, however, the economics of these plants will change dramatically as energy costs rise.[11]

Both third-party ownership and sophisticated financing are available in an ‘energy performance contract’, where a third party takes on part or all of the risk of the project and is refinanced through the energy savings. This may make certain projects more economic or operationally attractive.

[6] FAO Corporate Document Repository, 1994, Biochemical conversion technologies, www.fao.org/docrep/T1804E/t1804e06.htm
[7] Novolta Pty Ltd, Biomass, 2007, www.novolta.com.au/solutions/biomass.htm
[8] Resource Dynamics Corporation, 2003, Cooling, Heating, and Power for Industry: A Market Assessment, www.eere.energy.gov/de/pdfs/chp_industry_market_assessment_0803.pdf
[9] Clean Energy Council, 2007, All about Cogeneration, www.cleanenergycouncil.org.au
[10] The Carbon Trust, 2008, Micro-CHP, www.carbontrust.co.uk/energy/startsaving/tech_chp_micro_CHP.htm
[11] Industry Search Australia and New Zealand, Elgas Limited, 2008, The Benefits of Co-Generation Systems, www.industrysearch.com.au/Products/Co-Generation_systems-18549



COGENERATION IN A SUGAR MILL[12]

Rocky Point Sugar Mill uses bagasse from the sugar milling process and 130,000 tonnes of externally sourced biomass to power a 30 MW biomass co-generation plant year round. It produces steam, hot water and electricity. During the crushing season, one third of the electricity produced is used by the neighbouring sugar mill whilst the rest is sold back to the grid.[13] Outside that season approximately 95 per cent is sold to the grid. The year-round operation of the cogeneration plant has allowed the sugar mill to produce alternative products including fuel alcohol and organic sugar out of season.

For more information see the fact sheets at Sustainability Victoria, Sustainable Manufacturing, Resource Smart Business, www.seav.vic.gov.au/manufacturing/sustainable_manufacturing/, and The Carbon Trust, www.carbontrust.co.uk/energy/startsaving/tech_chp_introduction.htm

Trigeneration

An emerging technology is trigeneration, which harnesses the waste heat that is produced in cogeneration through absorptive chillers to provide air conditioning or even refrigeration. This can result in efficiencies of up to 93 per cent.

The refrigeration system can achieve a coefficient of performance (COP) – the ratio of output heat to the supplied work – of 0.7 for a one step process and 1.2 for a two step process.[14]

These systems are useful for food processing plants that need both heat and cooling either through refrigeration or even air conditioning of office space or the factory floor. The operating costs are low as are maintenance costs due to the lack of moving parts.[15]

Although not widely used in the Australian food industry, these systems are currently being used in office and residential buildings such as The University of Sydney's Parramatta campus, which was installed in 1998.[16]

BENEFITS OF TRIGENERATION FOR VEGETABLE FACTORY

A frozen vegetable factory in Spain operates a cogeneration plant with two gas engines and 4 MW of electricity supply. An absorption refrigeration plant is run off the thermal energy to maintain cooling rooms at -20°C from ammonia evaporators run at -30°C. At the same time approximately 200 kL of process water at 1°C is produced to pre-cool products and for air conditioning.[17]

This series of fact sheets provides examples and suggestions to the modern food processor on how to achieve both economic and environmental benefits from eco-efficiency. Visit the project website www.ecoefficiency.com.au for more ideas and case studies.

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[12] Renewable energy commercialisation in Australia:
www.environment.gov.au/settlements/renewable/recp/biomass/pubs/biomass12.pdf
[13] Waste Management and Environment Media, 2008, Rocky road to recovery, www.wme.com.au/categories/energy/aug6_07.php
[14] Davies, S, October/November 2007, The power of three, Power Engineering, The Institution of Engineering and Technology, 30-33 www.theiet.org/power
[15] Bassols, J., Kuckelkorn, B., Langreck, J., Schneiger, R., and Veelken, H., 2002, Trigeneration in the food industry, Applied Thermal Engineering 22, p. 595-602.
[16] Sustainability Victoria, 2006, Resource Smart Business: Sustainable Manufacturing: Gas Air conditioning, www.seav.vic.gov.au/manufacturing/sustainable_manufacturing/resource.asp?action=show_resource&resourcetype=2&resourceid=26
[17] Bassols, J et al, 2002, "Trigeneration in the food industry."

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