Mechanical Biological Treatment: Case Study 2: Eastern Creek UR 3R Sydney

Report to IEA Bioenergy Task 36

ED 51233
Issue 1
April 2007

Title	Case Study 2 – Eastern Creek UR 3R, Sydney
Customer	IEA Bioenergy Task 36
Customer reference	
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File reference	
Reference number	ED 51233001- Issue 1

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1.1 Background

As with many modern cities, Sydney is facing pressures of growing waste quantities. Conventional waste disposal as the sole means of waste management has inherent limitations. It relies on the ready availability of landfill sites, which in Sydney, as in other major cities throughout the world, are becoming increasingly scarce. To help address the waste management challenge a treatment facility was commissioned for the Eastern Creek area.

Eastern Creek in Sydney is the site of the World's first UR-3R technology facility. UR-3R stands for Urban Resource – Reduction, Recovery and Recycling Process. The facility at Eastern Creek began operations in September 2004 and is being co-managed by Global Renewables and WSN Environmental Solutions.

The facility neighbours a large operational landfill serving the Sydney area.

1.2 Waste management in Australia

Waste arisings in Australia have historically been one of the highest in the world at 690kg per capita. This has lead to pressure on the waste management infrastructure. Shortage of landfill, in addition to regulatory and public pressure to find waste disposal methods other than landfill, has lead to increases in recycling and composting.

However, as shown in Table 1, waste management in Australia is dominated by the disposal of the residual waste - the waste left after recycling and composting. As with many other countries in Australia the recycling of more discrete waste types, such as Construction and Demolition (C&D) waste (57%), is higher than the recycling of mixed waste, such as municipal wastes (30%).

Landfill is the predominant disposal technique and very little alternative waste treatment is employed for the residual waste materials.

Table 1 Waste generation by sector across the main states of Australia, 2002–03[1]

State/ Territory	Disposed *(tonnes)*				Recycled *(tonnes)*				Generated *(tonnes)*			
	Municipal	**C&I**	**C&D**	**Total**	**Municipal**	**C&I**	**C&D**	**Total**	**Municipal**	**C&I**	**C&D**	**Total**
NSW	2,170,000	2,831,000	1,340,000	6,341,000	1,156,000	1,365,000	3,309,000	5,830,000	3,326,000	4,196,000	4,649,000	12,171,000
Victoria	1,547,000	1,003,000	1,630,000	4,180,000	744,000	1,740,000	1,945,000	4,429,000	2,291,000	2,743,000	3,575,000	8,609,000
Qld	1,297,000	747,000	678,000	2,722,000	445,000	212,000	488,000	1,251,000 (1)	1,742,000	959,000	1,166,000	3,973,000
WA (2)	741,000	420,000	1,535,000	2,696,000	92,000	324,000	410,000	826,000	833,000	744,000	1,945,000	3,522,000
SA	365,000	208,000	704,000	1,277,000	235,000	469,000	1,452,000	2,156,000 (3)	600,000	677,000	2,156,000	3,433,000
ACT	82,000	98,000	27,000	207,000	29,000	52,000	223,000	467,000 (4)	111,000	150,000	250,000	674,000
Total (5)	**6,202,000**	**5,307,000**	**5,914,000**	**17,423,000**	**2,701,000**	**4,162,000**	**7,827,000**	**14,959,000**	**8,903,000**	**9,469,000**	**13,741,000**	**32,382,000**

(1) The total recycling and generation figure for Queensland includes 105,000 tonnes of organics which is recycled by the private sector and not included in the waste sector quantities as the split is unknown.
(2) The disposal figures for WA are for metropolitan Perth. Recycling figures are not yet publicly available for WA, but have been provided by the Department of Environment (WA) for inclusion in this report.
(3) The total recycling figure for SA includes meat waste, a prescribed industrial waste.
(4) The total recycling figure for the ACT includes 163,000 tonnes of organics which is not included in the waste sector quantities as the split is unknown.
(5) There is currently no data available for Tasmania and the Northern Territory.

OECD 2005 *Environment at a Glance*, OECD Environmental Indicators.

[1] Allan P, Waste and Recycling in Australia, Report no. 4, Australian Government, Department of Environment and Heritage, 6 Feb 2006, http://www.environment.gov.au/settlements/publications/waste/pubs/waste-recycling.pdf

Pressure to use alterative waste treatments is being driven by the landfill levy and the climate change agenda, with some states implementing carbon trading arrangements such as the Emission Reduction Units (which can be traded) and Renewable Energy Certificates. More importantly, in December 2004, the government supported the concept of product stewardship as a means to encourage recycling and diversion of waste away from landfill, through the use of voluntary schemes for particular waste streams[2]. This works on the basis of conserving the embedded energy within products and materials rather than disposing of it or just recovering the inherent energy held within the matrix of the material.

1.3 Process selection

The selection of the UR-3R technology for Eastern Creek was based on the Federal and State government requirements to optimise the recovery of value from the waste and the need to obtain a licence to operate from the community. The landfill prices in Australia are increasing and it has been estimated that average prices will rise to AU$55/t in 5 years and in particular the landfill charges including the landfill levy is AU$80-120/t.

The underlying principle is for the recovery of materials at their highest net resource value in line with the waste hierarchy.

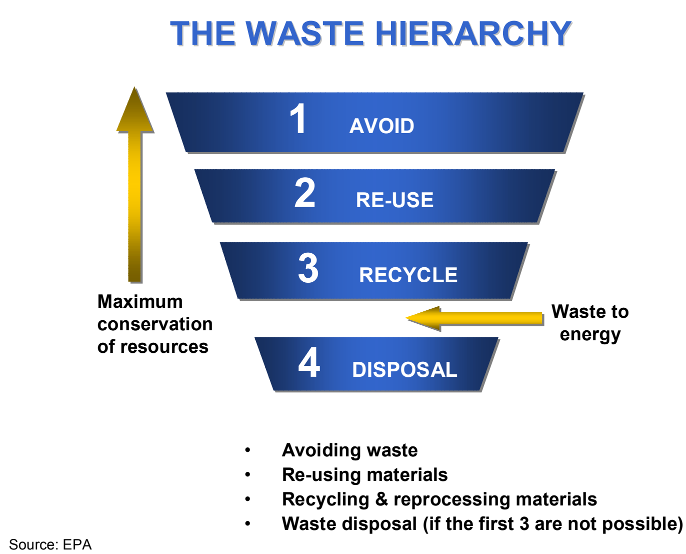

Figure 1 Waste hierarchy

This assessment of the net resource value accounts for not only the direct energy that can be obtained from burning or otherwise destroying the waste but also the embodied energy inherent in a material or product derived from the production of that material or product. From this assessment, the system of using a waste collection service, using a twin bin collection with paper for recycling and residual waste, together with a mechanical separation to recover additional metals, glass

[2] EPHC- Environment protection and heritage council, Industry discussion paper on Co-regulatory frameworks for product stewardship, December 2004, http://www.ephc.gov.au/pdf/product_stewardship/ProductStewardship_IndustryDP.pdf

and plastics for recycling and an organic fraction for the recovery of energy and a soil improver through anaerobic digestion and composting.

1.4 Waste composition

The waste supplied to the plant comes from the local communities in Sydney and is the residual waste after existing source separation of recyclables. The estimated composition of the delivered waste is shown in figure 2.

Sydney produces approximately 1.6 million tonnes of waste per year. At a processing capacity of 175,000 tpa the facility will be handling 11% of Sydney's household waste, with a potential to handle 16% when capacity is expanded to its predicted maximum capacity of 260,000 tpa[3].

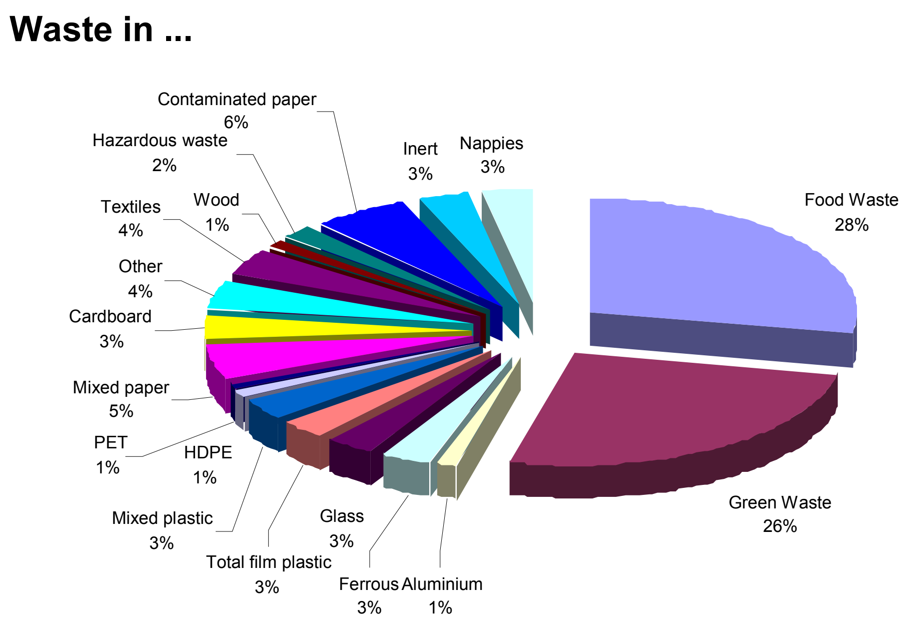

Figure 2 Waste composition of feedstock to Eastern Creek[4]

[3] Benchmarking AWT technology – a national TBL assessment of the UR-3R Process
[4] Global Renewables Corporate Brochure

2 The UR-3R Process

The process comprises four main stages as shown in Figure 3.

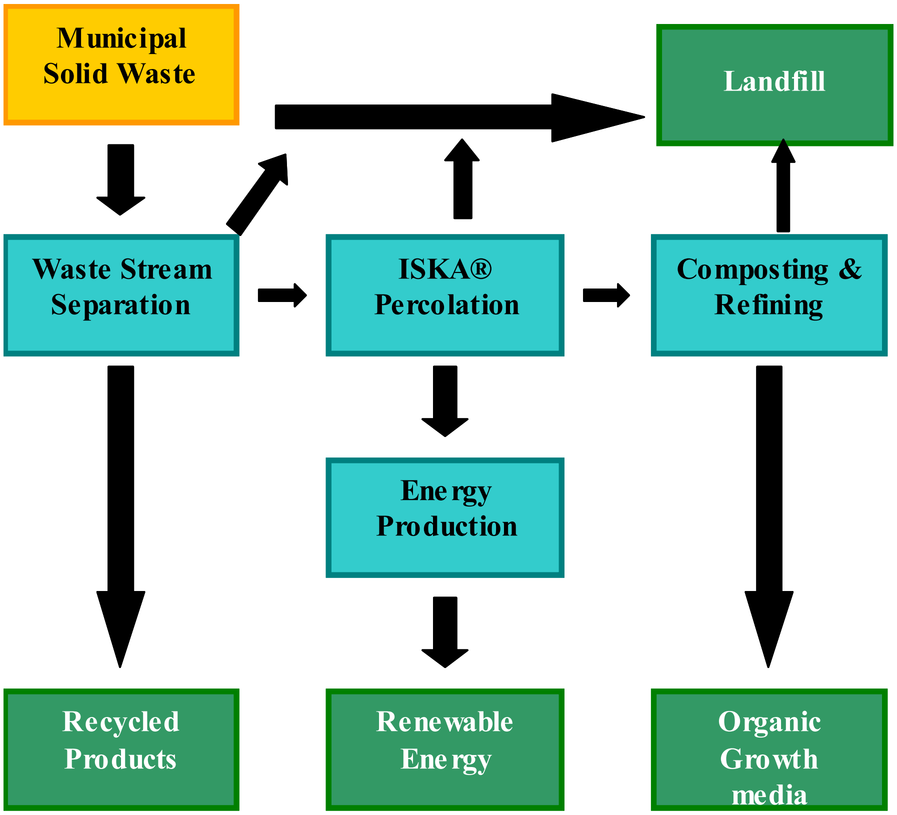

Figure 3 Outline of UR-3R process[5]

2.1 Mechanical Separation

Separation and sorting of waste begins with the waste being loaded onto a bag opener and then into a trommel screen. Additional sorters monitor this input waste to remove items that can cause problems later in the process. Car batteries are a particular problem at this plant as the lead content is both a lost resource and a potential contaminant for the final compost.

In addition, the plant managers are working with the collection authorities to facilitate greater recycling and fewer disposals of batteries.

At the time of the visit some 50-70 batteries per day were being collected. The number collected is higher than the estimated amount for the households in the area (based on waste analyses and sales). It may be that the community supports a disproportionate number of car repair businesses and end of life vehicles, possibly due to the socio-demographic profile of the area.

[5] Global Renewables Website

The oversize fraction from the trommel is air classified and the light fraction is sorted by hand to collect paper, card and plastics for recycling, and metals are separated through the use of a magnet and eddy current separator. The residue from this is sent to landfill. The heavy fraction is also landfilled.

Metals are extracted from the trommel undersize fraction by a magnet and eddy current separator and the organic rich fraction is passed to the anaerobic digestion stage.

The early concept of the facility was to segregate glass bottles from the undersize fraction, but in practice the amount of breakage has proven this to be impracticable.

2.2 Biological Treatment

2.2.1 Aerobic stage

The organic waste is transferred to the ISKA® Percolation section of the facility where there are four percolator units. The percolator can be described as a giant washing machine where the waste is constantly rotated and washed with recycled water. The waste is kept within the percolator for 2 days, with aerobic bacteria that helps break down the organics. The aims of the percolator are to:

- Degrade and recover the organic matter in the liquid fraction for subsequent digestion
- Stabilise the remaining solid material
- Reduce the odour of the remaining waste
- Reduce the mass of the remaining waste
- Cleans the organic waste of contaminants, such as sand, silt, ceramics
- Homogenises the remaining waste

The percolation is carried out within a vessel in which the waste is fed at one end and moved slowly along the length to the outlet, over a period of about 2 days, through the use of slowly moving paddle/augers. During this time water is sprayed on to the waste to extract the organic matter. The degradation to the soluble organics is assisted by the sequence of aeration and the filling, draining and the quantity of water that is retained at any one time. The temperature is maintained at approximately 45°C. These conditions and the filling sequence maximises the hydrolysis reactions, during which long chain organic compounds are reduced to short chain soluble compounds. The soluble compounds can be removed in the water leaving a residue that can be sent for composting. The percolator ensures that the liquid and fine solid residue is separated from the bulk of the waste though a screen (5mm) at the base of the unit.

2.2.2 Anaerobic Stage

The liquor in the percolator, which was used to wash the waste, now contains hydrolysed organic material that is passed to a settling tank to remove the dense grit and stones that would block the digester. This material is sent to landfill.

The liquor from the setting tank is passed to the anaerobic digester. The digester is a relatively standard anaerobic upflow hybrid wastewater digestion unit with a central packed bed design and sludge blankets above and below the bed. The feed utilises a large proportion of recirculated liquor to ensure that complete conversion and micro-organism populations are maintained in the digester. Here anaerobic bacteria works on the waste to produce biogas containing approximately 65-70% methane. The remaining biomass is re-circulated in the percolator so volatile solids can be released for re-digestion.

The biogas that is generated is burnt in two 1250 kW gas engines. The gas is scrubbed in an ETDA system to reduce the H_2S content as this will reduce the operating life of the engines and breach emission limits.

Gas and therefore electricity generation is currently between 600 and 800kW. It was originally anticipated that the export of electricity would be double this amount.

2.2.3 Composting

The residue from the percolators is composted using established Sorain Cecchini hall based composting technology, which is carried out in a separate sealed composting hall, to avoid odour and bioaerosol release. The hall contains two Biomax compost turning units. This process stabilises the waste over an initial intense composting period of 4 to 5 weeks, where the compost reaches and maintains temperatures of 45 to 75°C. The compost is then placed in outdoor windrows for a further 8 weeks where the compost matures.

The matured compost is sorted further through a refining process using screening, air classification and ballistic separation systems to generate a compost material (OGM - Organic Growth Medium) for sale in one of three grades designed for specific markets.

A key issue has been the lead content, which has been tracked to car batteries in the feedstock, which are being addressed by sorting before the process to remove them and education on the recycling options. With the active control of these contaminants the compost lead levels are now within the limits.

2.3 Mass balance

The original plans for recycling of glass were optimistic as the bottles are broken in the trommel screen. However the quantities of plastics were higher than expected and a mixed plastics fraction can now be collected and markets are being sought for this material.

Figure 4 shows a typical mass balance for the facility. A key aspect of this is the recyclables and compost that are collected that divert material away from landfill and recover the value within these materials. In addition the biogas provides not only the diversion of organic matter (and its associated pollution potential) but also provides renewable energy. The material that is landfilled is reduced by a further 23.9% due to atmospheric losses from the composting stages. Therefore the quantity of the landfilled material is less than a quarter of the original waste.

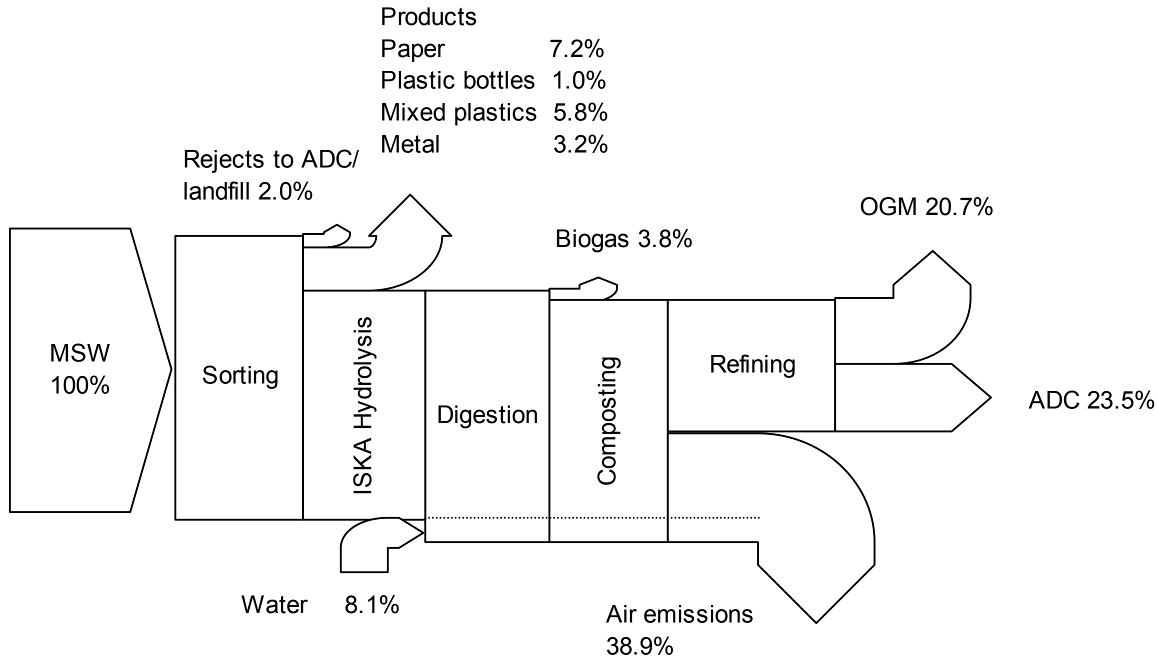

Figure 4 Mass flow for GRL Easter Creek

2.3.1 End Products

One of the driving principles of the project was to conserve the embedded energy in the products. The recycling element of the project is therefore key to the operation.

The products that are sent to external markets are the

- Paper
- Plastic bottles (HDPE, PET)
- Compost (OGM)
- Ferrous metal
- Non-ferrous metal
- Landfill cover (ADC)
- Plastic rich fraction (RDF)

The OGM compost is marketed to local farms and businesses. The compost analysis is shown in Table 2 and meets the Australian standard AS4454. This is an ad hoc market and marketing is a continuous process.

Table 2 OGM-P analysis

	Units	Limit	Typical
Total nitrogen	%	>0.6	1-2
Phosphorus (as P2O5)	%		0.5-1%
Potassium (as K2O)	%		0.6-1.2%

Magnesium	%		0.2-0.3%
Calcium	%		2.5-3.5%
Sulphur:	%		~0.1%
Water holding capacity	%		75-200
Physical Properties			
pH:		5-7.5	5.5-6.5
Electrical conductivity (EC):	mS/cm[6],	<12	6-11
Moisture content	%	25-65	30-55
Organic matter content	%	>25	55-70
Particle size	% passing 16 mm	>80	100
Bulk density:	kg/m^3	600-800	640
C : N ratio			15-20
Chemical Contaminants			
Arsenic:	mg/kg	<20	<10
Cadmium:	mg/kg	<20	<2
Chromium:	mg/kg	<500	<30
Copper:	mg/kg	<2000	<450
Lead:	mg/kg	<420	<360
Mercury:	mg/kg	<15	<6
Nickel:	mg/kg	<270	<60
Selenium	mg/kg	<50	<3
Zinc:	mg/kg	<2500	<1000
Total DDT / DDD / DDE:	mg/kg	<1.0	<0.2
Aldrin:	mg/kg	<0.5	<0.2
Dieldrin:	mg/kg	<0.5	<0.2
Chlordane:	mg/kg	<0.5	<0.2
Heptachlor:	mg/kg	<0.5	<0.2
HCB:	mg/kg	<0.5	<0.2
Lindane:	mg/kg	<0.5	<0.2
BHC:	mg/kg	<0.5	<0.2
PCB	mg/kg	<1	
Physical Contaminants			
Glass, metal & rigid plastic	(>2 mm): %	<0.5	0.3-1
Light and film plastic	(>5 mm): %	<0.05	0.02-0.2
Stones and other consolidated mineral contaminants)	(> 5 mm %	< 5	<1
Biological Contaminants			
Salmonella SPP.:	(MPN/25 g)	0	
Escherichia coli:	CFU/g dry matter	< 1000	
Weed seeds:	viable propagules/L	< 5	

The paper and metals are sold locally to reprocessors for recycling into new products.

The mixed plastics fraction has been a difficult material to market but the fraction is being sold to the cement industry as a fuel to replace coal. This market is relatively remote (>100miles) but the costs of haulage on large bulk haulage are modest compared to the cost of landfilling.

The facility is located neighbouring a large landfill and the ADC material is used to aid in the operations of that site. The other recyclables are all marketed to reprocessing industries.

[6] Units: mS/cm ≡ dS/m

A key element of the products are the carbon benefits that are generated through the process and emission reduction units are a valuable income to the plant. 1.5 million have been forward purchased by BP Australia Ltd. and Mitsui &Co (Australia) Ltd covering the first 5 years of production.

2.4 The Planning and Construction Stage

Global Renewables won a 25-year contract to build and operate a UR-3R facility at Eastern Creek in 2002. To finance the plant the New South Wales (NSW) Government's Public Private Partnership policy framework was followed3.

In the call for services, 101 expressions of interest were received and seventeen of these included pre-treatment and MBT processes[7]. Due to the resistance from the public and NGO's against waste treatment facilities such as incineration gasification and pyrolysis, an MBT solution was chosen.

The company conducted detailed environmental assessments and financial analysis to obtain the Development consent and the Permit to Operate. The contract was developed and financed in line with the NSW Government, Public, Private Partnership policy framework. The project was financed by a mixture of debt and equity for AU$130 to fund the AU$70m capital cost and initial capital requirements of the company.

The development of the project started after the contract award in 2002 and the detailed design commenced in August 2003. Construction started in September 2003 and was completed by July 2004 a very short 12 month construction period. Commissioning and testing started at hand over with full capacity expected to be achieved by early 2005.

During this period improvements were identified and this lead to expenditure of approximately AU$3m in additional sorting equipment to improve the recyclables and OGM product quality. Part of this was related to the pre-sort required by the high incidents of bulky items and car batteries.

The site is located next to a large landfill and occupies approximately 5.6 ha which is claimed to be sufficient for the full 260 ktpa capacity of the facility.

In May 2006 a fire broke out in the composting hall as a result of an electrical fault in a conveyor. The plant was off line until July 2006 where the plant was repaired and other improvements installed. The impacts of the fire were covered by insurance.

2.4.1 Environmental Impact

The environmental impacts of the plant were detailed in the Statement of environmental effects, which was prepared for the development of the facility. The key concerns for the plant are the air emissions arising from the gas engines and the composting process, water consumption and the compost quality.

[7] International Symposium MBT, Wasteconsult International

The gas engines are stated to be within the State EPA emission requirements for NOx, sulphur compounds and VOC destruction.

Pollutant	Limit
NOx	500 mg/Nm^3 @7%O_2
Sulphuric acid and Sulphur trioxide	100 mg/Nm^3
VOC destruction	98%

The biogas is scrubbed to remove H2S prior to combustion that ensures that the sulphur emissions are within the limits set.

The air emissions from the composting process and the process buildings contains a high level of odour and this is treated in a biofilter.

The anaerobic digestion process and percolation processes do use a lot of water but this is supplied from the dewatering stage prior to the waste being composted. The water is treated to remove major contaminants and then supplied to the percolation unit. The excess water generated in this process is used within the composting process, which is a net user of water. The plant aims to use surface water to supply the water for the composting process.

The compost that is produced meets the Australian AS4454 standard for compost quality and is detailed in Table 2.

2.4.2 Financial Breakdown

The initial capital cost of the Eastern Creek facility was AU$70m and a further AU$3m was required during the development of the facility.

A financial breakdown of operations was not available but the following data is known. The competing landfill cost is AU$77. The plant employs 80 staff and income is derived from the following sources.

- Sale of paper, metals and plastics
- OGM sales
- Sale of electricity and the associated renewable energy certificates
- Sale of Emission reduction units (ERU)

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