Snapshot Report

AUSTRALIAN MEAT PROCESSOR CORPORATION

Zero Waste to Landfill

Project Code	Prepared by	Date Submitted
2021-1046	All Energy Pty Ltd	26/10/22

Project Description

RMPs are challenged to achieve zero waste to landfill as certain contaminated / soiled materials (e.g., paper and cardboard having fat / protein / blood) and difficult to recycle plastics (e.g., laminated and multi-layer plastics such as vacuum packaging) are either not accepted for recycling, have no recycling option or are prohibitively expensive to recycle. Further, food processing, abattoir and animal wastes from food processing can be regulated wastes which attract a higher landfilling fee per tonne (in Qld, Category 2 which attracts a $105 /tonne landfill levy).

This project supported a pilot Energy from Waste (EfW) plant (e.g., pyrolysis/gasification) located at a third-party facility with detailed analysis of inputs and outputs (e.g. ash used as a soil conditioner). A key roadblock to sustainability technology adoption is the ‘knowledge gap’ and technical intensity of plant – high CapEx, modularity options, plant operability and environmental permitting. The project documented how EfW can deliver a zero waste solution for Australian RMPs whilst filling the knowledge gap. Capital and operational costs for a commercial operation were estimated based upon the pilot results along with the benefits of reduced waste management costs, no landfill levy, landfill reduction, clean energy production, and emissions reduction. Representative samples were sourced from interested RMPs with reporting on feedstock performance, gas, and char quality. The host ran the pilot plant with an ex-post cost benefit analysis to determine the technical and economic viability of EfW for zero landfill.

Project Content

The primary objective of this project was to demonstrate a pathway for RMPs to achieve zero wastes to landfill. A wide range of typical Australian red meat processor wastes were considered, such as contaminated / soiled cardboard, paper, and plastics; multi-layered and difficult to recycle plastic (e.g., vacuum packaging films); cafeteria and mixed wastes; construction and demolition wastes; green wastes; other in-organic and organic wastes currently sent to landfill.

Available wastes that were suggested by red meat processors included:

- Contaminated plastic
- Contaminated cardboard
- PPE
- Animal parts with inorganics (e.g., ears with tags, oesophagus and clips)
- Paunch and DAF sludge

The primary determinants in assessing feasibility for gasification are moisture content, ash content, calorific value and carbon content, particle size (ratio of surface area to volume). Plastic, cardboard, and PPE are the driest, low-ash, and high calorific value non-recyclable wastes produced by RMPs, so should be the first choice for gasification.

Figure 1: Gasification reactor showing mulched mix of paper, cardboard, and plastic, and residual char

Project Outcome

Testing of the waste was done to define the waste composition, syngas and hence energy generated, composition of the char/ash and to provide data for a detailed design phase. The pilot unit was hosted at a suitable R&D / testing facility to utilise existing infrastructure, safety systems, environmental systems / approvals, and skills. Comparative runs were completed using enriched air (50% O2) and pure O2 as the oxidant, with performance data summarised below.

Table 1: Summary of RMP waste gasification performance

Gas Composition Averages		**Period 10:00 – 12:00**	**Period 14:00 – 18:00**
Dry Gas	O2 (mol%)	0.00	0.00
	CO (mol%)	48.1	31.9
	CO2 (mol%)	20.6	22.2
	H2 (mol%)	26.9	31.1
	CH4 (mol%)	5.9	6.2
	N2 (by difference, mol%)	0	8.5
	C2+ (mol%)		
	LHV (dry, MJ/Nm3)	**10.7**	**9.6**
	CO+H2 (mol%)	75.1	63.1

Table 2: Stack emission composition data

	Unit	Result
Average flue gas temperature	degC	22
Average flue gas moisture	Vol%	2.8
Dry gas molecular weight	Kg/Nm3	0.88
Oxygen	Vol%	1.4
Methane	Vol%	4.9
Carbon Dioxide	Vol%	17.1
Nitrogen	Vol%	16.0
Carbon Monoxide	Vol%	24.7
Particulate Matter	mg/Nm3	5.0
Sulphur Dioxide	mg/Nm3	<2.8
Nitrogen Oxides	mg/Nm3	216
Hydrogen Sulphide	mg/Nm3	<2
Carbonyl Sulphide	mg/Nm3	62
Hydrogen Fluoride	mg/Nm3	<0.08
Cadmium	ug/Nm3	0.4
Chromium	ug/Nm3	1.6
Lead	ug/Nm3	21.9
Manganese	ug/Nm3	0.8
Nickel	ug/Nm3	4.9
Zinc	ug/Nm3	16.2
Mercury	ug/Nm3	1.8
Total Heavy Metals	ug/Nm3	55.0
Total Polycyclic Aromatic Hydrocarbons	ug/Nm3	243
Acetone	mg/Nm3	0.10
Hexane	mg/Nm3	1.22

Benzene	mg/Nm3	8.04
Toluene	mg/Nm3	0.05
Total VOCs	mg/Nm3	6.2

There were no reported issues or collection of residual ash/slag in either run due to the low ash content of the feedstock, however, runs should be repeated many times before any definitive assessments can be made. Analyses were done on the feedstock, char, and ash/slag to inform the mass balance and suggest possible uses of by-products in a circular economy. Refer to the report body for a full reporting of major and minor elements.

Table 3: Summary of Proximate and Ultimate Analyses

	Paunch	Plastic / Cardboard Mixed	Char	Slag	Unit
Gross Moisture	84.4	14.7	6.3	0.2	% w/w
Volatile Matter	68.4	73.1	4.9	n.d.	% w/w
Fixed Carbon	21.4	13.5	55.0	n.d.	% w/w
Ash Content	7.6	10.0	38.5	n.d.	% w/w
Bulk Density	0.91	0.10	0.18	1.83	Kg/m^3
Carbon	45.63	53.3	50.86	55.21	% w/w
Hydrogen	6.27	8.59	1.54	1.35	% w/w
Nitrogen	1.4	0.27	0.74	0.78	% w/w
Sulphur	0.24	0.52	0.28	0.29	% w/w
Oxygen	38.86	27.32	4.05	7.86	% w/w
Gross Calorific Value (Dry)	19.90	18.80			MJ / kg
Gross Calorific Value (Wet)	3.11	16.09			MJ / kg
Net Calorific Value (Dry)	18.61	17.03			MJ / kg
Net Calorific Value (Wet)	0.96	14.19			MJ / kg

Detailed *ex ante* cost-benefit analyses were completed taking into account Total Capital Investment (supply & installation), operating costs and benefits. Documentation of other co-benefits such as clean energy production, emissions reduction, cost reduction, co-product composition and value, and greenhouse gas lifecycle emissions reductions were considered.

The primary determinant of revenue is the application of the produced syngas, either for use in an existing gas boiler, minimising the invested capital, or directing to a syngas engine for power generation, a higher value but higher capital cost option. For comparison, 1 m3 of syngas at 9 MJ/m3 is worth approximately $0.12 when delivering heat in a gas boiler[1] and $0.20 generating power in a syngas engine[2]. For sites running a solid fuel boiler or with more-aggressive targets for decarbonisation, cost reduction, or energy security, power generation via syngas engine is an obvious choice.

The cost benefit analysis figures operated on are summarised below. The energy cost figures are typical for large consumers on the east coast, with the main variability being due to differences in state based landfill costs. For general municipal waste, these can range from[3]:

- QLD: $88 / tonne regional, $95 / tonne metro
- NSW: $87.30 / tonne in regional area, $151.60 / tonne in metro area
- VIC: $110.79 / tonne industrial regional, $125.90 / tonne industrial metro

Waste gate fee 117 $/t and 2%/yr CPI

Scenario	1	2	3
Capacity (tpd)	12.5	25	50
Capacity (tpa)	4,167	8,333	16,667
Total installed cost ($m)	4.4	6.8	10.6
EBITDA ($/yr, year 3)	319,776	1,243,336	2,858,096
Project IRR (%, real pretax, unlevered)	3.7	16.1	24.4
Project NPV ($)	-1,907,050	3,315,624	12,808,299
LCOE ($/MWh)	166	54	24.4

Waste gate fee 204 $/t and 2%/yr CPI

Scenario	1	2	3
Capacity (tpd)	12.5	25	50
Capacity (tpa)	4,167	8,333	16,667
Total installed cost ($m)	4.4	6.8	10.6
EBITDA ($/yr, year 3)	684,125	1,972,032	4,315,489
Project IRR (%, real pretax, unlevered)	13.5	26.6	37.6
Project NPV ($)	1,209,402	9,548,525	25,274,100
LCOE ($/MWh)	66	-46	-94

Figure 2: Cost benefit analysis scenarios

Conclusions from the above feasibility analyses are that available wastes produced by red meat processors are insufficient to match energy demand in its entirety i.e., only a portion of consumed power or thermal energy may be offset; small project economics can be very challenging without a higher waste gate fee or additional opportunity cost of landfill levies; and medium-to-large sized projects can be very economic. A key challenge of these scale of projects is the appetite of processors to accept outside organic wastes for recovering energy.

Benefit for Industry

Waste to energy projects provide the following benefits for RMPS:

- Reduced power costs

[1] Assumed 90% heat transfer efficiency and $15/GJ gas
[2] At 40% efficiency and $0.2 / kWh for power inclusive of volume and demand charge.
[3] Consider that there are further surcharges for regulated wastes including animal effluent and residues, food processing wastes, grease trap waste, liquid food processing waste, sewage sludge and residues, tannery wastes,

  - Expensive grid tariffs and the compounding year on year increases in prices present a significant risk to processors. W2E can deliver power cheaper over the life of plant, reducing operating costs.
- Reduced thermal energy costs
  - For RMPs on the east coast purchasing natural gas or LPG as a thermal fuel, this is a very large operating cost and continuity risk, able to be offset by burning syngas from gasification.
- Reduced waste disposal costs
  - Gasification can reduce the waste disposal costs paid by RMPs, particularly those located in metro areas or Queensland, where landfilling costs have suddenly increased by $75/t as of 1/7/2019, increasing by $5/t every year until 2023.
- Improved environmental outcomes and social license to operate
  - There is pressure from within the industry and the community to maintain the clean and green image of Australian red meat; W2E can aid in progressing towards the broad CN30 industry goal, individual business targets, international sustainability accreditation and circular economy solutions.
- Decreased reliance on fuels hauled / reticulated to site: onsite W2E provides energy security and a reduced reliance on fuels from third parties and / or energy utilities.
- Reduction in scope 1 and scope 2 greenhouse gas emissions
  - Scope 1 emissions may be reduced by offsetting thermal fossil fuels; scope 2 emissions may be reduced by reducing grid electricity consumption.
- Additional saleable products such as soil conditioner at a retail standard