Republic of the Marshall Islands Energy Future

Electricity Roadmap

Technical Note 02: Greenhouse Gas Emissions of Waste to Energy

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Summary

This technical note calculates and presents the expected potential reduction of greenhouse gases by using Waste to Energy (WTE) technology to partially displace the use of mineral diesel fuel to generate electricity in the Majuro, RMI context.

This technical note does not address the feasibility or performance of a WTE plant – this would require a detailed feasibility study. Instead it presupposes the performance of a WTE plant as proposed in an Entura prefeasibility study *TA-9225 RMI: Majuro Power Network Strengthening [1].*

The results suggest that such a 1 MWe Waste to Energy plant could potentially save up to 15.1 kilotonnes (kt) of CO_2-e (Carbon Dioxide equivalents) per year of operation. This total annual reduction consists of a reduction of 13.4 ktCO_2-e in the waste sector due to reducing Municipal Solid Waste to landfill emissions, as well as up to a further 1.7 ktCO_2-e due to replacing diesel fuel for electricity generation with Refused Derived Fuel (RDF). However, it is also apparent that the GHG savings will be very dependent on the composition of the waste dumped or combusted. If, for example, green waste is removed from the RDF to be composted, and additional waste oil is used in the WTE plant, the GHG benefits of WTE will be considerably less or even negative.

1 Background / Introduction

The Entura report *TA-9225 RMI: Majuro Power Network Strengthening* [1] described the potential performance of a 1 MWe Waste to Energy (WTE) gasifier and generator plant as part of a WTE prefeasibility study. Under the assumption that such a plant performs as described, this note examines the expected impact on greenhouse gas emissions (GHG) – in the Majuro context—of diverting Municipal Solid Waste (MSW) from landfill to WTE.

An annual quantity of 6.7 kt of MSW was identified as available on Majuro and suitable for processing into Refuse Derived Fuel (RFD), by removing non-combustibles, drying with excess thermal energy from the plant, and briquetting. Since this quantity would not be sufficient to run the plant at full capacity, an alternative option to supplement the feedstock with waste oil was also identified. Waste oil (e.g. engine lube changes from ships and gensets) is currently stockpiled and in need of disposal. The assumed electrical output of the WTE plant is shown in Table 1.

Table 1: Assumed WTE plant performance

Feedstock	Annual qty (tonne)	Lower heating value (MJ/kg)	Gross baseload power output (MW_e)
Raw Municipal Solid Waste	6,720		
Dried Refuse Derived Fuel	4,770	21	0.89
Waste Oil	330	47	Additional 0.14

The effect of a WTE generator on Majuro would affect national GHG emissions in a number of ways. First, the MSW converted to RDF would no longer decay in landfill, but would rather be combusted. Combustion results in carbon dioxide production rather than the methane production associated with decomposing organic material- methane being a much more potent greenhouse gas than carbon dioxide. In addition, burning biogenic materials is considered carbon neutral (i.e. not contributing to the greenhouse gas effect).

Second, the RDF will displace diesel fuel[1], reducing diesel fuel consumption and the resulting emissions.

Finally, combustion of RDF will include combustion of plastics and waste oil (non-biogenic carbon), so that carbon dioxide will be produced, which would not be the case if those plastics remained in landfill, or if the waste oil was disposed of by shipping off-island

2 Emissions reduction due to WTE

6.7 kt of Majuro MSW dumped at landfill would produce 13.4 $ktCO_2$-e over time[2 i]. This represents the reduction in waste emissions if this quantity of MSW was used for electricity generation rather than sent to landfill.

6.7 kt of Majuro MSW sorted into combustible materials and then combusted in a WTE plant would produce 3.2 $ktCO_2$-e[ii], however would save around 4.8 $ktCO_2$-e due to avoiding diesel

[1] Assuming the majority of electricity is produced by diesel generators rather than renewable energy
[2] The method used here to calculate emissions from landfill assumes that all emissions are attributed to the year the waste is deposited as per the mass balance method described in 1996 IPCC guidelines, rather than the first order decay method described in 2006 IPCC guidelines.

fuel for electricity production[iii]. Thus the potential net annual reduction in electricity emissions would be 1.7 ktCO_2-e per year. In total, diverting this quantity of MSW from landfill to WTE could potentially save up to 15.1 ktCO_2-e (i.e. save 2.24 tCO_2-e per tonne MSW).

6.7 kt of Majuro MSW combusted in a WTE plant along with 0.33 kt waste oil would produce 4.1 ktCO_2-e[iv], however would save around 5.6 ktCO_2-e due to avoiding diesel fuel for electricity production[v]. Thus the potential net annual reduction in electricity emissions would be 1.5 ktCO_2-e per year. In total, diverting this quantity of MSW from landfill to WTE, co-fired with waste oil, could potentially save up to 14.8 ktCO_2-e (i.e. save 2.21 tCO_2-e per tonne MSW).

3 Conclusion

Assuming WTE plant performance and RDF composition as described in the Entura report, a WTE plant on Majuro would have a favourable impact on national greenhouse gas emissions, potentially saving up to 15.1 ktCO_2-e per year of operation, consisting of a reduction of 13.4 ktCO_2-e in the waste sector due to reducing Municipal Solid Waste to landfill, as well as up to a further 1.7 ktCO_2-e per year due to displacing diesel fuel for electricity generation.

This favourable result is in part due to the high proportion of MSW of biogenic origin. Landfill methane emissions from biogenic MSW have been included in the calculations, but the carbon dioxide emissions from combustion of biogenic MSW have not been included, due to assuming a closed carbon cycle. (Note: If green waste and compostable materials were diverted from the waste stream, or if additional waste oil was included, these figures would need to be recalculated). Further reductions result from reducing the use of fossil fuels for electricity generation.

It is important to note that this technical note does not address the feasibility or performance of a WTE plant – this would require a detailed feasibility study.

4 References

[1] Hydro-Electric Corporation trading as Entura, FINAL REPORT TA-9225 RMI: Majuro Power Network Strengthening, Asian Development Bank, March 2018

[2] Why not burn waste lube oil as fuel, Southern Oil, http://www.sor.com.au/FAQRetrieve.aspx?ID=36406

5 Supporting calculations

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i. Using the giz-kfw-ifeu SWM-GHG Excel calculator (controlled dump/landfill without gas collection), with the waste composition of Table 2 column 2 (in turn from Table 10.10 of [1]), and a quantity of 6,721 MSW.

Table 2: Assumed Majuro MSW waste stream composition

Component	Collected MSW	WTE Feedstock (non-combustibles excluded)
Combustibles	**87.82%**	**100%**
Food waste	3.80%	3.49%
Garden and park waste	19.49%	25.98%
Paper, cardboard	22.52%	22.38%
Plastics	17.32%	17.25%
Textiles	4.23%	5.02%
Rubber, leather	4.33%	5.46%
Nappies (disposable diapers)	7.27%	10.37%
Wood	5.29%	7.53%
Mineral waste	0.00%	0.00%
Others	1.92%	2.51%
Non combustibles	**12.18%**	**0%**
Glass	3.51%	0%
Ferrous Metals	4.67%	0%
Aluminium	5.63%	0%

ii. [2] Using the giz-kfw-ifeu SWM-GHG Excel calculator (incineration), with the waste composition of 2, column 3, and a quantity of 5,900t MSW (87.82% of 6.721t) due to the removal of non-combustible materials. The non-combustible materials are assumed to produce no GHG emissions, and the ash residue is assumed to be of minor effect.

iii. The Entura report (table 10.14) has 6,721t MSW => 7,152 MWh electricity from WTE rather than diesel generators

7,152 MWh electricity => 1,509 tonne diesel savings (based on 4.74 kWh/kg, Pacific Power Utilities Benchmarking Report 2013&2014 Fiscal Years Table F1, assuming that adding 0.9MW baseload does not change the average efficiency of the diesel generators.)

Previous analysis of Majuro electricity emissions suggest 18.712 Gg diesel emits 59.700 Gg CO_2-e => 3.19 tCO_2-e per tonne diesel burned.

1,509 tonne diesel savings => 4,814 tCO_2-e savings

iv. 6,721 tpa MSW mixed with 333 tpa waste oil, Entura report table 10.14
6,721 tonne MSW incinerated as per iii
333 tonne waste oil incinerated emits 972 tCO_2-e (assuming 1 tonne waste oil incinerated emits 2.92 tCO_2-e [2])

v. The Entura report (table 10.14) has 6,7121t MSW + 333t waste oil => 8,272 MWh electricity
8,272 MWh electricity => 1,745 tonne diesel savings
1,745 tonne diesel savings => 5,567 tCO_2-e savings

t – metric tonne
tpa – metric tonnes per annum
Gg – giga-gram = kilo tonne
kt - kilo tonne
CO_2-e – carbon dioxide equivalent