Appendix 14 –Modelling of GHG Emissions

Section 1: GHG Inventory and Calculations

Section 2: Household Modelling of GHG Emissions

Section 1: GHG Inventory and Calculations

Construction Emissions

Project Area	Emissions Source	Emissions (tonnes CO2e)	Scope
Fuel Consumption	Construction plant and equipment	407.64	1
Electricity Use	Site Office	46.65	2
Materials	Steel & Concrete Production	6,524.78	3
Materials	Transport to site	406.43	3
Total		**7,385.50**	
	Annual emissions from construction amortised over 25 year life of plant	**295.42**	**t CO2e / year**

Site Equipment							
Equipment	# Units	Duration	Diesel Consumption rate (kL/month)	Total Diesel Consumption (kL)	Energy Content (GJ)	Emission Factor (kg CO2e/GJ)	Total GHG Emissions (t.CO2e)
Excavator	2	1	5.1	5.1	196.86	74.11	14.59
Grader	2	1	5.1	5.1	196.86	74.11	14.59
Piling Rig	1	3	7.9	23.7	914.82	74.11	67.80
Tower crane	1	6	7.9	47.4	1829.64	74.11	135.59
Mobile Crane	1	12	5.1	61.2	2362.32	74.11	175.07
						Total	**407.64**

Materials production emissions			
Material	Tonnes	Emission Factor (kg CO2e / kg)	GHG Emissions (t CO2e / tonne)
Steel	2,272.07	1.5469619	3,514.81
Concrete	15,786.32	0.19067006	3,009.98
		TOTAL	**6,524.78**

Site Office use	39.8736	mWh
	1.17	Emission factor
	46.65	Total GHG emissions (t.CO2e)

Construction Material Transport						
	Tonnes	Distance by sea (Km)	Emission Factor (kg CO2e / tonne Km)	Distance by road (Km)	Emission Factor (Kg CO2e / tonne Km)	**Total GHG Emissions (t CO2e)**
Steel	2,272.07	10823.088	0.016143	17	0.0609	**399.32**
Concrete	15,786.32			3	0.14999	**7.10**
					TOTAL	**406.43**

Operational Emissions

Scope	Emission Source	What used for	daily consumption	units	days of consumption/ year	Annual consumption	unit	Energy content (calorific Value)	Unit	Energy	Unit	emissions factor	Unit	Annual emissions	Unit
1	MSW - Biomass component	Normal operating fuel	420	tonnes	333.33	140000	tonnes	12.2	GJ/tonne	1,708,000.00	GJ/year	1.8	kgCO2e/GJ	3,074.40	tonnes CO2e
1	MSW - Non biomass component	Normal operating fuel	180	tonnes	333.33	60000	tonnes	10.5	GJ/tonne	630,000.00	GJ/year	88.9	kgCO2e/GJ	56,007.00	tonnes CO2e
1	Diesel	Start up, once per year	10588	Litres	2.00	21176	litres	38.6	GJ/kL	817.39	GJ/year	70.2	kgCO2e/GJ	57.38	tonnes CO2e
1	Wood	Start up, twice per year	60	tonnes	2.00	120	tonnes	16.2	GJ/tonne	1,944.00	GJ/year	1.3	kgCO2e/GJ	2.53	tonnes CO2e
2	Electricity use	Start up, once per year 1/3 of normal parasitic demand of 2100kW (for a 24 hour period)	16800	kWh	2.00	33600	kWh			33,600.00	kWh/year	1.16	kgCO2e/kWh	38.98	tonnes CO2e
2	Diesel	Transport of PIW to Landfill				6.4911888	kL	38.6	GJ/kL	250.5598877	GJ/year	70.46	kgCO2e/GJ	17.65	tonnes CO2e
													Total	**59,197.94**	**tonnes CO2e**

Proportion of Metropolitan Melbourne Residual Waste Bins that is Biomass derived (MRA Data)	
100% of Paper (paper/ cardboard/ LPB)	10.30%
100% of Food/ Organics (kitchen/ garden waste)	55%
100% of Timber (wood/ timber products)	1%
50% of nappies considered to be biomass derived (as per table 43 of National GHG account factors July 2018)	3.70%
Total	0.7

Annual GHG Emissions

Source	Energy (MJ)	GHG emissions (tCO2e)
Electricity from Grid	120,960	38.98
Diesel	817,394	57.38
Wood	1,944,000	2.53
Total	2,882,354	98.88

Source	Energy (GJ)	GHG emissions (tCO2e)
MSW - Biomass component	1,708,000.00	3,074.40
MSW - Non biomass component	630,000.00	56,007.00
Totals for Start-up	2,882.35	98.88
Annual total	2,340,882.35	59,180.28

Electricity Generation and Dispatch to Grid	
137,600.00	total mWh generated
16,800.00	mWh consumed internally
120,800.00	mWh to grid / year

Emissions from Disposal of PIW				
PIW Ash generated /year (tonnes)	5640	Full operation at 600t/day will generate 14.1t/day of Boiler ash and Baghouse dust	Assume stabilisation required before disposal and that this increases mass by 20%	So operation will generate 14.1 x 333.3333 3 x 1.2 = 5640 tonnes of ash / year
Trips to lyndhurst PIW landfill / year @30t / load	188	Assume use of general access articulated B-double with 30 tonne load for PIW Ash transport	Assume transport to Lyndhurst Cat B landfill	
Km travelled to Lyndhurst	11674.8			
Diesel consumed (kL)	6.4911888			

REA Emissions Profile

Scope 1, 2 and 3 Emissions from REA Facility		
Emission Source	Annual emissions	Unit
Processing of Residual MSW	59,081.40	tonnes CO2e
Emissions from facility start up	59.91	tonnes CO2e
Electricity required from NEM	38.98	tonnes CO2e
Transport of PIW for disposal	17.65	tonnes CO2e
Amortised Construction emissions	295.17	tonnes CO2e
Total Annual GHG Emissions	**59,493.11**	**tonnes CO2e**

Scope 1, 2 and 3 Emissions avoided by operation of REA Facility		
Emission Source	Annual Emissions	Unit
Electricity sourced from NEM	140,128.00	tonnes CO2e
GHG emissions from Landfill	155,600.00	tonnes CO2e
Transport Emissions	773.06	tonnes CO2e
Total Annual GHG Emisions Avoided	**296,501.06**	**tonnes CO2e**

Total Impact of REA Facility on GHG emissions from disposal of 600t/day of residual MSW (t CO2e / year)	
GHG Emissions Generated	59,493.11
GHG Emissions Avoided	296,501.06
Net annual emission reduction over BAU	**237,007.96**

Avoided GHG Emissions

Electricity Generation and Dispatch to Grid	
137,600.00	total mWh generated
16,800.00	mWh consumed internally
120,800.00	mWh to grid / year
140,128.00	**tCO2e / year to generate this amount of power at normal emissions intensity in Victoria**

Reduced waste transport emissions	
600	Tonnes / day
8	tonnes / garbage truck
75	Number of trips per day
41.8	Km / trip saved by going to REA rahter than Wyndham Landfill
3,135	Km saved / day
1,045,000	Km Saved / year
284.24	kL of diesel saved / year
773.06	**Tonnes CO2e saved per year**

Emissions generated from landfill in Municipal Melbourne (t CO2e)	
600	tonnes / day
200,000	tonnes / year
0.778	Emission Factor (t CO2e / tonne)
155,600.00	**t CO2e released if waste went to landfill**

Emission Factors

	Emission Factor (kg CO2e/GJ)								
		Scope 1				Source	Scope 3	**TOTAL**	Source
Source	Energy Content (GJ/tonne - solids) (GJ/kL - liquids)	CO2	CH4	N2O	Total CO2e (Scope 1)		CO2e	**CO2e**	
Combustion of Non-Biomass municipal materials	10.5	87.1	0.7	1.1	88.9	Table 1		**88.9**	No scope 3 estimate available
Combustion of Biomass municipal materials	12.2	0	0.7	1.1	1.8	Table 1		**1.8**	No scope 3 estimate available
Combustion of Diesel - stationary uses	38.6	69.9	0.1	0.2	70.2	Table 3	3.6	**73.8**	Table 40
Combustion of Dry Wood	16.2	0	0.1	1.2	1.3	Table 1		**1.3**	No scope 3 estimate available
Diesel Fuel - Heavy Vehicles (Euro IV or higher)	38.6	69.9	0.06	0.5	70.46	Table 4	3.6	**74.06**	Table 40
Diesel Fuel - Post-2004 Vehicles	38.6	69.9	0.01	0.6	70.51	Table 4	3.6	**74.11**	Table 40

	Emission Factor (kg CO2e/kWh)		
	Scope 2	Scope 3	**TOTAL**
Electricity Consumption (in Victoria)	1.07	0.1	**1.17**

	Emission Factor (t CO2e / tonne of waste to melbourne municipal		
Emissions from residual waste sent to landfill		Scope 1	**TOTAL**
			0.778

	Emission Factor	Unit
Site Office Power Use	21.3	W/m2

Embedded GHGs Emission Factor (kg CO2e / kg)	
Fine Aggregate	0.007584317
Coarse Aggregate	0.014458965
Cement	0.99393196
Steel	1.5469619

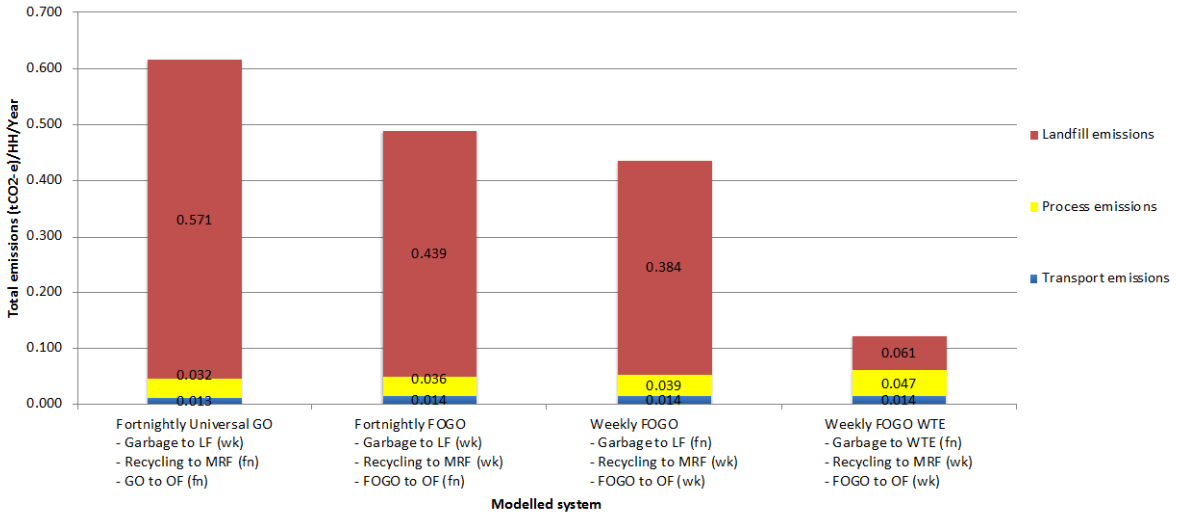
Truck Fuel Consumption		
Articulated Trucks	55.6	L/100km
Rigid Trucks	27.2	L/100km

Distance from REA to Lyndhurst Cat B Landfill	62.1	Km
Distance saved going to REA rather than Wyndham Landfill (one way)	20.9	Km

Section 2: Household Modelling of GHG Emissions

REA: Modeled on a typical Metropolitan Council:

CO2-e generation per household per annum



Raw Data:

	Fortnightly Universal GO - Garbage to LF (wk) - Recycling to MRF (fn) - GO to OF (fn)	Fortnightly FOGO - Garbage to LF (wk) - Recycling to MRF (wk) - FOGO to OF (fn)	Weekly FOGO - Garbage to LF (fn) - Recycling to MRF (wk) - FOGO to OF (wk)	Weekly FOGO WTE - Garbage to WTE (fn) - Recycling to MRF (wk) - FOGO to OF (wk)
Transport emissions	0.013	0.014	0.014	0.014
Process emissions	0.032	0.036	0.039	0.047
Landfill emissions	0.571	0.439	0.384	0.061
Total emissions	0.615	0.489	0.437	0.123

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21 August 2018

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VIA EMAIL ONLY

To whom it may concern,

Re: Assessment of net CO_2e emission per tonne of waste landfilled in metropolitan Melbourne.

This letter outlines MRA's assessment of the net CO_2e emission factor per tonne of residual waste sent by metropolitan Melbourne Councils to landfills operating within the metropolitan Melbourne catchment. This information is to be used for the purpose of a comparison against the net CO_2e emissions factor to process the same tonne of waste through REA's proposed Waste to Energy facility.

In making this assessment MRA has relied upon:

a) Average composition of the residual garbage bin for Melbourne metropolitan councils as determined by MRA through a review of audit data from a range of councils and Waste and Resource Recovery Groups to identify the average waste composition for each kerbside bin system. These compositions were validated through stakeholder engagement and research and are published by Sustainability Victoria's in Optimising Kerbside Collection - Supporting evidence and analysis[1];

b) An average methane capture rate by metropolitan Melbourne landfills of 45% of the gas produced from the decomposition of organic waste in landfill. A significant amount of decomposition occurs prior to completing the construction of the gas capture systems and final capping of each landfill cell[2]. Completion of the construction of the gas capture systems and final capping of each landfill cell are required prior to the landfill being able to effective capture and combust landfill gas; and

[1] SV-MRA Optimising Kerbside Collection - Supporting evidence and analysis. http://www.sustainability.vic.gov.au/Government/Waste-and-Resource-recovery/Kerbside-waste-and-recycling/Guide-to-preferred-standards-for-kerbside-collection-in-Victoria

[2] 45% is the gas capture rate used by the Clean Energy Regulator in the Source Separation of Organic Waste Methodology Determination. International authorities (such as the Intergovernmental Panel on Climate Change (IPCC)) suggest that this figure is as low as 20%. https://www.tandfonline.com/doi/abs/10.1080/20430779.2012.730798?src=recsys&journalCode=tgmm20

c) The National Greenhouse and Energy Reporting (NGER) Solid Waste Emissions Calculator (the "Calculator") to determination of CO_2e emission factor per tonne of waste, of composition as described in point a) above.

Method:

MRA has determined the CO_2e emission factor for metropolitan Melbourne council waste in a Victorian landfill using the calculation:

$$A = B\times(1-D) + C\times D$$

Where:

A = is the CO_2e emission factor of a tonne of council waste sent to a metropolitan landfill;

B= the CO_2e emission factor generated from a tonne of waste disposed in landfill in the absence of a landfill gas capture system;

C= the CO_2e emission generated from a tonne of waste disposed in landfill if 100% is of gas is captured and combusted through a gas capture system; and

D=The landfill gas capture efficiency of Victorian landfills (45%)

Results

By applying the National Greenhouse and Energy Reporting (NGER) Solid Waste Emissions Calculator MRA produced the following CO_2e emission factors:

B= 1.298

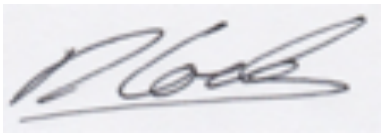
C= 0.143

By inserting these in the calculation $A = B\times(1-D) + C\times D$, MRA have determine the resulting CO_2e emission factors for metropolitan Melbourne landfill is: 0.778 t-CO_2e/tonne of council waste.

Other considerations

The production of renewable energy displaces the need for electricity generated through combustion of brown coal, providing a further CO_2e abatement. 100% of the renewable[3] energy content per tonne of waste processed at the REA facility is eligible for this purpose. Compared with landfill where only 45% of the gas is captured and hence is made available for renewable electricity generation and abatement claims.

Best Regards



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[3] Clean Energy Regulator, Guideline for Determining the Renewable Components in Waste for Electricity Generation. http://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/guidelines-determining-renewable-components-waste-electricity-generation-0312.pdf