Appendix F. Energy use and greenhouse gas emissions

Appendix F. Energy use and greenhouse gas emissions

This appendix provides detailed workings and assumptions related to the calculation of GHG emissions presented in Chapter 7. The methods used for the workings and calculations of GHG emissions accord with:

- EPA Victoria Publication 1658 *Works approval application guideline* (June 2017)
- The Greenhouse Gas Protocol (GHG Protocol) issued by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI)
- ISO 14064-1:2006 Greenhouse gases - Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

F.1 Construction

This section outlines the calculations for energy consumption and greenhouse gas emissions resulting from construction of the EfW plant.

F.1.1 Construction fuel consumption

Construction fuel has been identified for the following sources:

- Site vehicles used in management of construction (e.g. utility vehicles)
- Generators used to power site offices
- Construction plant and equipment (e.g. earth movers, drill rigs, cranes etc.)
- Trucks and trailers used for haulage of cut and fill material.

1.1.1.1 Site vehicle fuel consumption

The Transport Authorities Greenhouse Group (TAGG) 2013 provides a methodology for determination of fuel consumption associated with site management vehicles. This provides fuel consumption projections for utility vehicles for small (<$2m), medium ($2-10m) and large (>$10m) projects. These correspond to usage of 2, 4 or 10 Toyota Hilux vehicles per month respectively. Although the project value will be greater than that for a ‘large’ project it is assumed that a factor for 4 Hilux vehicles would be appropriate (given that this is not a road project, and so vehicles will not be needed to traverse long distances). As such, consumption of petrol only vehicles, at a rate of 2.05 kL per month is assumed. Multiplied by an expected construction duration of 36 months, this results in total petrol fuel consumption of 74 kL.

This results in the following emissions projections:

- 176 tCO_2e (Scope 1 – direct emissions from combustion)
- 9 tCO_2e (Scope 3 – emissions associated with production of the fuel).

1.1.1.2 Site office power

TAGG (2013) provides a methodology for determination of fuel consumption from generators used to power site offices, on the assumption that diesel powered generators are required. It is not clear at this stage whether power will be provided from an Australian Paper feeder on site, and as such this has been calculated separately.

The TAGG (2013) value for diesel consumption for an office (assuming a 500 m^2 of office space, equivalent of 2 star NABERS rating, operating 12 hours a day, Monday to Friday) is 3.1kL diesel per month of construction. Multiplied by an expected construction duration of 36 months, this results in total diesel fuel consumption of 112 kL.

This results in the following emissions projections:

- 302 tCO_2e (Scope 1 – direct emissions from combustion)
- 14 tCO_2e (Scope 3 – emissions associated with production of the fuel)

Construction plant and equipment

Construction scheduling is likely to be approximately 3 years in total, with 3 months allocated to earthworks and ground preparation, 9 months to piling and concrete pouring, and 2 years allocated to civil construction. Assumptions were made regarding the plant and equipment used for the construction phases, with fuel consumption factors derived from TAGG (2013) with proxy figures used where an appropriate figure was not available. The equipment projected and projected fuel consumption is shown in Table F.1.

Table F.1 : Construction equipment – diesel fuel consumption

Equipment	Number	Time in Use (months)	Consumption Rate (kL / month)	Diesel Consumption (kL)
Earthworks and group prep (1 year)				
Graders	3	3	5.1	46
Excavator	3	3	5.1	46
Piling Rig	1	9	7.9	71
Civil construction (2 years)				
Cranes	2	24	7.9	379
Rollers	2	24	4.8	230
Total				**773**

This results in the following emissions projections:

- 2,093 tCO_2e (Scope 1 – direct emissions from combustion)
- 96 tCO_2e (Scope 3 – emissions associated with production of the fuel)

Haulage of cut and fill material

It is AP's intention that all spoil generated by the Project during the construction phase is to be reused on the EfW Plant site or within the broader Mill site. It is expected that there will be a net positive amount of cut material and if reuse at the EfW Plant site or the broader Mill site is not possible, it will need to be transported off site for disposal. A material cut and fill balance was derived from 3-dimensional site modelling. From this, the net amount cut material to be exported was 42,500 m^3. This value was converted into tonnes using a medium density factor from the EPA (EPA, 2017). Factors from the UK (DBEIS, 2017) were used to determine emissions associated with haulage of the material to a local disposal point. The exact location for disposal has yet to be identified, but the proponent will be seeking local beneficial reuse or disposal, hence a 20km haulage distance was assumed.

This results in the following emissions projections:

- 62 tCO_2e (Scope 3)

F.1.2 Construction materials

Construction materials for the EfW plant include aggregate and concrete used in site establishment and foundations (including hard stand areas), steel used for the majority of process equipment and a range of other smaller materials used throughout the EfW plant.

To provide an indication of the embedded emissions associated with construction, emissions associated with major uses of aggregate, concrete and steel only was conducted. At this stage of the project, the preferred design has not been selected, so this is deemed appropriate. Estimations of the quantities of these materials were made by engineers working on the project feasibility study. These material quantities were multiplied by emissions factors derived from ISCA (2016). Table F.2 provides details of the construction material quantities assumed for this project.

Table F.2 : Construction Material Quantities

Material	Quantity (tonnes)
Aggregate	5,970
Concrete – 40MPa	3,572
Steel	6,923
Total	16,465

The relevant emissions factors used in the IS Materials Calculator were as follows:

- Aggregate – referenced to ‘Gravel, crushed, at mine/CH U/AusSD U’
- Concrete – referenced to ‘ISCA Calculator40MPA concrete 0%SCM’ (with the higher strength grade used as a conservative assumption); and
- Steel – referenced to ‘Worldsteel data, global Plate, C2G, GLO S & Welding, arc, steel/RER U/AusSD U’

This resulted in a total of 9,790 tCO2e GHG emissions:

- Aggregate – 65 tCO_2e (Scope 3)
- Concrete – 1,382 tCO_2e (Scope 3)
- Steel – 8,344 tCO_2e (Scope 3)

F.1.3 Construction Material Transport

Transport of construction materials to site was determined by assuming the following transport distances:

- Aggregate – 60km (one way) by road (assumed local supply);
- Concrete – 60km (one way) by road (assumed local supply);
- Steel – 9,617km by ship from China (assumed Shanghai) to Melbourne, and 150km by road from Melbourne to site;

Emissions factors for material transport were derived from DBEIS (2017) for the following transport types:

- Articulated truck (>33t) 100% Laden
- General Cargo Ship (Average)

Emissions factors referencing transport in tonne kilometres (i.e. scaling the emissions to transport of one tonne one kilometre) and multiplying by the tonnage carried and distance were used from this source. This resulted in the following Scope 3 emissions:

- Aggregate Transport – 21 tCO_2e (Scope 3)
- Concrete Transport – 24 tCO_2e (Scope 3)
- Steel Transport – 483 tCO_2e (Scope 3)
- A total of 528 tCO2e GHG emissions (Scope 3)

F.1.4 Vegetation Clearance (Loss of carbon sink)

Vegetation clearance was calculated using the vegetation removal calculation method provided in TAGG (2013). This tool assigns default values for loss of carbon sink for regions of Australia based on tonnes dry matter per hectare, and specific vegetation classes. Vegetation removed from the proposal was derived from ecological studies, which from state government Ecological Vegetation Classes (EVC) mapping shows that approximately 5 Ha of Open forest will be removed and is shown in Table F.3. It should be noted that this corresponds to plantation forest (not native vegetation or old growth forest) and as such the values attributed to loss of carbon sink will be an over-estimation. They are presented here as a ‘worst case’ value.

Table F.3 : Construction Vegetation Removal

Vegetation Class (Carbon Gauge Definition)	Area of Clearing (Ha)
Class A (Rainforest and vine thicket)	0
Class B (Eucalypt tall open forest)	0
Class C (Open forest)	5
Class D (Open woodlands)	0
Class E (Callitris forest & woodland)	0
Class F (Mallee & Acacia woodland)	NA
Class G (Open shrubland)	NA
Class H (Heathlands)	NA
Class I (Grasslands)	0
Total	0

Note that classes F, G and H are deemed not applicable for the area identified, as they are rarely identified in areas with a biomass class of 3 (relating to 100-150t dry matter per hectare – the class identified for the project location within Carbon Gauge).

For the above values entered into Carbon Gauge, a value of GHG emissions relating to vegetation removal is 1,535 tCO_2e (Scope 1).

F.2 Operation

This section outlines the calculations for energy consumption and greenhouse gas emissions resulting from operation of the EfW plant.

F.2.1 Facility Emissions – Waste Combustion

Emissions associated with the operation of the EfW plant include:

- Direct emissions from combustion of the waste. Waste includes both fossil and biogenic source carbon, and only fossil source carbon dioxide is accounted, but fossil and biogenic source methane and nitrous oxide;
- Emissions associated with ancillary fuel consumption (natural gas).

Waste Combustion - Carbon Dioxide

For this project, the carbon dioxide emissions associated with combustion of waste are determined according to the following equation:

$$\mathrm{E_{Com}} = C_{Fossil} \times C \rightarrow CO_2$$

Where:

- E_{Com} means the facility emissions in tCO_2e, which for this project is 340,885 tCO_2e (Scope 1).
- C_{Fossil} means the total carbon content of the waste combusted in the facility of fossil origin, in tonnes,
- $C \rightarrow CO_2$ is the conversion factor for carbon to carbon dioxide (and is equal to '(1/12) * 44')

The total fossil carbon content of the waste combusted in the facility is summed from the fossil carbon content of the individual compositional parts of the waste feedstock compositional fraction 'w' and determined using the following formula:

$$C_{Fossil,w} = W_{MW} \times FCF \times TCF$$

Where:

- $C_{Fossil,w}$ means the total carbon content, for waste compositional fraction 'w' combusted in the facility, of fossil origin, in tonnes. The sum of this value for all compositional fractions in this project is 92,969 tonnes.
- W_{MW} means the quantity of waste compositional fraction 'w' present in the waste feedstock, in tonnes. This figure has been derived from modelling undertaken and as presented in Table F.4). For this energy use and GHG assessment, it has been assumed that a split of 80% municipal solid waste (MSW) and 20% commercial and industrial waste (C&I) has been targeted. The waste categories present in the compositional modelling have been amended to fit the definitions in the NGER (Measurement) Determination and the IPCC categories for waste carbon, and fossil carbon content, and are shown in Table F.4 and Table F.5.
- FCF means the fossil carbon factor, which is expressed as a decimal, and represents the fossil carbon proportion of the incoming waste for waste compositional fraction 'w'. This is derived from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Chapter 2 Waste Generation, Composition and Management Data) as shown in Table F.5. The factors used for each waste compositional fraction are shown in Table F.4. The average fossil carbon content (or total carbon content) in this assessment, across all waste compositional fractions, is approximately 46%.
- TCF means the total elemental carbon proportion (by mass) of the waste compositional fraction 'w' (both fossil and biogenic origin carbon, expressed as a decimal. This is derived from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Chapter 2 Waste Generation, Composition and Management Data) as shown in Table F.5. Appropriate values for each material were derived from the 'total carbon content in % of dry weight', and the 'dry matter content in % wet weight'. The results of this are shown in Table F.4. It should be noted that Where 'miscellaneous combustible' and 'fines' materials were categorised from the waste composition data, these have been re-categorised as 'plastics' to give a conservative estimation of the fossil carbon present. Hazardous and waste electronic materials have been categorised as 'inert' – and it should be noted that these would represent contamination only, and are not accepted feedstock to the plant.

Table F.4 : Composition (80% MSW 20% C&I split) with total carbon and fossil carbon factors

Waste Compositional Fraction	Waste Feedstock (tonnes)	Total Carbon Factor	Fossil Carbon Factor	Fossil Carbon in Feedstock (tC / year)
Food	241,153	0.152	0	0
Paper and paper board	99,892	0.414	0.01	414
Garden and park	78,638	0.196	0	0
Wood and wood waste	9,146	0.425	0	0
Textiles	18,186	0.4	0.2	1,455
Sludge	-	0.239	0	0
Nappies	19,826	0.28	0.1	555

Waste Compositional Fraction	Waste Feedstock (tonnes)	Total Carbon Factor	Fossil Carbon Factor	Fossil Carbon in Feedstock (tC / year)
Rubber and Leather	2,614	0.5628	0.2	294
Inert Material	30,120	0.027	1	99813
Plastics	119,250	0.75	1	89,438
Metals	14,038	NA	NA	
Glass	17,138	NA	NA	
Total	**650,000**			**92,969**

Table F.5 : Default dry matter content, DOC content, total carbon content and fossil carbon fraction of different MSW components (Source 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Chapter 2 Waste Generation, Composition and Management Data)

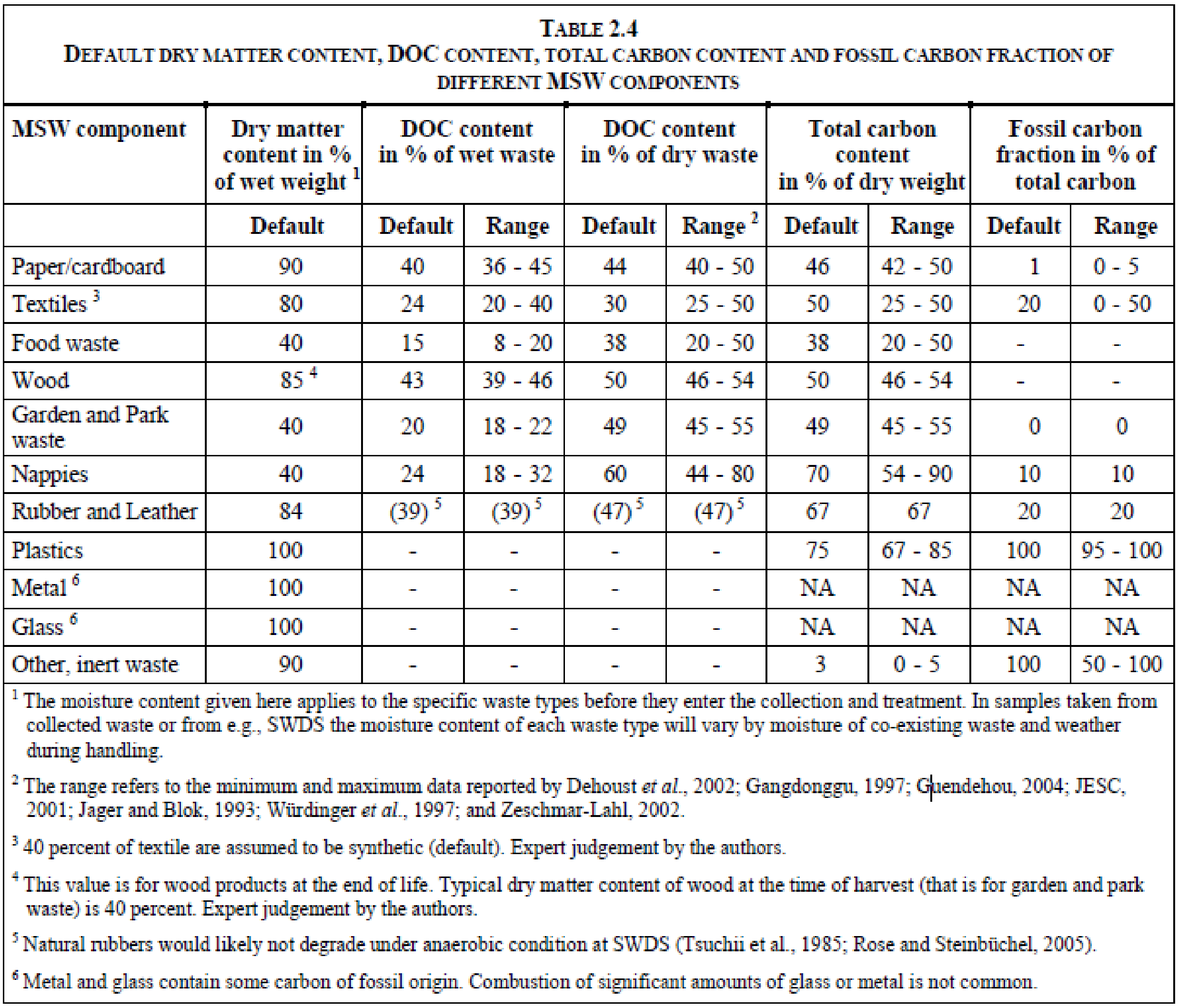

TABLE 2.4
DEFAULT DRY MATTER CONTENT, DOC CONTENT, TOTAL CARBON CONTENT AND FOSSIL CARBON FRACTION OF DIFFERENT MSW COMPONENTS

MSW component	Dry matter content in % of wet weight[1]	DOC content in % of wet waste		DOC content in % of dry waste		Total carbon content in % of dry weight		Fossil carbon fraction in % of total carbon	
	Default	Default	Range	Default	Range[2]	Default	Range	Default	Range
Paper/cardboard	90	40	36 - 45	44	40 - 50	46	42 - 50	1	0 - 5
Textiles[3]	80	24	20 - 40	30	25 - 50	50	25 - 50	20	0 - 50
Food waste	40	15	8 - 20	38	20 - 50	38	20 - 50	-	-
Wood	85[4]	43	39 - 46	50	46 - 54	50	46 - 54	-	-
Garden and Park waste	40	20	18 - 22	49	45 - 55	49	45 - 55	0	0
Nappies	40	24	18 - 32	60	44 - 80	70	54 - 90	10	10
Rubber and Leather	84	(39)[5]	(39)[5]	(47)[5]	(47)[5]	67	67	20	20
Plastics	100	-	-	-	-	75	67 - 85	100	95 - 100
Metal[6]	100	-	-	-	-	NA	NA	NA	NA
Glass[6]	100	-	-	-	-	NA	NA	NA	NA
Other, inert waste	90	-	-	-	-	3	0 - 5	100	50 - 100

[1] The moisture content given here applies to the specific waste types before they enter the collection and treatment. In samples taken from collected waste or from e.g., SWDS the moisture content of each waste type will vary by moisture of co-existing waste and weather during handling.

[2] The range refers to the minimum and maximum data reported by Dehoust *et al.*, 2002; Gangdonggu, 1997; Guendehou, 2004; JESC, 2001; Jager and Blok, 1993; Würdinger *et al.*, 1997; and Zeschmar-Lahl, 2002.

[3] 40 percent of textile are assumed to be synthetic (default). Expert judgement by the authors.

[4] This value is for wood products at the end of life. Typical dry matter content of wood at the time of harvest (that is for garden and park waste) is 40 percent. Expert judgement by the authors.

[5] Natural rubbers would likely not degrade under anaerobic condition at SWDS (Tsuchii et al., 1985; Rose and Steinbüchel, 2005).

[6] Metal and glass contain some carbon of fossil origin. Combustion of significant amounts of glass or metal is not common.

Waste Combustion - Methane and Nitrous Oxide

Methane and nitrous oxide emissions associated with combustion of waste fuel feedstock are determined in line with guidance provided in IPCC (2006). This provides standard factors for estimation of these greenhouse gases based on waste throughput. The factors are identified in Chapter 7, and when multiplied by the intended waste throughput (650,000 tonnes per year) result in emissions of:

- Methane – 3 tCO_2e / year (Scope 1)
- Nitrous oxide – 10,847 tCO_2e / year (Scope 1)

F.2.2 Facility Emissions – Other Fuel and Electricity Consumption

In addition to waste as a fuel feedstock, the project will also use natural gas on occasions when the fuel mix doesn't have sufficient calorific value to allow combustion temperatures to be maintained at the correct level. This may occur when, for example, a large quantity of waste containing garden or kitchen waste enters the combustion chamber. This is not a planned scenario, and good mixing of the waste feedstock will assist to avoid it. This value cannot be accurately predicted, but an approximate figure used in this assessment is that natural gas will represent 1% of waste throughput on an energy basis.

Assuming that the waste feedstock has an approximate calorific value of 9.4 MJ/kg, and that there is waste throughout of 650,000tpa, this would require 61,100 GJ of natural gas per year, resulting in emissions of:

- 3,148 tCO_2e / year (Scope 1)
- 238 tCO_2e / year (Scope 3).

The site will also operate a diesel generator (approximately 6MW power output) to support operations in time of shutdown. This is not expected operation and so is maintained for non-expected periods only. The anticipated fuel consumption associated with this use is not material, and hence has been not included in the assessment.

However, it is possible that this generator will be operated during periods of peak electricity usage in the National Electricity Market to provide peaking power. The assessment assumes that this will be for approximately 160 hours per year. Based on performance statistics for a 5.85 MW Wärtsilä 6L50DF generator, this would result in fuel consumption of 213kL of diesel per year, resulting in the following emissions:

- 578 tCO_2e / year (Scope 1)
- 30 tCO_2e / year (Scope 3).

In addition, the generated electricity would offset emissions for the use of the electricity by others. This would be 936MWh per year. Applying the same electricity generation emissions factor as that described in Chapter 7 for electricity generated by the EfW plant (also described later in this appendix), this would result in the following emissions offsets:

- 768 tCO_2e / year (Scope 2).

F.2.3 Logistics

Logistics modelled includes:

- Train delivery of waste from metro Melbourne to Maryvale (and return journey for containers). Assumption include 150,000tpa of waste via this route, with a one-way distance of 150km. In addition, there are 4,762 containers weighing 4 tonnes each
- Truck delivery of waste from SE Melbourne to Maryvale (and return journey for trucks). Assumptions include 416,000tpa of waste delivered by truck (5,833 movements per year) of a one-way distance of 125km. Trucks are modelled both fully laden and empty
- Truck delivery of waste from Gippsland to Maryvale (and return journey for trucks). Assumptions include 84,000tpa of waste delivered by truck (both direct delivery and bulk hauled)) and distances split between local and regional. Trucks are modelled both fully laden and empty
- Truck removal of Bottom Ash (BA) to landfill in Melbourne – assuming that 22% of the input waste volume leaves as Bottom Ash, utilising empty containers to haul waste to Maryvale on the return journey, and travelling 123km to landfill

- Truck removal of Air Pollution Control (APC) residue to landfill (and empty return trips for trucks) – assuming that 4% input waste volume leaves as APC residue in trucks, transported 131km to landfill. Both empty outward and fully laden return is modelled
- Fuel used in waste handling equipment on site, including:
  - Unloading containers from train to ground; ground to transfer tipping truck with reach stacker; load internal transfer tipping truck with reach stacker; move container to tipping hall; tip to empty; return to empty container stack area; unload empty container with reach stacker to stack or to train if available
  - Assume 31.5 t / container – and approximately 60 containers per day to / from train; Worst case = 4 lifts per receive from train-empty-stack-load train @ 2 mins / lift = 480 mins lifting time = 8 hours reach stacker working per day; Estimate reach stacker fuel consumption 100 l / hour = 800 l / day = **208 klpa**
  - Estimate internal transfer truck fuel consumption 60 l / with 10 hours per day operation = 600 l / day = **156 klpa.**

The results of the assessment are presented in Table F.6.

Table F.6 : Logistics Operations – GHG Emissions

Stage	Total (tCO_2e)	Carbon Dioxide (tCO_2e)	Methane (tCO_2e)	Nitrous Oxide (tCO_2e)
Metro Train Waste Delivery (Scope 3)	861	852	1	8
Metro Train Return Journey for Containers (Scope 3)	97	96	0	1
SE Melbourne Truck Delivery (Fully Laden) (Scope 3)	3,545	3,505	1	39
SE Melbourne Truck Return Journey (Empty) (Scope 3)	479	470	0	9
Gippsland Waste Delivery (Fully Laden) (Scope 3)	229	226	0	3
Gippsland Return Journey (Empty) (Scope 3)	246	242	0	5
Transport of waste to site	5456			
Train removal of IBA to landfill (Scope 3)	1,026	1,015	0	11
Trucks removal of APC residue / boiler ash to landfill (Scope 3)	199	196	0	2
Empty return trip for truck (Scope 3)	56	55	0	1
Transport of residues to landfill	1153			
Fuel used in waste handling equipment on site (Scope 1)	986	982	1	3
Total	**7,724**	**7,639**	**4**	**81**

F.2.4 Avoided emissions from Landfill Waste

Landfill baseline emissions are determined using a method adapted from the ERF Carbon Credits (Carbon Farming Initiative—Alternative Waste Treatment) Methodology Determination 2015

From the ERF AWT method – the following equation (Equation 4 in the ERF AWT method) is used to determine the methane generation potential of the degradable organic carbon content in the waste feedstock to the plant:

$$\mathrm{M_B} = \sum_{w} (WM_{W} \times DOCW \times DOCF_{,W}) \times MCF \times WLFG_{,CH4} \times FC_{\rightarrow CH4}$$

Where (interpreted for this assessment):

- M_B means the methane generation potential of the degradable organic carbon content in the waste feedstock processed per year, in tonnes CH_4, which for this assessment is 42,306 tCH_4
- WM_W means the quantity of waste compositional fraction W present waste feedstock, in tonnes (as shown in Table F.4
- DOCW means the degradable organic carbon value for waste compositional fraction w mentioned in section 5.12 of the NGER (Measurement) Determination.
- $DOCF_W$ means the fraction of degradable organic carbon dissimilated for waste compositional fraction w mentioned in section 5.14A of the NGER (Measurement) Determination.
- MCF means the methane correction factor for aerobic decomposition mentioned in section 5.14B of the NGER (Measurement) Determination (set as ‘1’ for aerobic decomposition).
- $WLFG_{CH4}$ means the fraction, by volume of methane generated in landfill gas, mentioned in section 5.14C of the NGER (Measurement) Determination (set as ‘0.5’ in accordance with the 2017 NGER (Measurement) Determination).
- $FC_{\rightarrow CH4}$ means 1.336, being the factor to convert a mass of carbon to a mass of methane.

The above formula was applied to the waste volumes assumed as feedstock to the plant (and identified in Table F.4).

The sum of the methane generation potential of each waste mix type is then converted to baseline landfill emissions using the following formula, also taken from (Equation 3 of) the ERF AWT method:

$$E_B = (1 - W_{LFG}) \times M_B \times (1 - OF_{LF}) \times GWP_{CH_4}$$

Where (interpreted for this assessment):

- E_B means the baseline Emissions, in tonnes CO_2-e, which for this assessment is 523,531 tCO_2-e (Scope 3)
- W_{LFG} means the average capture rate for methane emissions from landfill in the State or Territory in which the project is located (45% (or 0.45) for Victoria)
- M_B means the methane generation potential of the degradable organic carbon content in waste feedstock processed per year, in tonnes CH_4, worked out using the previous formula
- OF_{LF} means the oxidation factor for near surface methane in landfill mentioned in subsection 5.4(1) of the NGER (Measurement) Determination (set as ‘0.1’ in accordance with the 2017 NGER (Measurement) Determination).
- GWP_{CH4} means the value specified as the Global Warming Potential for methane in regulation 2.02 of the NGER Regulations (set as ‘25’ in accordance with the 2017 NGER (Measurement) Determination).

F.2.5 Avoided emissions from displaced grid electricity

The displaced electricity emissions associated with supply of electricity to the project (and to the grid) is determined in accordance with the displaced electricity equations of the ERF *Carbon Credits (Carbon Farming Initiative – Coal Mine Waste Gas) Methodology Determination 2015*

Equation 28 of the CMWG method outlines the calculation for the displaced electricity emissions, which (edited for this project) is:

$$A_G = NEG_P \times EF_{Elec}$$

- A_G means the displaced electricity emissions from electricity production (determined for 1 year), in tonnes CO_2-e, which for this project is 227,387 tCO_2e (Scope 2).
- NEG_P means the net amount of electricity produced by electricity production devices as part of the project (determined for 1 year), in megawatt hours which for this assessment is which for this project = 277,301 MWh.
- EF_{Elec} means:
    - for electricity supplied to an electricity grid that is a grid in relation to which the NGA Factors document, in force on the declaration day, includes an emissions factor—that factor, in kilograms CO2-e per kilowatt hour (or its equivalent of tonnes CO_2e per megawatt hours).

Note that the Emissions Factors used for ERF methods (and for this assessment) differ from those used for annual emissions reporting, and for the National Electricity Market (including Victoria) is 0.82 tCO_2e / MWh.

The amount of electricity produced is determined in accordance with Equation 29 of the CMWG ERF Method:

$$NEG_P = TEG - \Big(FSL + AUX + \big(DEG \times (1 - MLF)\big)\Big)$$

Where (adapted for this assessment):

- NEG_P means the net amount of electricity produced by installed and existing electricity production devices as part of the project in the reporting period, in megawatt hours, which for this project = 265,066MWh.
- TEG means the total amount of electricity produced as part of the project in the reporting period, in megawatt hours, which for this project is 42.321MW x 95% availability x 8,000 hours = 321,640MWh.
- FSL means the amount of electricity produced using energy sources that are not solid waste by installed electricity production devices, in megawatt hours (assumed to be zero for this project – emissions from ancillary fuels used in the facility are captured separately and not subtracted here).
- AUX means the auxiliary loss for the project in the reporting period, in megawatt hours, which for this project is 5.834MW x 95% availability x 8,000 hours = 44,338MWh.
- DEG means the amount of electricity transmitted or distributed as part of the project in the reporting period (other than electricity used by installed and existing electricity production devices as part of the project or the local distribution network), in megawatt hours, which for this project is hours = 277,301 MWh.
- MLF means the marginal loss factor for the project, as the majority of the electricity generated will be used on site, is set to ‘1’.

F.2.6 Avoided emissions from displaced natural gas consumption (for on-site steam production

In addition to producing electricity, the site will also produce steam energy output, which will be used at the Maryvale site within the pulp and paper production process. The steam output from the facility will be 87.29 MW over 8,000 hours’ operation (with 95% availability), resulting in production of 663,432 MWh steam (or 2.39 PJ).

This steam output will offset the mill’s requirement for steam generated in gas boilers. Assuming that these boilers produce steam with 85% generation efficiency then they would require 2.81 PJ of natural gas. The greenhouse gases associated with this offset gas are 144,791 tCO_2e (Scope 1) and 10,958 tCO_2e (Scope 3).

F.2.7 Electricity and Steam Carbon Intensity

The carbon intensity of the electricity and steam generated as part of the process are useful value for comparing the energy generated by the EfW plant with other forms of energy generation. This has been calculated in accordance with the GHG Protocol Calculator: Allocation of Emissions from a Combined Heat and Power (CHP) Plant (GHG Protocol, 2006).

This method uses the following approach:

- A = Annual Total direct emissions from CHP facility (tCO_2e)
- B = Annual Steam output per (district heat, process heat, other steam) (kWh)
- C = Annual Power output (kWh)
- D = Assumed efficiency of typical steam production (fraction)
- E = Assumed efficiency of typical power production (fraction)
- F = Emissions share steam production (tCO_2e). Calculated using the formula: F = A * {(B / D) / [(B / D) + (C / E)]}
- G = Emissions share electricity production (tCO_2e). Calculated using the formula: G = A - F
- H = Emissions factor – steam (tCO_2e / kWh). Calculated using the formula: H = F / B
- I = Emissions factor – electricity (tCO_2e / kWh). Calculated using the formula: I = G / C

For this assumed energy production efficiencies were assumed of:

- 29.1% for electricity (277,301,200kWh exported in total); and
- 60.2% for steam (780,511,059kWh exported in total).

Based on total emissions direct emissions of 384,179tCO_2e / year (relating to waste and ancillary fuel combustion), the resulting carbon intensity factors for electricity and steam production are:

- 0.54 tCO2e/MWh for electricity; and
- 0.26 tCO2e/MWh for steam

F.2.8 R1 Value

As taken from EPA publication 1559.1 (Guideline: Energy from waste):

For thermal processes, proponents must demonstrate that the proposal targets genuine energy recovery. As most EfW technologies produce a fuel or gas instead of energy, the overall environmental benefits will depend not only on the thermal treatment step but also on the energy conversion technology (combustion) to which it is coupled and how much of the produced energy is used to run the overall process. The important factor in assessing any plant is therefore the overall efficiency net of any energy required to run the process. Depending on the type of facility, the thermal efficiency should be assessed as follows:

- Where waste or RDF is used as fuel replacement for co-combustion in an existing facility, the proponent must demonstrate through a mass balance that the traditional fuel required will be reduced.
- For dedicated EfW plants, the proponent should demonstrate the thermal efficiency of the proposed technology using the R1 Efficiency Indicator as defined in the European Union’s Waste Framework Directive 2008/98/EC (WID). For a plant to be considered a genuine energy recovery facility, R1 will be expected to be equal or above 0.65. Alternatively, if R1 is below 0.65, proponents will be expected to provide a justification as to why this value cannot be reached.

$$R_1 = \frac{E_p - \left(E_f + E_i\right)}{0.97 \times \left(E_w + E_f\right)}$$

Where:

E_p = annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (GJ/year) which for this project is 5,637,739 GJ

E_f = annual energy input to the system from fuels contributing to the production of steam (GJ/year) which for this project is 30,550 GJ

E_w = annual energy contained in the treated waste calculated using the net calorific value of the waste (GJ/year) which for this project is 6,110,000 GJ

E_i = annual energy imported excluding E_w and E_f (GJ/year) which for this project is 445,557 GJ

0.97 = factor accounting for energy losses due to bottom ash and radiation.

This produces an R1 result of 0.87.

Note that the figures above were generated using a thermal engineering model (Thermoflow) of the EfW Plant.

F.3 References

AGEIS (2017) – Australian Greenhouse Emissions Information System, 2015 Data, Accessed at http://ageis.climatechange.gov.au/

Carbon Credits *(Carbon Farming Initiative—Alternative Waste Treatment) Methodology Determination 2015*, Accessed at: https://www.legislation.gov.au/Details/F2015L00060

Carbon Credits (*Carbon Farming Initiative – Coal Mine Waste Gas) Methodology Determination 2015*. Accessed at: https://www.legislation.gov.au/Details/F2016C01045

Carbon Gauge (2013) – Carbon Gauge GHG Calculator for Road Projects - version 01.130612, 2013, VicRoads

CER (2017) - 2015–16 Greenhouse and energy information for designated generation facilities, 2017, Clean Energy Regulator. Accessed at http://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/electricity-sector-emissions-and-generation-data/electricity-sector-emissions-and-generation-data-2015-16

DBEIS (2017) – (UK) Department for Business, Energy & Industrial Strategy, Greenhouse gas reporting: conversion factors 2017, accessed at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2017

EPA (2013) - Energy from Waste, Publication 1559 December 2013, Victorian EPA, Accessed at: http://www.epa.vic.gov.au/~/media/Publications/1559.pdf

EPA (2017) - Waste Materials – Density Data, accessed at:http://www.epa.vic.gov.au/business-and-industry/lower-your-impact/~/media/Files/bus/EREP/docs/wastematerials-densities-data.pdf

GHG Protocol (2006) – Greenhouse Gas Protocol, Allocation of GHG emissions from a combined heat and power (CHP) plant (Calculation Tool), 2006, Accessed at http://www.ghgprotocol.org/calculation-tools#cross_sector_tools_id

IPCC (2006) - 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5 Incineration and Open Burning of Waste, Accessed at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_5_Ch5_IOB.pdf

ICE (2017) – Institute of Civil Engineers - Cory Riverside Energy: A Carbon Case. Accessed at https://www.ice.org.uk/ICEDevelopmentWebPortal/media/Documents/Disciplines%20and%20Resources/Case%20Studies/Cory-Riverside-Energy-A-Carbon-Case.pdf

ISCA (2016) – Infrastructure Sustainability Materials Calculator Version 1.2, Release date 30/03/2016, Infrastructure Sustainability Councils of Australia

NGA 2017 – National Greenhouse Accounts (NGA) Factors July 2017, Australian Government Department of the Environment and Energy

TAGG (2013) - Greenhouse Gas Assessment Workbook for Road Projects, 2013, Transport Authorities Greenhouse Group