Australian Capital Territory

Climate Change and Greenhouse Gas Reduction (Greenhouse Gas Emissions Measurement Method) Determination 2016

Disallowable instrument DI2016–257

made under the

Climate Change and Greenhouse Gas Reduction Act 2010 (the Act), s 11 (Measuring greenhouse gas emissions – determinations)

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1 Name of instrument

This instrument is the *Climate Change and Greenhouse Gas Reduction (Greenhouse Gas Emissions Measurement Method) Determination 2016.*

2 Commencement

This instrument commences on the day after it is notified.

3 Determination of method for measuring greenhouse gas emissions

I determine the method for measuring the amount of greenhouse gas emissions in the ACT as set out in the schedule.

Note The Greenhouse Gas Emissions Measurement Method is used, under s12 of the *Climate Change and Greenhouse Gas Reduction Act 2010*, by an independent entity to prepare a report for the Minister about greenhouse gas emissions in the ACT for the year.

4 Revocation

I revoke the *Climate Change and Greenhouse Gas Reduction (Greenhouse Gas Emissions Measurement Method) Determination 2015* (DI2015-264).

Simon Corbell MLA
Minister for the Environment and Climate Change
5 September 2016

Schedule to the Climate Change and Greenhouse Gas Reduction (Greenhouse Gas Emissions Measurement Method) Determination 2016

1. Objects of the determination

This determination sets out the method for the measurement of greenhouse gas emissions arising from sources, or attributable to activities, located within the geographic boundary of the Australian Capital Territory (ACT).

2. Application of the determination

The method determined in this instrument must be used to measure the amount of greenhouse gas emissions in the ACT for the year (the annual emissions amount) in the annual report prepared by an independent entity as required under section 12 of the Act.

3. Greenhouse gas emissions covered

The emissions covered by this determination are:

- Scope 1 emissions from:
  - fuel combustion
  - fugitive emissions from fuels
  - industrial processes
  - agriculture
  - land use, land use change and forestry
  - waste.
- Scope 2 emissions from electricity consumption in the ACT, adjusted for scope 3 electricity transmission and distribution losses.

4. Definitions

In this Determination:

Action Plan 2 means AP2 – A new climate change strategy and action plan for the Australian Capital Territory

carbon dioxide equivalence or ***CO2-e***, means the amount of greenhouse gas multiplied by its specific global warming potential.

dry wood means wood that:

a) has a moisture content of 20% or less if the moisture content is calculated on a wet basis; and
b) is combusted to produce heat.

emission factors refer to the kilograms of carbon dioxide equivalent emitted per unit of activity.

energy content factor, for a fuel, means gigajoules of energy per unit of the fuel measured as a gross calorific value.

fugitive emissions means the release of emissions that occur during the extraction, processing and delivery of fossil fuels.

global warming potential refers to an index (on a 100 year time horizon) representing the combined effect of the differing times greenhouse gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation.

greenhouse gas emissions has the meaning given by the *Climate Change and Greenhouse Gas Reduction Act 2010*.

GreenPower means renewable energy purchased in accordance with the Australian Government's GreenPower program.

scope 1 emissions refer to the emission of greenhouse gases directly resulting from an activity, or series of activities (including ancillary activities).

scope 2 emissions refer to the emission of greenhouse gases that occurs outside the ACT as a consequence of using grid-supplied electricity, heating and/or cooling within the ACT.

scope 3 emissions refer to the emission of greenhouse gases not included as a scope 1 or scope 2 emission that occur outside the ACT as a result of activities within the jurisdiction due to use of goods and services. Scope 3 emissions include electricity transmission and distribution losses.

5. Method for calculating emissions from stationary energy

The method for calculating the emissions from stationary energy will be made using the equations presented below:

5.1 Electricity

The calculation of Scope 2 emissions attributable to consumption of electricity by ACT consumers using the market based method is particularly complex because of the many different sources of zero emission electricity for which ACT consumers are paying and because of the interaction between the physical and the financial transactions in the National Electricity Market. Relating to this latter point, the calculation relies on the propositions that the ACT is part of the NSW region of the NEM, that the NSW region exchanges electrical energy with Victoria and Queensland through the relevant interconnectors, that interconnector flows are sourced from the marginal source of generation in each region, and that the marginal source in all three regions is coal fired generation.

In order to make the steps in the calculation somewhat easier to follow, the methodology is structured in three parts.

The first part calculates the total quantity of zero emission electricity (electricity supplied by renewable generators) being paid for by ACT electricity consumers. This includes three components:

- electricity being supplied to the National Electricity Market under contract with the ACT government,
- the ACT share of national Large Renewable Energy Target scheme generation, and
- the ACT share of "old" (pre-RET) hydro generation (mainly from the Snowy Hydro power stations) forming part of the generation supplying the NSW pool of the National Electricity Market.

The second part calculates the average emissions intensity of non-renewable electricity being supplied through the National Electricity Market in the NSW region. The third part calculates how much of this electricity is required to meet the total demand for electricity by ACT consumers (including electricity lost in the ActewAGL distribution network) and the total quantity of emissions associated with that quantity of electricity, based on the average emissions intensity of NSW region non-renewable electricity, as calculated in the preceding part of the overall calculation.

5.1.1 Calculate total renewable electrical energy being paid for by ACT electricity consumers

5.1.1.1 LRET purchases

$$S_1 = \alpha_i \times (\beta_i + \gamma_i)$$

Where,

S_1 = Total LRET purchases;
α_i = Renewable power percentage;
β_i = Total electricity supplied to residential customers;
γ_i = Total electricity supplied to non-residential and other customers.

Data sources:

α_i - Clean Energy Regulator http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/The-certificate-market/The-renewable-power-percentage.
β_i - ActewAGL Distribution (a component of the annual RIN submission to the AER).

5.1.1.2 GreenPower

$$S_2 = \sum_i \delta_i$$

Where,

S_2 = Total GreenPower sales in the ACT;
$\sum_i \delta_i$ = Sum of Quarterly GreenPower Sales in the ACT

Data sources:

$\sum_i \delta_i$ = National GreenPowerTM Accreditation Program. Annual Compliance Audit for 1 January 2013 to 31 December 2013 http://www.greenpower.gov.au/Business-Centre/Annual-Audit/~/media/7E75EC20541B4CA39E97DE708D1816B6.pdf (see Table 8: Summary of GreenPower Sales 2013 (MWh)).
Also National GreenPower Accreditation Program Status Report. Executive Summary. Quarterly status of National GreenPower Accreditation Program http://www.greenpower.gov.au/~/media/Business%20Centre/Quarterly%20Reports/2014_Q4_Report.pdf

5.1.1.3 Rooftop PV

$$S_3 = \sum_i \varepsilon_i$$

Where,

S_3= Total Rooftop PV output;
$\sum_i \varepsilon_i$ = Sum of metered output in the year of all PV installations with capacity less than 200 kW in the following categories:

- supplied with ACT feed in tariff (f.i.t.)
- supplied under gross metering but without f.i.t.
- supplied under net metering.

Data sources:

$\sum_i \varepsilon_i$ - As advised by ActewAGL Distribution in regular reports to the ACT Environment and Planning Directorate

5.1.1.4 Below Baseline NSW region NEM renewable generation

For each of the following Stations: Hume, Blowering, Guthega, Tumut 1, Tumut 2, Tumut 3 (net of pump energy input)[i]:

$$S_4 = \sum_{n=1}^{6} \left(Min\left(ES_n, \left(\frac{\omega_n + \varphi_n}{2} \right) \right) \right) \times \left(\frac{ED}{(ND_{NSW} - NG_{NSW} - TL_{NSW})} \right)$$

Where,

For each of the following Stations:
1 = Hume;
2 = Blowering;
3 = Guthega;
4 = Tumut 1;
5 = Tumut 2;
6 = Tumut 3 (net of pump energy input);
$Min\left(ES_n, \left(\frac{\omega_n+\varphi_n}{2}\right)\right)$ = the lesser of:

- ES_n = electrical energy sent out in the inventory year, and
- $\frac{\omega_n+\varphi_n}{2}$ = the simple average of the RET Baseline in the calendar year covering the first half of the reporting year and the calendar year covering the second half of the reporting year.

ED = Electrical energy supplied by TransGrid to ActewAGL Distribution;
ND_{NSW} = Total NSW region Native demand;
NG_{NSW}= NSW region Small Non-scheduled Generation;
TL_{NSW} = NSW region transmission losses.

Data sources:

Info for each station - Clean Energy Regulator https://www.rec-registry.gov.au/rec-registry/app/public/power-station-register
ED - Australian Energy Regulator http://www.aer.gov.au/node/24311

ND_{NSW} - Australian Energy Market Operator http://forecasting.aemo.com.au/AnnualConsumption
NG_{NSW} - Australian Energy Market Operator http://forecasting.aemo.com.au/AnnualConsumption
TL_{NSW} - Australian Energy Market Operator http://forecasting.aemo.com.au/AnnualConsumption

5.1.1.5 Total metered electrical energy sent out from all renewable generators contracted by the ACT Government under Action Plan 2.

$$S_5 = \sum_i \mu_i$$

Where,

$\sum_i \mu_i$= Sum of metered electrical energy sent out by all renewable generators contracted by the ACT Government under Action Plan 2.

5.1.1.6 Total renewable electrical energy being paid for by ACT electricity consumers

$$S_{renew} = \sum_{n=1}^{5} S_n$$

Where,

S_1 = Total LRET purchases;
S_2 = Total GreenPower sales in the ACT;
S_3 = Total Rooftop PV output;
S_4 = Below Baseline NSW region NEM renewable generation;
S_5 = Total metered electrical energy sent out from all renewable generators contracted by the ACT Government under Action Plan 2.

5.1.2 Calculate the emissions intensity of other electricity supplied through the NEM

5.1.2.1 Calculate the average sent out emissions intensity of NSW coal fired generation

$$El_{NSW} = \frac{\sum_i \left(\frac{S_i \times E_i}{(1 - aux_i)}\right)}{\sum_i \left(\frac{S_i}{(1 - aux_i)}\right)}$$

Where

El_{NSW} = The average sent out emissions intensity of NSW coal fired generation
S_i = Electricity generated at coal fired generator i in the inventory year
E_i = As generated emissions intensity of coal fired generator i in the inventory year
aux_i = Auxiliary factor for generator i

Data sources:

S_i - Data on *S*, *Exp* and *Imp* from Australian Energy Market Operator: http://www.aemo.com.au/Electricity/Data/Market-Management-System-MMS/Generation-and-Load and http://www.aemo.com.au/Electricity/Data/Market-Management-System-MMS/Dispatch

aux_i - Data on *e* and *aux* from Australian Energy Market Operator : http://www.aemo.com.au/Electricity/Planning/Related-Information/Planning-Assumptions

5.1.2.2 Calculate the average sent out emissions intensity of Queensland coal fired generation

$$El_{Qld} = \frac{\sum_j \left(\frac{S_j \times E_j}{(1 - aux_j)}\right)}{\sum_j \left(\frac{S_j}{(1 - aux_j)}\right)}$$

Where

El_{Qld} = Average sent out emissions intensity of Queensland coal fired generation

S_j = Electricity generated at coal fired generator j in the inventory year

E_j = As generated emissions intensity of coal fired generator j in the inventory year

aux_j = Auxiliary factor for generator j

5.1.2.3 Calculate the average sent out emissions intensity of Victorian coal fired generation

$$El_{Vic} = \frac{\sum_k \left(\frac{S_k \times E_k}{(1 - aux_j)}\right)}{\sum_k \left(\frac{S_k}{(1 - aux_k)}\right)}$$

Where,

S_k = Electricity generated at coal fired generator k in the inventory year

E_k = As generated emissions intensity of coal fired generator k in the inventory year

aux_k = Auxiliary factor for generator k

5.1.2.4 Calculate the total emissions from coal fired generation consumed in NSW

$$E_{coal} = \left(\sum_i \frac{S_i}{(1 - aux_i)} - Exp_{Vic} - Exp_{Qld}\right) \times El_{NSW} + Imp_{Vic} \times El_{Vic} + Imp_{Qld} \times El_{Qld}$$

Where,

E_{coal} = Total emissions from coal fired generation consumed in NSW

Exp_{Vic} = Exports of electricity from NSW to Victoria

Exp_{Qld} = Exports of electricity from NSW to Queensland

Imp_{Vic} = Imports of electricity to NSW from Victoria

Imp_{Qld} = Imports of electricity to NSW from Queensland

5.1.2.5 Calculate the average sent out emissions intensity of fossil fuel electricity consumed in NSW

$$El_{fossil} = \left(E_{coal} + \frac{\Sigma_g \left(\frac{S_g \times E_g}{(1 - aux_g)} \right)}{\Sigma_g \left(\frac{S_g}{(1 - aux_g)} \right)} - Exp_{Vic} - Exp_{Qld} + Imp_{Vic} + Imp_{Qld} + \sum_g \frac{S_g}{(1 - aux_g)} \right)$$

Where,

El_{fossil} = Sent out emissions intensity of NSW fossil fuel generation

S_g = Electricity generated at NSW gas and petroleum fired generator g in the inventory year

E_g = As generated emissions intensity of gas and petroleum fired generator g in the inventory year

aux_g = Auxiliary factor for generator g

5.1.3 *Calculate total Scope 2 emissions attributable to electricity consumed in the ACT*

$$E_{elec} = (D - S_{renew}) \times El_{fossil}$$

Where,

E_{elec} = Scope 2 emissions of electricity consumed in the ACT

D = Total consumption of electricity, including distribution losses, in the ACT in the inventory year

Data sources:

D - ActewAGL Distribution (a component of the annual RIN submission to the AER)

5.2 Natural gas

Annual emissions are calculated using the following equation:

$E_{NG} = (Q_{NG} - Q_{Action} \times EC_{NG}) \times EF_{NG} / 10^6$ (2)

Where:

E_{NG} is emissions from natural gas consumption in kilotonnes of CO_2-e

Q_{NG} is the consumption of purchased natural gas in the ACT, in gigajoules

Q_{Action} is natural gas used by the ACTION bus fleet, in cubic metres

EC_{NG} is the energy content of natural gas, in gigajoules per cubic metre

EF_{NG} is the Scope 1 emission factor for natural gas combustion in kilograms of CO_2-e per gigajoule.

Data sources:

Q_{NG} ActewAGL Distribution

Q_{Action} ACTION

EC_{NG}, EF_{NG} The most recent published edition of Department of the Environment, *National Greenhouse Accounts Factors* http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-dec-2014

5.3 LPG stationary combustion

Annual emissions are calculated using the following equation:

$E_{LPG} = Q_{LPG}\ x\ EC_{LPG}\ x\ EF_{LPG} / 10^6$ (3)

Where:

E_{LPG} is emissions from LPG stationary combustion expressed in kilotonnes of CO_2-e

Q_{LPG} is the consumption of LPG for stationary combustion expressed in tonnes

EC_{LPG} is the energy content factor for LPG expressed in gigajoules per tonne

EF_{LPG} is the Scope 1 emissions factor for LPG in kilograms of CO_2-e per gigajoule.

Data sources:

Q_{LPG} Total bulk and bottled sales of LPG to ACT consumers; data to be collected from Elgas, Boral and Supagas

EC_{LPG} and EF_{LPG} The most recent published edition of Department of the Environment, National Greenhouse Accounts Factors http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-dec-2014

5.4 Fuel oil

$$E_{FO} = E_{IW} + Q_{FO} \times EC_{FO} \times EF_{FO}$$

Where:

E_{FO} is emissions from fuel oil consumption expressed in kilotonnes of CO_2-e.

E_{IW} is annual Scope 1 emissions from combustion of fuel oil by ICON Water, as included in the annual report by the business under the National Greenhouse and Energy Reporting Scheme (NGERS).

Q_{FO} is the consumption of fuel oil in the ACT by users other than ICON Water (if any)

EC_{WF} is the energy content factor for fuel oil expressed in gigajoules per tonne

EF_{WF} is the Scope 1 emissions factor for fuel oil in kilograms of CO_2-e per gigajoule.

Data sources:

E_{IW} ICON Water

Q_{FO} Total sales of fuel oil to ACT consumers; data to be collected by a survey of users/and/or suppliers.

EC_{FO} and EF_{FO} The most recent published edition of Department of the Environment, National Greenhouse Accounts Factors http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-dec-2014

5.5 Wood-fuel

Annual emissions are calculated using the following equation:

$E_{WF} =\ \ x\ _{WF}\ x\ EF_{WF} / 10^6$ (3)

Where:

E_{WF} is emissions from wood fuel consumption expressed in kilotonnes of CO_2-e
Q_{WF} is the consumption of dry wood expressed in tonnes
EC_{WF} is the energy content factor for dry wood expressed in gigajoules per tonne
EF_{WF} is the Scope 1 emissions factor for dry wood in kilograms of CO_2-e per gigajoule.

Data sources:

Q_{WF} The most recent available ACT government *Firewood Sales* report

EC_{WF} and EF_{WF} The most recent published edition of Department of the Environment, National Greenhouse Accounts Factors http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-dec-2014

5.6 Fugitive energy emissions: Natural gas distribution

Annual emissions are calculated using the following equation:

$$E_{fug} = Q_{NG} \times UAG/(1 - UAG) \times 0.55 \times (C_{CO2} + C_{CH4}) / 10^3$$

Where:

E_{fug} is the fugitive emissions from the ACT gas distribution network in tonnes CO_2-e.

Q_{NG} is the consumption of purchased natural gas in the ACT, in gigajoules
UAG is Unaccounted for gas in the ACT gas distribution network in the inventory year, in percent; it has the value 1.7% for the period 2010 to 2015.

C_{CO2} is the composition factor for CO_2 in gas supplied to the ACT, in tonnes CO_2-e per terajoule, and is equal to 0.8 in the 2014-15 inventory year.

C_{CH4} is the composition factor for methane in gas supplied to the ACT, in tonnes CO_2-e per terajoule, and is equal to 328 in the 2014-15 inventory year.

Data sources:

Q_{NG} ActewAGL Distribution

UAG Australian Energy Regulator, 2010. *Access arrangement for the ACT, Queanbeyan and Palerang gas distribution network, 1 July 2010 – 30 June 2015*. http://www.aer.gov.au/node/4785

$C_{CO2} + C_{CH4}$ Department of the Environment, 2014. *Technical guidelines for the estimation of greenhouse gas emissions by facilities in Australia*. http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/nger-technical-guidelines-2014

6. Method for calculating emissions from transport

Annual emissions are calculated using the following equation:

$$E_{Trans} = (\Sigma (QP_i \times ECP_i \times EFP_i) + Q_{Action} \times EC_{NG} \times EF_{NG}) / 10^6$$

Where:

E_{Trans} is emissions from consumption of road transport fuels in kilotonnes of CO_2-e
QP_i is the consumption of road transport fuel type i, where i is LPG, petrol, diesel, in kilolitres

ECP_i is the energy content factor for road transport fuel type i, in gigajoules per kilolitre

EFP_i is the Scope 1 emissions factor for road transport fuel type i, in kilograms of CO_2-e per gigajoule.

Q_{Action} is natural gas used by the ACTION bus fleet, in cubic metres

EC_{NG} is the energy content of natural gas, in gigajoules per cubic metre

EF_{NG} is the Scope 1 emission factor for natural gas combustion in kilograms of CO_2-e per gigajoule.

Data sources:

QP_i The Fuel Survey undertaken by the Environment and Planning Directorate

ECP_i , EFP_i , EC_{NG} , EF_{NG} The most recent published edition of Department of the Environment, National Greenhouse Accounts Factors http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-dec-2014

Q_{Action} ACTION

7. Method for calculating emissions from industrial processes and product use

7.1 Product uses as substitutes for ozone depleting substances

$E_{SG} = G_{t-2} \times (t - 1999) + I_{t-2}$

Where:

E_{SG} = is emissions from use of synthetic gases in the inventory year t

t = financial year ending 30 June

G_{t-2} = the gradient of the linear regression of each annual value of ACT emissions from use of synthetic gases from 2000 to year t-2 inclusive, as contained in the National Greenhouse Accounts compiled by the Department of the Environment for year t-2

I_{t-2} = the intercept on the y-axis of the linear regression of each annual value of ACT emissions from use of synthetic gases from 2000 to year t-2 inclusive, as contained in the National Greenhouse Accounts compiled by the Department of the Environment for year t-2.

8. Method for calculating emissions from agriculture

ACT emissions are the value for the ACT for total emissions from Agriculture, emissions source category 3 under the 2006 IPCC Guidelines, contained in the most recent National Greenhouse Accounts compiled by the Department of the Environment. The year concerned will normally be the year two years prior to the year for which the ACT inventory is being compiled.

9. Method for calculating emissions from land use, land-use change and forestry

ACT emissions are the value for the ACT for total emissions from Land-use, land-use change and forestry, emissions source category 4 under the 2006 IPCC Guidelines, contained in the most recent National Greenhouse Accounts compiled by the Department of the Environment. The year concerned will normally be the year two years prior to the year for which the ACT inventory is being compiled.

10. Method for calculating emissions from waste

10.1 Solid waste disposal

10.1.1 Introductory explanation of methodology

The calculations below follow the IPCC (and thus the NGERS) method for estimating emissions from landfills. Various constants and defaults have been used consistent with the current usage in the NGERS method. The output can be achieved by inserting the relevant data into the NGERS calculator.

The model for decomposition works by creating a record of landfill stock levels of waste in various types for which decomposition is well understood (e.g. food; paper and cardboard; etc), and then assessing how much of that stock will decompose to create landfill gas in a given year. The overall amount of degradable organic carbon (DOC) is calculated for each waste type as it enters the landfill. The amount of this that subsequently degrades to produce landfill gas is termed decomposable degradable organic carbon (DDOC) and this stock amount is tallied year on year, accounting for degradation, for each waste type.

10.1.2 Methodology in detail

Methane released from landfills (other than from flaring of methane) in the inventory year is calculated by the following equation:

$$Ej = [CH_4{*} - \gamma (Q_{cap} + Q_{flared} + Q_{tr})] \times (1 - OF)$$

where:

Ej is the emissions of methane released by the landfill during the year measured in CO_2-e tonnes.

$CH_4{}^*$ is the estimated quantity of methane in landfill gas generated by the landfill during the year and measured in CO_2-e tonnes.

γ is the factor $6.784 \times 10^{-4} \times 25$ converting cubic metres of methane at standard conditions to CO_2-e tonnes.

Q_{cap} is the quantity of methane in landfill gas captured for combustion from the landfill during the year and measured in cubic metres.

Q_{flared} is the quantity of methane in landfill gas flared from the landfill during the year and measured in cubic metres.

Q_{tr} is the quantity of methane in landfill gas (if any) transferred out of the landfill during the year and measured in cubic metres.

OF is the oxidation factor (0.1) for near surface methane in the landfill.

The estimation of CH_4* takes account of the following factors:

(a) the tonnage of total solid waste disposed of in the landfill in previous years, as set out in Table 1;
(b) the tonnage of total solid waste disposed of in the landfill in the inventory year;
(c) the composition of the solid waste disposed of in the landfill during the year estimated in the categories municipal solid waste (MSW), commercial and industrial waste (C&I), and construction and demolition (C&D) as in Table 1

for years prior to 1975-2016 and thereafter equal to the reported total tonnage divided into the percentages in Table 2 (unless a more accurate measured breakdown is available);

(d) the proportions in each of the three categories of the different types of degradable waste, as set out in Table 3;

(e) the degradable organic carbon content of each of the types of degradable waste disposed of in the landfill by waste type, as set out in Table 4;

(f) the opening stock of degradable organic carbon in the solid waste at the landfill at the start of the first reporting period (financial year 1975) for the landfill is zero;

(g) methane generation constants (*k values*) for the solid waste at the landfill as per Table 5;

(h) the fraction of degradable organic carbon dissimilated (DOC_F) estimated in accordance with Table 6;

(i) the methane correction factor for aerobic decomposition is 1;

The quantity of methane generated by the landfill is calculated by the following equation:

$$CH_4^* = (\Delta C_{ost} + \Delta C_{at}) \times F \times 1.336 \times 25$$

where:

CH_4^* is the quantity of methane generated by the landfill measured in CO_2-e tonnes

F is the fraction of methane generated in landfill gas and is 0.5.

1.336 is the factor to convert a mass of carbon to a mass of methane

25 is the 100-year Global Warming potential (GWP) of methane, which converts tonnes of methane to tonnes of carbon dioxide equivalent

ΔC_{ost} is the change in the quantity of the opening stock of decomposable degradable organic carbon derived from the sum of all waste mix types located in the landfill during the reporting year, measured in tonnes, lost through decomposition, and estimated by the following equation:

$$\Delta C_{ost} = \sum_i C_{osit} \times (1 - e^{-ki})$$

where:

C_{osit} is the quantity of decomposable degradable organic carbon accumulated in the landfill at the beginning of the reporting year from all waste mix types deposited in all prior years, measured in tonnes and equals:

$$C_{osit} = C_{csit-1}$$

where:

C_{csit-1} is the closing stock of decomposable degradable organic carbon accumulated in the landfill in the year immediately preceding the reporting year from all waste mix types defined above, measured in tonnes and equals:

$$C_{csit} = C_{osit} - \Delta C_{osit} + C_{ait} - \Delta C_{ait}$$

and

k_i is the methane generation constant for each waste mix type as specified in Table 5.

and:

ΔC_{at} is the change in the quantity of decomposable degradable organic carbon derived from the sum of all waste mix types deposited at the landfill during the reporting year, measured in tonnes, lost through decomposition, and equals:

$$\Delta C_{at} = \sum_i C_{ait} \times [1 - e^{-ki \times (13 - M)/12}]$$

where:

C_{ait} is the quantity of degradable organic carbon in all waste mix types specified in Table 3 deposited at the landfill during the year concerned, measured in tonnes and is equal to:

$$C_{ait} = (Q_{it} \times DOC_i \times DOC_{fi} \times MCF)$$

where:

Q_{it} is the quantity of each waste mix type defined in Table 3 deposited at the landfill during the year concerned, measured in tonnes.

DOC_i is the fraction of the degradable organic carbon content in each waste type, as specified in Table 4 of the solid waste for all waste mix types defined above and deposited at the landfill.

DOC_{fi} is the fraction of decomposable degradable organic carbon for each waste mix types as specified in Table 6.

MCF is the methane correction factor for aerobic decomposition for the facility during the reporting year and is equal to 1.

and where:

i is the waste type.

t is the reporting year.

M is the number of months before commencement of methane generation at the landfill (here zero) plus seven.

Σ_i is the sum for all waste mix types specified in Table 3

Table 1: Waste deposition baseline for emissions model

Financial Year	MSW	C&I	C&D	Total waste
1975	20,896	14,105	17,239	52,239
1976	26,790	18,083	22,102	66,975
1977	32,677	22,057	26,959	81,693
1978	38,556	26,026	31,809	96,391
1979	44,345	29,933	36,585	110,862
1980	50,421	34,034	41,597	126,052
1981	56,613	38,214	46,706	141,533
1982	63,556	42,900	52,434	158,890
1983	70,901	47,858	58,494	177,254
1984	78,593	53,050	64,839	196,482
1985	86,629	58,474	71,469	216,572
1986	95,424	64,411	78,725	238,560
1987	104,205	70,338	85,969	260,513
1988	113,336	76,502	93,502	283,341
1989	121,752	82,182	100,445	304,379
1990	135,618	91,542	111,885	339,045
1991	125,331	84,599	103,398	313,328
1992	124,123	83,783	102,402	310,308
1993	122,128	82,437	100,756	305,321
1994	166,319	112,265	137,213	415,798
1995	108,822	73,455	89,778	272,054
1996	100,827	68,058	83,182	252,068
1997	95,192	64,255	78,534	237,981
1998	95,890	64,726	79,110	239,726
1999	101,074	68,225	83,386	252,686
2000	103,634	69,953	85,498	259,084
2001	89,690	60,541	73,994	224,225
2002	88,866	63,161	68,302	220,328
2003	84,207	62,810	60,049	207,067
2004	85,440	66,685	56,265	208,390
2005	84,484	68,813	51,099	204,396
2006	80,130	67,951	44,232	192,313
2007	82,919	73,047	41,459	197,425
2008	87,937	80,320	39,468	207,725
2009	91,293	86,301	36,375	213,969
2010	98,344	96,057	34,306	228,706
2011	115,240	112,560	40,200	268,000
2012	136,672	133,494	47,676	317,842
2013	109,689	107,138	38,264	255,091
2014	102,471	100,088	35,746	238,304

Table 2: Waste stream proportions of total solid waste to landfill

Waste stream	Proportion
Municipal solid waste	43%
Commercial and industrial	42%
Construction and demolition	15%

Table 3 Default proportions of each waste type in the three solid waste streams

Waste mix type	Municipal solid waste default %	Commercial and industrial waste default %	Construction and demolition waste default %
Food	35	21.5	0
Paper and cardboard	13	15.5	3
Garden and park	16.5	4	2
Wood and wood waste	1	12.5	6
Textiles	1.5	4	0
Sludge	0	1.5	0
Nappies	4	0	0
Rubber and Leather	1	3.5	0
Inert waste	28	37.5	89

Table 4: Waste mix types DOC values.

Waste mix type	Degradable organic carbon value
Food	0.15
Paper and cardboard	0.40
Garden and green	0.20
Wood and wood waste	0.43
Textiles	0.24
Sludge	0.05
Nappies	0.24
Rubber and Leather	0.39
Inert waste	0.00
Alternative waste treatment residue	0.08

Table 5: Waste type k values

Waste mix type	k values
Food	0.06
Paper and cardboard	0.04

Garden and Green	0.05
Wood	0.02
Textiles	0.04
Sludge	0.06
Nappies	0.04
Rubber and Leather	0.04
Alternative waste treatment residue	0.04

Table 6: Fraction of DOC dissimilated (DOC_F)

Waste mix type	DOC_F value
Food	0.84
Paper and cardboard	0.49
Garden and green	0.47
Wood	0.23
Textiles	0.5
Sludge	0.5
Nappies	0.5
Rubber and leather	0.5
Inert waste	0.0
Alternative waste treatment residues	0.5

10.2 Wastewater treatment and discharge

Annual emissions from nitrous oxide emissions arising from wastewater treatment by ICON Water, as included in the annual report by the business under the National Greenhouse and Energy Reporting Scheme (NGERS).

Data source: ICON Water