

# Climate Change and Greenhouse Gas Reduction (Greenhouse Gas Emissions Measurement Method) Determination 2017

Disallowable instrument DI2017–250

made under the

Climate Change and Greenhouse Gas Reduction Act 2010, 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 2017*.

## 2 Commencement

This instrument commences on the day after its notification day.

## 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

The *Climate Change and Greenhouse Gas Reduction (Greenhouse Gas Emissions Measurement Method) Determination 2016* (DI2016-257) is revoked.

Shane Rattenbury MLA  
Minister for Climate Change and Sustainability  
25 September 2017

## Schedule

(see section 3)

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### 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 *Climate Change and Greenhouse Gas Reduction Act 2010* (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 **CO<sub>2</sub>-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;  
 $\alpha_i$  = Renewable power percentage;  
 $\beta_i$  = Total electricity supplied to residential customers;  
 $\gamma_i$  = Total electricity supplied to non-residential and other customers.

Data sources:

$\alpha_i$  - Clean Energy Regulator <http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/The-certificate-market/The-renewable-power-percentage>.  
 $\beta_i$  - 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 GreenPower™ 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](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, Planning and Sustainable Development Directorate

### 5.1.1.4 Below Baseline NSW region NEM renewable generation

$$S_4 = \frac{\sum_{m=1}^5 G_m}{5} \times \left( \frac{ED}{(ND_{NSW} - NG_{NSW} - TL_{NSW})} \right)$$

Where,

- 1 = Inventory year – 4;
- 2 = Inventory year – 3;
- 3 = Inventory year – 2;
- 4 = Inventory year – 1;
- 5 = Inventory year.

and

For each of the following Stations: Hume, Blowering, Guthega, Tumut 1, Tumut 2, Tumut 3 (net of pump energy input)<sup>1</sup>:

$$G_m = \sum_{n=1}^6 \left( \text{Min} \left( ES_n, \left( \frac{\omega_n + \varphi_n}{2} \right) \right) \right)$$

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);

$\text{Min} \left( ES_n, \left( \frac{\omega_n + \varphi_n}{2} \right) \right)$  = 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

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

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

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

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:

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

Where:

$E_{NG}$  is emissions from natural gas consumption in kilotonnes of CO<sub>2</sub>-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<sub>2</sub>-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.



### 5.3 LPG stationary combustion

Annual emissions are calculated using the following equation:

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

Where:

$E_{LPG}$  is emissions from LPG stationary combustion expressed in kilotonnes of CO<sub>2</sub>-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<sub>2</sub>-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.

### 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<sub>2</sub>-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<sub>2</sub>-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.

### 5.5 Wood-fuel

Annual emissions are calculated using the following equation:

$$E_{WF} = Q_{WF} \times EC_{WF} \times EF_{WF} / 10^6 \quad (3)$$

Where:

$E_{WF}$  is emissions from wood fuel consumption expressed in kilotonnes of CO<sub>2</sub>-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<sub>2</sub>-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.

## 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<sub>2</sub>-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<sub>2</sub> in gas supplied to the ACT, in tonnes CO<sub>2</sub>-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<sub>2</sub>-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:

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

Where:

$E_{Trans}$  is emissions from consumption of road transport fuels in kilotonnes of CO<sub>2</sub>-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<sub>2</sub>-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<sub>2</sub>-e per gigajoule.

Data sources:

$QP_i$  The Fuel Survey undertaken by the Environment, Planning and Sustainable Development Directorate

$ECP_i$ ,  $EF_{P_i}$ ,  $EC_{NG}$ ,  $EF_{NG}$  The most recent published edition of Department of the Environment, National Greenhouse Accounts Factors.

$Q_{Action}$  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 Methane released from landfills**

#### **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:

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

where:

$E_j$  is the emissions of methane released by the landfill during the year measured in CO<sub>2</sub>-e tonnes.

$CH_4^*$  is the estimated quantity of methane in landfill gas generated by the landfill during the year and measured in CO<sub>2</sub>-e tonnes.

$\gamma$  is the factor  $6.784 \times 10^{-4} \times 25$  converting cubic metres of methane at standard conditions to CO<sub>2</sub>-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<sub>2</sub>-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

$\Delta C_{ost}$  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:

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

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:

$\Delta C_{at}$  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.

$\Sigma_i$  is the sum for all waste mix types specified in Table 3

**Table 1: Waste deposition baseline for emissions model**

| <b>Financial Year</b> | <b>MSW</b> | <b>C&amp;I</b> | <b>C&amp;D</b> | <b>Total waste</b> |
|-----------------------|------------|----------------|----------------|--------------------|
| 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<sub>F</sub>)**

| Waste mix type                       | DOC <sub>F</sub> 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 Biological treatment of solid waste

Methane and nitrous oxide released from the composting of biomass materials in an un-enclosed composting facility is calculated by the following equation

$$E_j = (M \times EF_j) - R$$

where:

$EF_j$  is the emission factor for each gas type ( $j$ ), being methane or nitrous oxide, released from the composting process measured in tonnes of CO<sub>2</sub>-e per tonne of waste processed, having the following values:

For the gas type methane 0.019

For the gas type nitrous oxide 0.029

$E_j$  is the emissions of the gas type ( $j$ ), being methane or nitrous oxide, released from the landfill during the year from the composting process measured in CO<sub>2</sub>-e tonnes.

$M$  is the mass of biomass materials treated by composting during the year measured in tonnes of waste.

*R* is:

- (a) for the gas type methane—the total amount of methane recovered during the year at the site from the composting of biomass materials measured in tonnes of CO<sub>2</sub>-e; or
- (b) for the gas type nitrous oxide—zero.

### **10.3 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

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