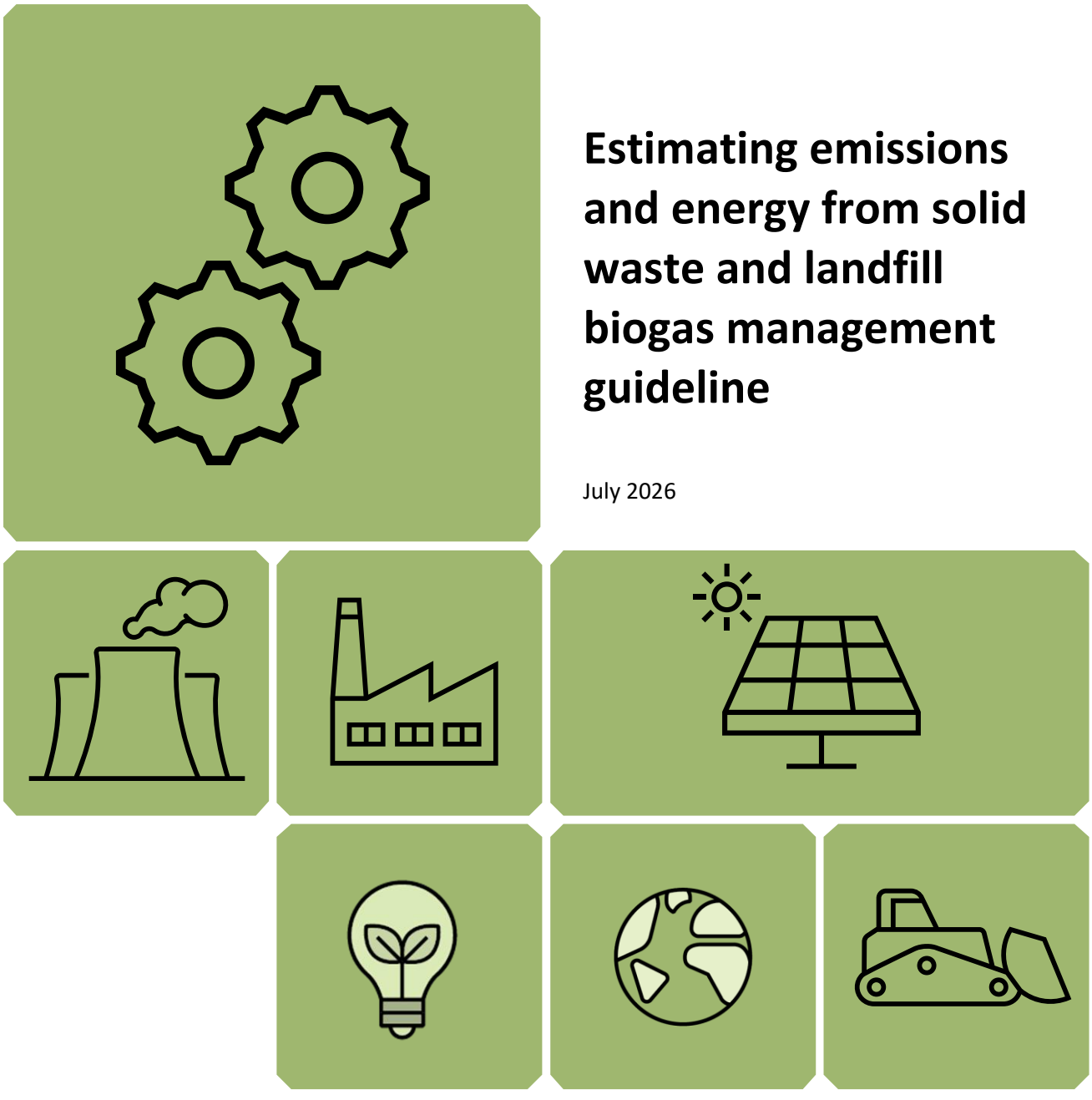
Australian Government
Clean Energy Regulator



Estimating emissions and energy from solid waste and landfill biogas management guideline

July 2026

National Greenhouse and Energy Reporting

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Definitions and abbreviations

Term	Meaning
ANZSIC	Australian and New Zealand Standard Industrial Classification
AWT	Alternative waste treatment
BOM	Bureau of Meteorology
C&D	Construction and demolition
C&I	Commercial and industrial
CH_4	Methane
CO_2	Carbon dioxide
DOC	Degradable organic carbon
EERS	Emissions and Energy Reporting System
MTBI	Matters to be identified, as specified in Schedule 4 of the NGER Measurement Determination.
MRF	Materials recovery facility
MSW	Municipal Solid Waste
NGER	National Greenhouse and Energy Reporting
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
NGER Measurement Determination	National Greenhouse and Energy Reporting (Measurement) Determination 2008
NGER Regulations	National Greenhouse and Energy Reporting Regulations 2008
Phytocap	An evapotranspiration landfill capping system that makes use of soil and vegetation to store and release surface water
Safeguard Mechanism	The Australian Government's mechanism to contribute to the achievement of Australia's greenhouse gas emissions reduction targets. See the Safeguard Mechanism[1] for more information.
Scope 1 emissions	The release of greenhouse gas into the atmosphere as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility.
STP	Standard temperature and pressure. Standard temperature (15°C = 288 K) and pressure (101.325 kPa) per subsection 2.32(7) of the NGER Measurement Determination.
SWC	Solid Waste Calculator
t CO_2-e	Tonnes carbon dioxide equivalence
Tpa	Tonnes per annum

[1] https://cer.gov.au/schemes/safeguard-mechanism

Terms in NGER legislation may have specific meanings within the law. These key words and phrases are normally identified under a heading such as Definitions, Interpretation or Dictionary or in other parts of the document.

For more information on interpreting legislation see Federal Register of Legislation - Understanding Legislation[2].

[2] https://www.legislation.gov.au/help-and-resources/understanding-legislation/reading-legislation

Disclaimer

This guideline has been developed by the Clean Energy Regulator (CER) to assist entities to comply with their reporting obligations under the *National Greenhouse and Energy Reporting Act 2007*[3] (NGER Act) and associated legislation.

This guideline only applies to the 2025–26 NGER reporting year and should be read in conjunction with the NGER Act, National Greenhouse and Energy Regulations 2008[4] (NGER Regulations), and National Greenhouse and Energy Reporting (Measurement) Determination 2008[5] (NGER Measurement Determination), as in force for this reporting period. These laws and their interpretation are subject to change, which may affect the accuracy of the information contained in the guideline.

The guidance provided in this document is not exhaustive, nor does it consider all circumstances applicable to all entities. This guidance is not intended to comprehensively deal with its subject area, and it is not a substitute for independent legal advice. Although entities are not bound to follow the guidance provided in this document, they must ensure they meet their obligations under the National Greenhouse and Energy Reporting (NGER) Scheme[6] at all times. CER encourages all users of this guidance to seek independent legal advice before taking any action or decision based on this guidance.

CER and the Australian Government will not be liable for any loss or damage from any cause (including negligence) whether arising directly, incidentally, or as consequential loss, out of or in connection with, any use of this guideline or reliance on it, for any purpose.

If an entity chooses to meet their obligations under the NGER Scheme in a manner that is inconsistent with the guidance provided in this document, CER, or an independent auditor, may require the entity to demonstrate that they are compliant with requirements of the NGER Act, NGER Regulations, and/or the NGER Measurement Determination. Entities are responsible for determining their obligations under the law and for applying the law to their individual circumstances.

[3] https://www.legislation.gov.au/Series/C2007A00175/latest/versions
[4] https://www.legislation.gov.au/Series/F2008L02230/latest/versions
[5] https://www.legislation.gov.au/Series/F2008L02309/latest/versions
[6] https://cer.gov.au/schemes/national-greenhouse-and-energy-reporting-scheme

2025–26 updates

Changes in this document for the 2025–26 reporting year

- Minor stylistic and formatting changes have been made to this document.

Read about the changes to the NGER legislation for the 2025–26 reporting period[7] and contact us[8] if you have any questions.

1. Purpose of this guideline

Landfill operators and landfill biogas managers have reporting obligations under the NGER Act, NGER Regulations and the NGER Measurement Determination.

It is important for users of NGER information to have accurate information related to greenhouse gas emissions, energy consumption and energy production of corporations. The information is used to:

- inform Australian government policy formulation and the Australian public
- meet Australia's international reporting obligations
- assist Commonwealth, state and territory government programs and activities
- ensure, under the Safeguard Mechanism, that net covered emissions of greenhouse gases from the operation of a designated large facility do not exceed the baseline applicable to the facility.

This guideline is intended to promote better reporting by assisting:

- landfill operators to estimate and report emissions from solid waste management at landfills
- landfill biogas managers to estimate and report their emissions
- landfill operators and landfill biogas managers to estimate and report energy production and energy consumption.

It may also be useful for auditors and other users or preparers of NGER data and reporting from landfill operations and landfill biogas management.

The guideline outlines the general principles and rules concerning how to measure and estimate emissions from different waste streams, waste mix types and climatic conditions, and how to distinguish between legacy and non-legacy waste. It also provides guidance on the use of industry estimation practices. It is important this guideline be read in conjunction with Chapter 5 of the NGER Measurement Determination.

1.1 Focus of this guideline

The NGER Measurement Determination and the NGER Regulations contain the requirements for estimation and reporting of emissions and energy from landfill sites and landfill biogas management.

[7] https://cer.gov.au/schemes/national-greenhouse-and-energy-reporting-scheme/report-emissions-and-energy/amendments-to-national-greenhouse-and-energy-reporting-legislation
[8] https://cer.gov.au/about-us/contact-us

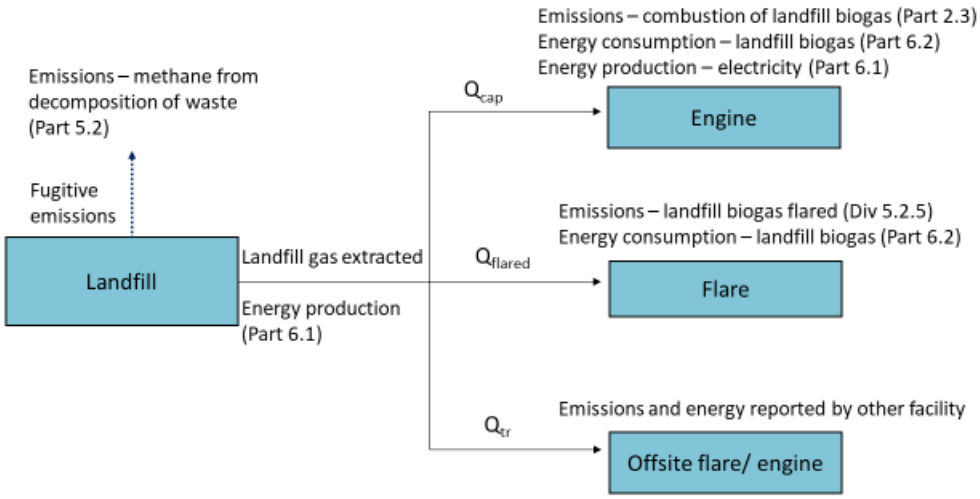
This guideline focuses on providing guidance on the appropriate application of the methods defined in NGER, accounting for the largest instances of emissions and energy from reporting entities engaged in landfill and landfill biogas management.

The methods and criteria for calculating direct (scope 1) greenhouse biogas emissions from solid waste disposal on land are included in Chapter 5 of the NGER Measurement Determination. The NGER Measurement Determination provides three methods for determining scope 1 emissions from solid waste disposal on land. These are:

- Method 1 (default method) – based on national average estimates
- Method 2 (facility specific method) – uses industry practices for sampling and Australian or equivalent standards for analysis
- Method 3 (facility specific method) – uses Australian or equivalent standards for both sampling and analysis.
- This guideline aims to assist landfill operators and landfill biogas managers to estimate their emissions using Method 1 only. Additionally, it assumes the reporter uses the Solid Waste Calculator (SWC)[9] developed by CER, as described at chapter 3.2 of this guideline.
- Information sources required in preparing an NGER report specific to this sector, as prescribed in the NGER Measurement Determination, is summarised below.

[9] The SWC has been created in Microsoft Excel and saved in '.xlsx' format. This calculator has not been tested with other spreadsheet applications. The document is available at: https://cer.gov.au/schemes/national-greenhouse-and-energy-reporting-scheme/report-emissions-and-energy/nger-calculators

Figure 1 – Emissions and energy sources described in this guideline.



1.2 Good practice in NGER reporting

Landfill operators and landfill biogas managers liable to report under NGER must keep records of the activities across its group to allow it to produce accurate reports prepared in accordance with the NGER Legislation. Records must be kept for 5 years and must enable CER to ascertain whether the registered corporation or liable entity has complied with the obligations under the NGER Legislation. This includes keeping records that are easily accessible for inspection and audit.

Records of data should be accompanied by documentation of how the data was captured and processed, noting that data must be captured and processed in accordance with the general estimation principles in section 1.13 of the NGER Measurement Determination (refer to Table 1).

CER expects registered corporations to apply the principles set out in section 1.13 of the NGER Measurement Determination to all emissions estimates, energy production and energy consumption.

Table 1 – General principles for NGER reporting for solid waste and landfill biogas management.

General estimation principles	Implication for solid waste and landfill biogas NGER reporting
Transparency Emission estimates must be documented and verifiable	• All key decisions and assumptions made to prepare NGER reporting must be documented and updated each year, in a 'Basis of preparation' document or procedure. This includes assumptions for estimating waste streams percentages and waste mix types, reporting/facility boundary, operational control of individual facilities at the landfill, as well as other decisions. • All data must be recorded with a clear audit trail. This includes all sampling made to support landfill biogas captured, flared or transferred and fugitive emissions estimates. • All data and assumptions must be kept safe for five years.

General estimation principles	Implication for solid waste and landfill biogas NGER reporting
Comparability Emission estimates using a particular method and produced by a registered corporation in an industry sector must be comparable with emission estimates produced by similar corporations in that industry sector using the same method and be consistent with the emission estimates published by the Department of Climate Change, Energy, the Environment and Water in the National Greenhouse Accounts[10]	• Appropriately using the rules and requirements of the NGER Measurement Determination will achieve this for most activity data and emissions estimates in solid waste and landfill biogas management. • When using solid waste specific approaches, for example when estimating solid waste tonnages, following industry practice is a minimum but it must also meet other requirements, e.g. on 'Transparency' and 'Accuracy'.
Accuracy Having regard to the availability of reasonable resources by a registered corporation and the requirements of the NGER Measurement Determination, uncertainties in emission estimates must be minimised and any estimates must be neither over nor under estimates of the true values at a 95% confidence level[11]	• Sampling, e.g. for methane content or for energy production, must be performed for a duration and frequency to enable reliable estimates. • Estimates must be neutral without bias - use of a 'conservative' estimate, e.g. overstating or understating fugitive emissions when compared to the likely true value is not allowed. • Reporters should consider the availability of reasonable resources to achieve the accuracy level described.

[10] https://www.industry.gov.au/policies-and-initiatives/australias-climate-change-strategies/tracking-and-reporting-greenhouse-gas-emissions

[11] It is standard practice in science to estimate the 95% statistical confidence interval. The 'confidence interval' is defined by a probability value (in this case 95%) and confidence limits on either side of the mean value. This means that the uncertainty level (the +/- percentages – otherwise known as the confidence limits) is to be calculated so that there is a 95% probability that the true value of the estimate is encompassed by the estimated uncertainty levels (the confidence limits). For example, an emission estimate of 100kt +/- 10% at the 95% confidence interval means that the true value lies between 90kt and 110kt with a probability of 95%.

General estimation principles	Implication for solid waste and landfill biogas NGER reporting
Completeness Subject to any applicable reporting thresholds, all emission sources identified in section 1.10 of the NGER Measurement Determination, and production and consumption of all fuels and energy commodities listed in Schedule 1 of the NGER Regulations, must be accounted for	• All typical source types for solid waste and landfill biogas management identified in the NGER Measurement Determination. • A key issue is identifying the reporting boundary and documenting all emissions and energy sources that the registered corporation or liable entity must report, and those that must be reported by contractors or landfill biogas managers.

An executive officer must sign the report to be submitted to CER, confirming that the reporting has been prepared in accordance with the NGER Legislation, including that the general principles have been appropriately applied.

It is up to the liable entity to prepare the NGER report and its signing executive officer to determine what reporting processes and controls are deemed appropriate to achieve transparency, comparability, completeness and accuracy. However, formalised and repeatable processes are expected. A few observations for solid waste and landfill biogas management NGER reporting are worth mentioning in this regard:

- individuals responsible for NGER report compilation may not control the data – for landfills, NGER reporting responsibility may be delegated to a person with little control over the data required to prepare the report. Whilst this may be appropriate for report compilation purposes, it may be difficult for a person physically removed from landfill operations to confirm whether data is complete and accurate
- formalising reliance on data processes – existing measurement processes controlled by parties external to the liable entity may be suitable to rely upon for NGER reporting. For example, data on landfill biogas quantities combusted and flared, and methane (CH_4) content, may be derived from another party such as the landfill biogas manager
- it is good practice to appoint individual 'data owners' who conduct checking and validation of specific data used for NGER reporting who are formally accountable for ensuring the specific data is complete and accurate. Executive officers rely on the work of others when they provide confirmation that the general principles have been appropriately applied, hence it is prudent to have data owners sign-off on the completeness and accuracy of the annual data for which they are accountable. Where possible, it can also include 'sense-checks' on total amounts to be reported in the NGER report to underlying systems – for example the tonnages received at and diverted from the landfill compared to previous years.

2. Determining reporting obligations

At the landfill, there may be several separate activities that form part of a single undertaking or enterprise and are reported as a single facility (Subdivision 2.4.2 of the NGER Regulations). Alternatively, the activities may be reported as separate facilities. These facilities may include:

- Materials Recovery Facility (MRF), where waste is sorted and recovered/recycled prior to residual waste disposal in the landfill. Emissions and energy from MRFs are primarily from fuel and electricity use and are not covered in this guideline.
- landfill, where waste is deposited
- landfill biogas management, where landfill biogas is collected and flared, combusted, upgraded to biomethane, or used for electricity generation
- organic waste treatment, where wastes are composted or anaerobically digested.

Facilities should be determined using Division 2.4 of the NGER Regulations, in particular regulation 2.16. Guidance for this is given in the document 'Defining a facility for National Greenhouse and Energy Reporting'[12]. This guideline does not provide any further guidance on this matter.

Where several facilities are defined for a landfill site, the facilities will typically also be under the operational control of different entities. It is necessary for the different parties to agree who has responsibility to report the different emissions and energy data required. This may include:

- Determining who reports the production of energy when capturing landfill waste gas. Where the gas captured meets the definitions for reporting energy production, it should be reported once only by one of the parties as energy production - refer chapter 5.1.1 of this guideline.
  - » This may be the landfill biogas management facility where the biogas captured is deemed part of the activities that form the production process for that facility.
- Determining who reports the consumption of energy when consuming captured landfill waste biogas that has been produced. If the biogas has met the definition for energy production, and it is consumed through flaring or fuel combustion for electricity generation, then it should be reported once only by one of the parties as energy consumption - refer chapter 5.2 of this guideline.
  - » This energy consumption should be reported by the facility that consumes the produced energy, typically the landfill biogas management facility. If another facility has reported production of the landfill waste gas consumed, the landfill biogas manager in this case only reports the consumption of the energy.
- CER expects the different parties controlling the different facilities to agree who has the reporting obligation. A reportable data should be reported once only, regardless of how the parties have determined facilities for the site.

2.1 Example facility configurations

Different facility configurations that may occur at landfills are outlined below, with the reporting responsibility outlined. The case studies below refer to a determination of operational control over the facilities performed by the parties. Further information on operational control is given in the Operational control supplementary guideline[13]. This guideline does not provide guidance on this matter – the cases simply illustrate how the determination impacts the reporting obligation.

2.1.1 Landfill waste activities and landfill biogas management as one facility

One facility, comprising both landfill operations and landfill biogas management, may be under the operational control of the landfill owner or the contracted landfill operator. The following case studies

[12] https://cer.gov.au/document_page/defining-facility-national-greenhouse-and-energy-reporting
[13] https://cer.gov.au/document_page/operational-control-supplementary-guideline

describe how reporting responsibilities for emissions and energy production and consumption are defined under this arrangement.

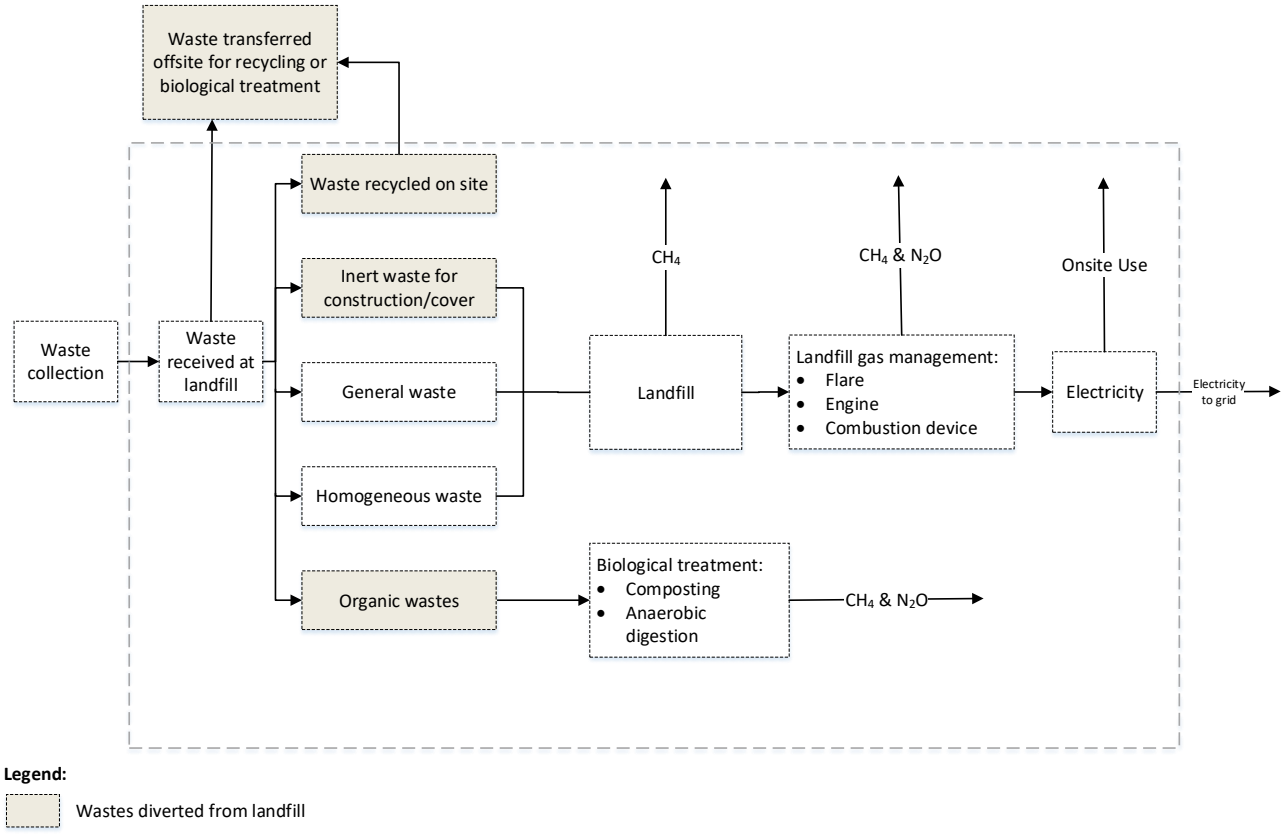
Reporting obligation case study 1

Company 1 owns and operates the landfill site, which is defined as covering both landfill operations and landfill biogas management. Company 1 contracts Company 2 to install landfill biogas infrastructure and equipment on the site with such infrastructure and equipment operated by Company 1. However, Company 1 has been determined by the parties to have operational control over the facility. Accordingly, Company 1 is required to report all emissions, energy consumed, and energy produced from the landfill and from combustion of the landfill biogas. Refer to Figure 2 which shows the reporting boundary.

Reporting obligation case study 2

Company 1 owns the landfill site. Company 1 contracts Company A to operate the landfill, including landfill biogas infrastructure and equipment on the site, which is defined as one facility. Company A has been determined by the parties to have operational control over the facility. In this case, Company A must report all emissions and energy data for the site.

Figure 2 – Reporting obligation case study 1 – landfill and biogas management at the same facility.



2.1.2 Landfill operations and landfill biogas management as separate facilities

Several facilities may be defined, including separate facilities for landfill operations and landfill biogas management operated by different entities – which may comprise the landfill owner, the contracted landfill operator, or the contracted landfill biogas manager depending on the configuration and how the parties applied the facility determination. The following case studies are examples of how reporting responsibilities for emissions and energy production and consumption are defined under such arrangements.

Reporting obligation case study 3

Company 1 owns and operates the landfill site. Company 1 contracts Company 2 to install and operate landfill biogas infrastructure and equipment on the site (under the operational control of Company 2). The two series of activities have been determined by the parties to constitute two different facilities under the operational control of the two different parties.

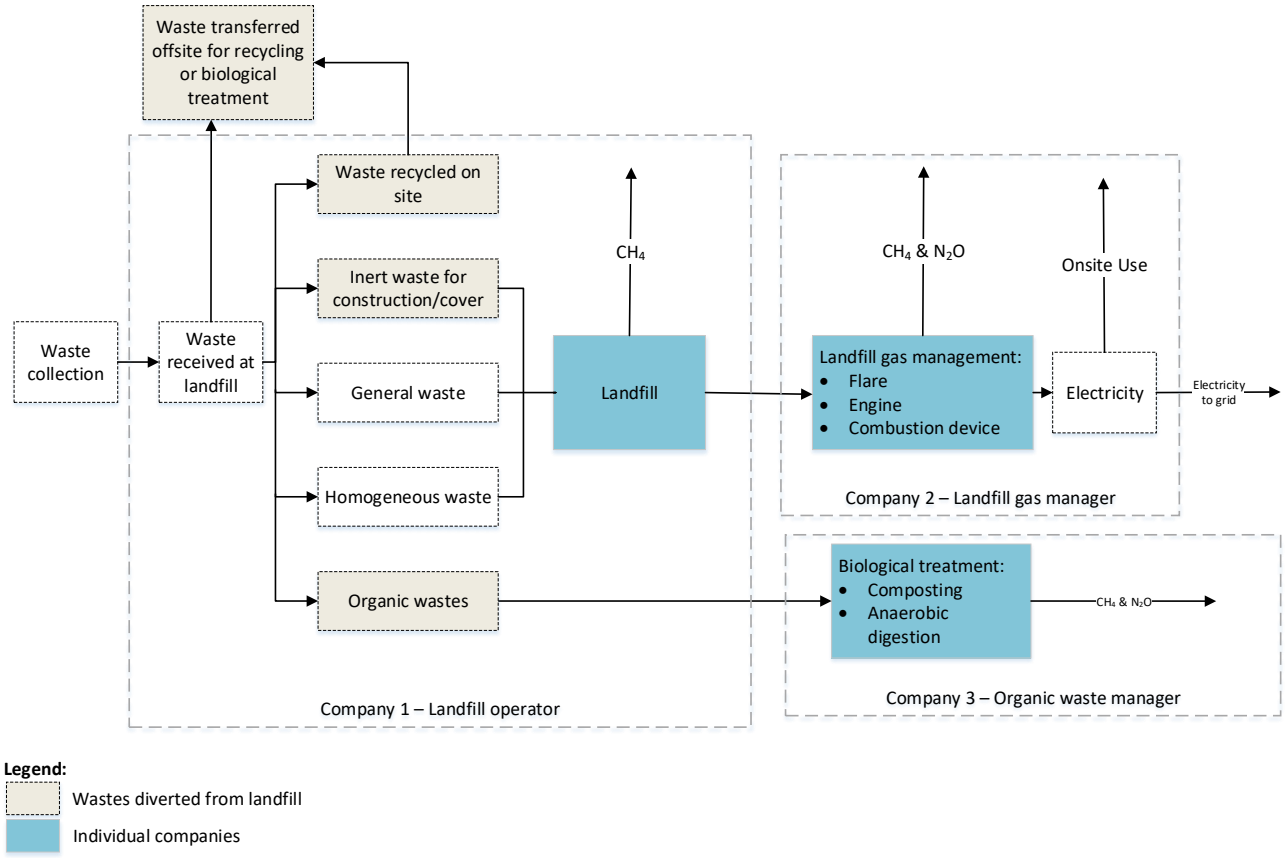
In this case, Company 1 must report all emissions from the landfill and Company 2 should report on energy production from the landfill biogas, as well as energy consumption and emissions from combustion of the landfill biogas, as it has operational control over that facility. Accordingly, it must report all the emissions and energy data related to the activities for the production process at that facility. Refer to Figure 3 which shows the reporting boundaries for Companies 1 and 2.

Reporting obligation case study 4

Company A owns the landfill site. Company A contracts Company 1 to operate the landfill (operated under Company 1 operational and environmental policies). Company 1 then sub-contracts landfill biogas management duties to Company 2. Company 2 installs its own landfill biogas infrastructure and equipment on the landfill site, and subsequently manages site landfill biogas.

As in case study 3, the two series of activities have been determined by the parties to constitute two different facilities under the operational control of two different parties. Company 1 is deemed to control the landfill facility and must report all emissions from that facility. Company 2 should report on energy production from the landfill biogas, as well as energy consumption and emissions from combustion of the landfill biogas, as it has operational control over that facility. Accordingly, it must report all the emissions and energy data related to the activities for the production process at that facility.

Figure 3 – Reporting obligation case study 3 – landfill, biological treatment and biogas management at three separate facilities.



The company that manages the organic waste treatment facility is normally clear, based on the contract for the company that conducts the activity (Company 3 in Figure 3 above). This company must report on emissions from biological treatment.

Note: Where 2.16 of the NGER Regulations allows separate activities on a single site to be considered part of the same facility, CER prefers one facility to be defined. For example, if the landfill operator also operates the onsite organic waste management, a single facility for these two activities would be preferred.

3. Estimating emissions

3.1 Sources of emissions

Emissions from landfills vary greatly based on a range of factors including:

- the amount of waste deposited
- the type of waste deposited
- the location of, and climatic conditions at, the landfill
- all sources of emissions from landfills that are reportable under NGER are shown in Figure 1, Figure 2 and Figure 3
- methane from decomposing waste in the landfill
- methane and nitrous oxide from combusting landfill biogas

- methane and nitrous oxide from composting or anaerobic treatment of organic wastes
- landfill gas collection efficiency.

Once waste is placed in a landfill, organic matter in the waste decomposes, under anaerobic conditions, to produce methane. Methane, as a component of landfill gas, can be emitted from the landfill. Division 5.2.2 of the NGER Measurement Determination includes calculations of how the methane generated can be calculated. Total emissions from the landfill are equal to the methane generated less any methane captured for on or offsite combustion (including flaring). Calculation of total emissions from the landfill is done by the solid waste calculator described below.

3.2 Solid Waste Calculator

CER has developed a Microsoft Excel based NGER Solid Waste Calculator[14] (SWC) to assist landfill operators report emissions data relating to landfill activities and recommends that reporters use it to ensure that reporting requirements are met. The SWC calculates the total landfill emissions from the total solid waste tonnage disposed of in the landfill over the life of the landfill. The emissions calculations are in accordance with the relevant equations and factors set out in Division 5.2.2 of the NGER Measurement Determination (Method 1).

The SWC allows users to input activity data in editable fields and does not allow users to edit equations and factors that are required by the NGER Measurement Determination. The calculator assists landfill operators to calculate and report current emissions and predict emissions for future years, using Method 1. The calculator tabulates the information provided, and results from calculations undertaken, in a form that can be manually entered into the Emissions and Energy Reporting System (EERS). This feature simplifies the process of reporting in EERS and allows the submission of complete and accurate reports even if the reporter does not have a comprehensive technical understanding of the subject matter.

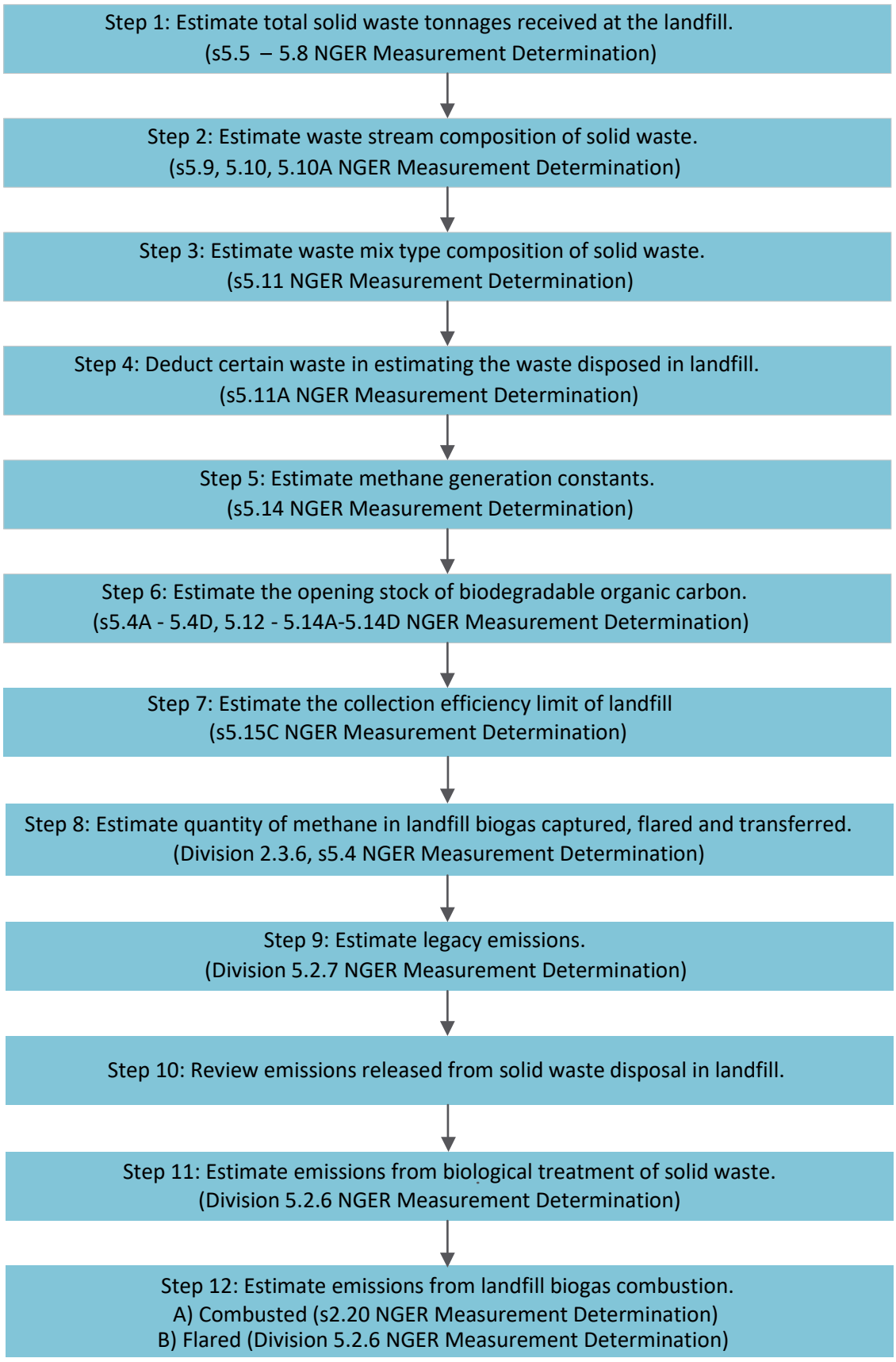
The SWC is reviewed and updated as necessary to remain consistent with the NGER Measurement Determination. It is important to ensure correct versions of the NGER Measurement Determination and the latest version of the SWC are used for each reporting year.

3.3 Information required for estimating emissions

All reporters preparing emissions estimates should follow the steps in Figure 4 below and understand why they are needed. Individual steps are described in chapter 4 of this guideline. The steps generally follow the order of the relevant sections of the NGER Measurement Determination.

[14] https://cer.gov.au/schemes/national-greenhouse-and-energy-reporting-scheme/report-emissions-and-energy/nger-calculators

Figure 4 – Steps for estimating emissions from waste disposal at a landfill.



There are several fixed factors and constants used in estimating emissions, such as:

- fraction of degradable organic carbon dissimilated (s5.14A NGER Measurement Determination)

- methane correction factor for aerobic decomposition (s5.14B NGER Measurement Determination)
- fraction by volume of methane generated in landfill biogas (s5.14C NGER Measurement Determination)
- number of months before methane generation at landfill commences (s5.14D NGER Measurement Determination).

4. Procedure for estimating emissions

4.1 Estimate total solid waste tonnage received at the landfill

4.1.1 Waste received and waste disposed

All reporters must understand the difference between waste 'received at the landfill' and waste 'disposed of in landfill'. Generally, waste received at the landfill is waste that passes over the weighbridge at the landfill site entrance and is often the same figure as that reported to the relevant state or territory government. Waste disposed of in a landfill is defined as waste received at the landfill minus waste diverted from disposal. Waste diverted is the quantity of material that is biologically treated, recycled, or reused onsite.

For all years up until the first reporting period for the landfill, it is only necessary to estimate and report the total tonnage of solid waste disposed of in landfill. See chapter 4.2 of this guideline for more information.

However, for the first and subsequent reporting periods of the landfill, reporters must determine the amount of waste received at the landfill and the amount of waste diverted from disposal. Wastes received and wastes diverted are entered into the SWC. The SWC subtracts the amount diverted from the amount of waste received at the landfill to calculate the waste disposed of in the landfill. See chapter 4.4 of this guideline for guidance on how to account for waste diverted from the landfill.

A common mistake made by reporters is calculating the amount of waste disposed of in the landfill themselves and entering this in the SWC as the amount of waste received at the landfill. This will affect the way the SWC breaks down the waste into the waste mix types and will introduce error into the estimation of emissions.

4.1.2 Measurement criteria

Sections 5.5 to 5.8 of the NGER Measurement Determination provide guidance on the total solid waste tonnage received at the landfill. The total solid waste received for the year must be estimated using either Criterion A, AAA or BBB.

Criterion A is used to estimate total solid waste received at the landfill during the year through either:

- evidence by invoices
- measurement in accordance with the relevant State or Territory legislation which applies to the landfill.

Criterion AAA is used to estimate total solid waste received at the landfill during the year by direct measurement of quantities using appropriate measuring equipment calibrated to a measurement requirement. Direct measurement involves statistically valid sampling and analysis of incoming waste across the year.

Criterion BBB is used to estimate total solid waste received at the landfill during the year in accordance with industry estimation practices (including the use of accepted industry weighbridges). Criterion BBB is the most used criterion, primarily due to the flexibility this offers to reporters and the fact that most landfills have weighbridges, so records are available.

4.2 Estimate composition of solid waste streams

The composition of solid waste received at the landfill must be reported in terms of the waste streams defined in the NGER Measurement Determination, as either of the following:

- general waste stream (s5.9 & s5.10 NGER Measurement Determination)
- homogenous waste stream (s5.9 & s5.10A NGER Measurement Determination).

4.2.1 General waste streams

The general waste streams are:

- municipal solid waste (MSW), separated into class I (MSW I) and/or class II (MSW II)
- commercial and industrial (C&I) waste
- construction and demolition (C&D) waste.

Note**:** Municipal solid waste may be reported separately as either MSW class I or MSW class II or both MSW class I and II. MSW class I and MSW class II are defined at s1.8 of the NGER Measurement Determination. MSW class I comes from sources where organic material is combined with other municipal wastes, and MSW class II comes from sources where organic material is segregated via dedicated bins.

4.2.2 MSW, C&I and C&D waste streams received

The reporter must estimate the tonnage of each general waste stream in the following order of priority as per s5.10(2) of the NGER Measurement Determination:

1. The data collected on waste tonnage as required under a law of the State or Territory in which the landfill is located.
2. Estimate of the solid waste tonnage made by the landfill operator, using acceptable industry practices.
3. If neither of the above are applicable, then by using the default waste stream percentage values.

This is shown in Figure 5.

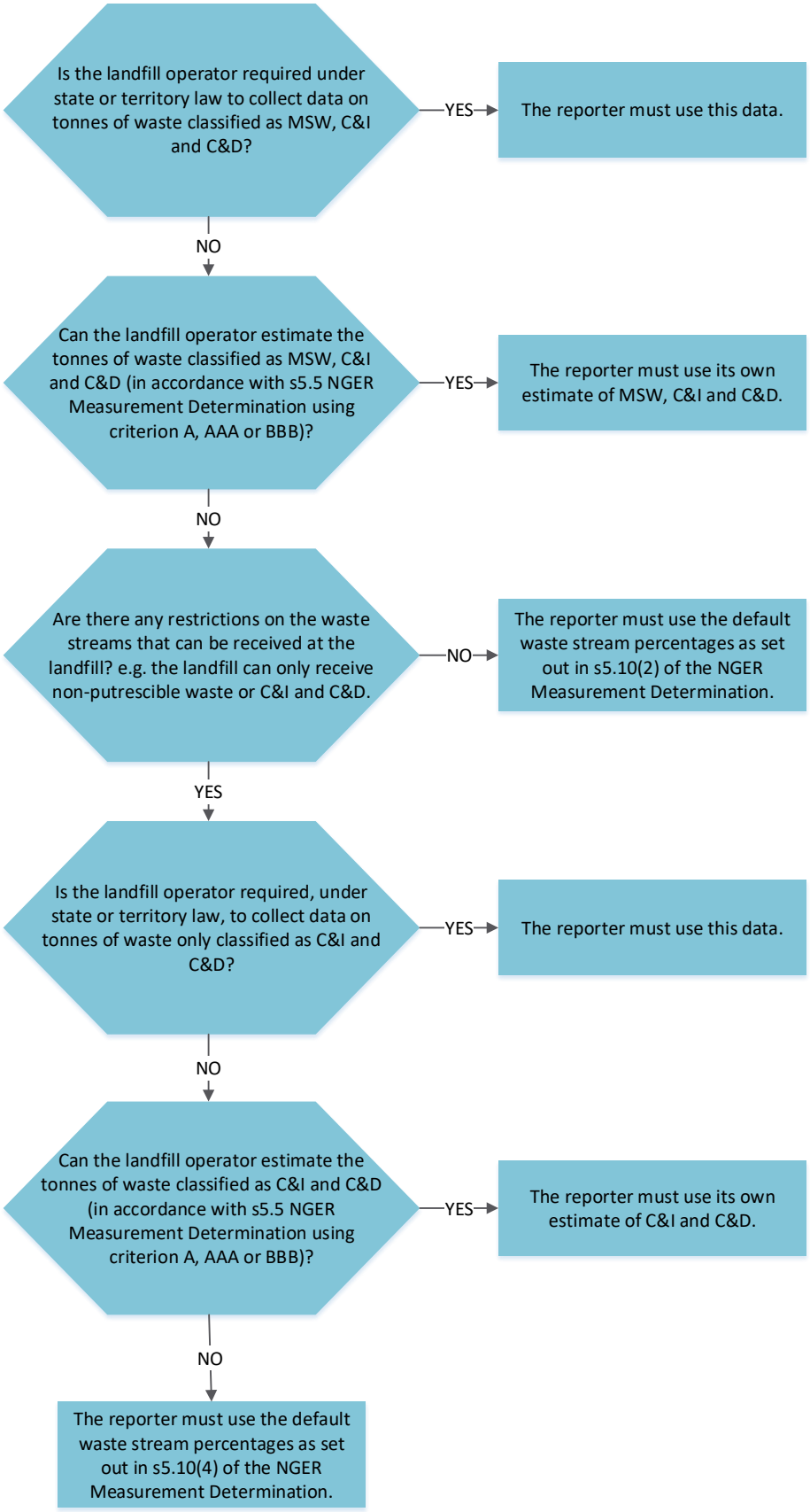
Reporters should adopt the classifications adopted for state-based levy systems where applicable, and if not, classify waste according to the principal activity leading to the generation of the waste. Acceptable industry practices for estimating waste streams are expected to involve the use of weighbridges and an appropriate assessment of how each waste load has been classified as either MSW, C&I or C&D. This may be based on records of the typical waste streams collected by individual waste transporters. The Australian, New Zealand Standard Industry Classification (ANZSIC) system may also be useful in classifying the waste generating activities.

For example:

- waste from domestic premises, council collections and other municipal sources may be classed as municipal solid waste
- waste from activities within ANZSIC divisions C (Manufacturing), G (Retail Trade) or H (Accommodation, Cafes and Restaurants) may be classified as commercial and industrial waste
- waste from activities within ANZSIC division E (Construction) may be classified as construction and demolition waste
- waste from mixed load deliveries of domestic and commercial waste should be classed according to the dominant source.

Waste streams can comprise material from multiple diverse sources. Waste streams may also be derived from several limited sources, be delivered in discretely quantifiable loads, and comprise homogenous material. See chapter 4.2.3 of this guideline for more information.

Figure 5 – Estimating general waste stream tonnages.



Facility specific values of waste streams are expressed as a percentage of the total tonnes (t) of general waste received at the landfill. If custom values are used, it is necessary to keep sufficient records of these

quantities and the methodology used to determine which wastes are MSW, C&I or C&D. See below example for calculating waste stream percentages.

Example of waste stream calculation

A landfill receives 100,000 tonnes per annum (tpa) of waste, as measured at the weighbridge. Of this, the landfill operator estimates the following quantities of waste were received:

- 5 tpa of AWT residue (homogenous waste)
- 10 tpa inert waste (homogenous waste)
- 25 tpa MSW
- 20 tpa C&I
- 40 tpa C&D

The estimated waste stream percentages are:

- MSW 29% = 25/(25+20+40)
- C&I 24% = 20/(25+20+40)
- C&D 47% = 40/(25+20+40)

Note: The quantities of homogenous waste are not included in the calculation, as they are not considered part of a general waste stream.

Custom values of waste streams can be entered in the SWC to comply with state or territory law or the landfill operator's own estimates, if applicable. If custom data is not entered, the SWC defaults to the percentages listed at ss5.10(3) of the NGER Measurement Determination.

If the landfill is permitted to receive only non-putrescible waste or C&I and C&D, the waste may be assumed to consist of C&I and C&D waste exclusively.

If the landfill is only permitted to receive either C&I or C&D waste, then that waste stream (as applicable) is taken to constitute all the waste received.

Custom values for C&I and C&D waste streams can be entered in the SWC to comply with state or territory law. If custom data is not entered, the SWC defaults to the percentages listed at ss5.10(4) of the NGER Measurement Determination.

Note: Waste must not be reclassified because of processes at transfer stations. For example, MSW waste must not be reclassified as C&I waste when transferred through a transfer station to reduce calculated emissions. This applies to all landfills and transfer stations, regardless of state and territory regulations and local waste handling and waste processing practices. Reclassification of waste because of processes at transfer stations is not in accordance with the general principles for measuring emissions which are described in section 1.13 of the NGER Measurement Determination.

4.2.3 Homogenous waste streams

Homogenous waste streams must be estimated where the landfill receives discrete waste composed of a homogenous composition during the year. Homogenous waste streams present the landfill operator the

opportunity to undertake stream-specific sampling and analysis for waste loads of single origin together with default compositions for waste loads of dispersed origin. Homogenous waste streams (s5.10A NGER Measurement Determination) are as follows:

- AWT residues
- shredder flock (such as waste from scrap metal recycling facilities)
- inert waste.

Homogenous waste streams have the following characteristics (ss5.10A(2) NGER Measurement Determination):

- they are from a single known and verifiable origin, as evidenced by invoices (or other delivery documentation if delivery does not involve a commercial transaction)
- they are not extracted from a general waste stream
- they do not undergo compositional change between generation and delivery to a landfill
- they are delivered in loads only containing AWT residue, shredder flock or inert waste.

If inert waste is received at the landfill, but does not meet all the above characteristics, it cannot be classified as homogenous waste.

Examples of homogenous waste classification

If a truck brings in an inert waste load from a demolition site but does not have appropriate documentation that the waste is from a single known and verifiable origin, it cannot be classified as a homogenous waste stream. This waste should be classified as C&D.

If a truck transfers AWT residue, such as from a facility adjacent to the landfill (a single known and verifiable origin) that includes other waste materials, it cannot be classified as a homogenous waste stream. In this case, a more appropriate classification would be C&I waste.

The requirement to report homogenous waste separately from general waste came into effect in 2013–14. Waste accepted in the landfill from 2013–14 onwards that meets the homogenous waste stream characteristics should be reported separately. This will affect the calculation of the opening stock of degradable organic carbon at the beginning of the reporting year for all waste types.

4.3 Estimate the waste mix types received

A further classification of the above waste streams must be undertaken (s 5.11 NGER Measurement Determination), showing the waste mix types in each waste stream (expressed as a percentage of the total tonnage of solid waste in the general waste stream).

The percentage of the total waste tonnage of each general waste stream for each waste mix type must be estimated by using one of the following methods:

- sampling techniques specified in waste audit guidelines issued by the State or Territory in which the landfill is located
- if no such guidelines have been issued, sampling techniques specified in ASTM D 5231- 92 or an equivalent Australian or international standard

- the tonnage of each waste mix type received at the landfill estimated by the landfill operator (using the Criteria set out in s 5.5 of the NGER Measurement Determination)
- the default waste mix types listed in ss 5.11(2) of the NGER Measurement Determination can be used (subject to the matters described in ss 5.11(3) of the NGER Measurement Determination).

The reporter may choose any of these methods to estimate waste mix types (unlike estimating waste streams, where a priority of measurement methods applies). Custom values can be entered in the SWC. If custom data is not entered, the SWC defaults to the percentages listed in ss 5.11(2) of the NGER Measurement Determination.

It may be possible to use an industry estimation practice that enables the tonnage of discrete waste mix types from limited sources to be estimated based on appropriate sampling and analysis, combined with default percentages for the remaining mixed waste from diverse sources (based on those set out in paragraph 5.11(2)(c) of the NGER Measurement Determination). All industry estimation practices, including those used in combination with default elements, must comply with the general principles of s 1.13 of the NGER Measurement Determination.

In meeting the requirement for estimates to achieve the required confidence level, the availability of reasonable resources by the relevant corporation and the requirements of the NGER Measurement Determination should be considered. In some instances, the availability of reasonable resources may limit the ability of a landfill operator to ensure that estimates using industry estimation practices are neither over nor under-estimates of the true values to a 95% confidence level. Nevertheless, it is expected that operators will make reasonable efforts in this regard.

Landfill operators are subject to general obligations to keep records, and CER has powers to seek and obtain information to ensure compliance. Where non-default waste mix types are used, landfill operators must keep records to demonstrate the data used.

4.3.1 MSW class I and II

The reporter must select whether the landfill receives MSW class I or II. If both are received, the amount (expressed as a percentage of total tonnage of solid waste) of MSW class I and MSW class II must be estimated. If reporting both MSW I and MSW II, and the split is not known, the SWC will assume equal amounts of each class are being reported and will calculate using the percentages in

Table 2 – Waste mix type/waste stream for reporting both MSW I and MSW II.

Waste mix type/waste stream	Municipal solid waste class I and class II (%)
Food	37.7
Paper and paper board	14.0
Garden and park	10.2
Wood and wood waste	1.1
Textiles	1.6
Sludge	0.0
Nappies	4.3
Rubber and leather	1.1
Inert waste (including concrete, metal, plastic and glass)	**30.1**

4.3.2 Restricted waste mix type

If the licence or authorisation allowing the operation of the landfill restricts the waste mix types that may be received at the landfill, the percentage of the total waste tonnage for each waste mix type must be estimated using the formula outlined in paragraph 5.11(3)(b) of the NGER Measurement Determination[15].

Note: The SWC automatically calculates the adjusted percentage for each unrestricted waste mix type (W_{mtadj}) after the maximum percentage for each restricted waste mix type (W_{mtrmax}) is entered by the reporter.

4.3.3 Shredder flock

The composition of the homogenous waste stream for shredder flock, broken down into its associated waste mix type must be estimated using one of the methods outlined above (paragraph 5.9(3)(d) NGER Measurement Determination) and entered in the SWC.

Shredder flock is the residual waste generated from the process of scrap metal processing which ends up in landfills. This type of waste stream is primarily from metal recyclers receiving waste from the metal recycling industry. Shredder flock includes plastics, rubber, metals, textiles, and fines with traces of mineral oils and hydrocarbons, with average shredder flock composition shown below. This data may assist the reporter to make an estimation of shredder flock waste mix types in accordance with Criterion BBB, industry estimation practices.

Table 3 – Average shredder flock composition[16].

[15] An example of the calculation to be used is given at s5.11(3)(b) of the NGER Measurement Determination

[16] Source: Hyder Consulting, 2014, "Market summary – shredder floc" fact sheet

Material type	Average composition range (% weight)	NGER Measurement Determination waste mix type
Plastics	35 – 55	Inert waste
Rubber	10 – 20	Rubber and leather
Metals	6 – 13	Inert waste
Textiles	7 – 15	Textiles
Fines (paint, glass, sand)	10 – 20	Inert waste

Note: Breakdown of inert waste or AWT residue homogenous waste streams into waste mix types is not required.

4.4 Estimate waste disposed of in the landfill

The tonnage of the following waste is to be deducted from the estimates of waste received at the landfill:

- waste that is taken from the landfill for recycling or biological treatment
- waste that is received at the landfill for recycling or biological treatment at the landfill site
- waste that is used at the landfill for construction purposes, daily cover purposes, intermediate cover purposes or final capping and cover purposes.

These wastes diverted are identified in Figure 2 and Figure 3 in the orange boxes.

For solid waste diverted from the landfill, no specific method of determining the tonnage is specified. The general principles for measuring emissions which are described in section 1.13 of the NGER Measurement Determination and Table 1 of this document must be applied. It is expected that tonnages are based on weighbridge records or invoices where they exist. Records must be kept to support the estimates of tonnages of waste diverted.

Wastes that are recycled or undergo biological treatment, either onsite or transferred offsite, should be broken down into waste mix types.

An example of entering the waste diverted from the landfill in the SWC is provided below.

Waste received and diverted example

A landfill receives 100,000 tpa waste, as measured at the weighbridge. Of this:

- 5,000 tpa inert waste is used for cover material
- 3,000 tpa food waste is composted on site
- 50 tpa wood waste and 400 tpa scrap metal (inert material) is separated and transferred offsite for recycling

The above values are entered into the table in the SWC. The reporter would enter 100,000 tpa as waste received (column B of 'Subfacility' tab) and the other waste in columns CM, CD, BX, and CC of the 'Subfacility' tab.

Figure 4 – Screenshot of entering the waste diverted from the landfill in the SWC

For years including and after the first reporting year: Waste transferred offsite for recycling or biological treatment (if any) (t)								For years including and after the first reporting year: Waste recycled or biologically treated on-site (if any) (t)								For years including and after the first reporting year: Inert waste for construction/cover (if any) (t)
Paper and paper board	Garden and park	Wood and wood waste	Textiles	Sludge	Nappies	Rubber and Leather	Inert Material	Food	Paper and paper board	Garden and park	Wood and wood waste	Textiles	Sludge	Nappies	Rubber and Leather	Inert Material	Inert Material
		50					400	3,000									5,000

Note: The SWC does not allow a reporter to enter a quantity of waste recycled, biologically treated or reused on site that is greater than that calculated from the waste streams and waste mix types.

Note: If homogenous inert waste is received at the landfill and used for construction/cover material, it should be entered in the SWC as homogenous waste and inert waste for construction/cover.

4.5 Estimate the opening stock of degradable organic carbon

The degradable organic carbon (DOC) of material defines the fraction of that material made up of organic carbon that can degrade biologically to form organic compounds including CH_4. DOC varies by waste mix type alone.

Correctly estimating the opening stock of degradable organic carbon ensures that estimates of emissions from landfill activities are accurate. This requires historical data on quantities and composition of waste disposed of in the landfill for all prior years of the landfill's operation. The reporter only needs to enter the historical data – the SWC then estimates the opening stock of DOC.

However, it is noted this data may not be readily available on all occasions. For this reason, section 5.13 of the NGER Measurement Determination outlines the two methods that can be used to determine the opening stock of carbon at the start of the first reporting period (broken down in the SWC into six techniques), as follows:

- using the details of the total solid waste tonnage disposed of (not received at) in the landfill each year over the lifetime of the landfill until the start of the first reporting period of the landfill (Techniques 1, 2 or 3 in the SWC, 'Inputs and data checks' tab)[17]
- using the following information associated with the landfill:
  - » the number of years that the landfill has been in operation
  - » the state and territory in which the landfill is located
  - » the estimated annual tonnage of solid waste disposed of in the landfill over the lifetime of the landfill until the start of the first reporting period for the landfill (NGER Measurement Determination ss 5.13(2)) as determined using one of three methods:
    - › by using the annual average tonnage for the years for which data is available, where the same value must be used for each year prior to the first reporting year (Technique 5 in the SWC)
    - › by conducting a volumetric survey (Technique 6 in the SWC)
    - › by using industry estimation practices (Technique 4 in the SWC).

The technique used to estimate opening stock of DOC and the year that the landfill first reported under NGER should be entered in the 'Inputs and data checks' tab of the SWC. The number of sub facility zones in the landfill and their opening year is also considered in the SWC calculations, also entered in the 'Inputs and data checks' tab.

Reporters must not combine the following methodologies (as set out in the NGER Measurement Determination) to estimate the opening stock of carbon:

- the measured total tonnage of waste disposed of in the landfill, where available, in each given year prior to the first reporting period (paragraph 5.13(1)(a))
- the estimated average annual tonnage of solid waste disposed of in the landfill for the years when data is not available (paragraph 5.13(1)(b)).
- Reporters should also note that use of site-specific density factor in combination with a volumetric survey, to estimate the quantity in t of waste disposed of in landfill, is only allowed where that figure was used during the most recent reporting year to comply with state or territory legislation (paragraph 5.13(4)(a)). If this condition does not apply, a volume to mass conversion factor of 1.1 tonnes per cubic metre must be used instead (paragraph 5.13(4)(b)).

4.6 Estimate methane generation constants

The methane generation constant (k value) determines the rate at which the breakdown of DOC occurs. The k values vary by both waste mix type and climatic conditions to reflect that organic decay is principally a biological process affected by ambient moisture and temperature conditions. Note that the emissions calculations only explicitly consider ambient moisture due to climatic conditions, and not from recycling of leachate within the landfill.

Landfill operators have two options for selecting k values under Method 1. The first option is to select k values based on climate zones established from the climatic conditions (mean annual temperature,

[17] Solid waste tonnage estimated in accordance with Section 5.5 of the NGER Measurement Determination, broken down into waste streams and waste mix types.

precipitation, and evaporation) at or near the landfill site. The second option is to select k values based on the state or territory in which the landfill is located.

4.6.1 Using site-specific or BOM weather data

The first option involves determining mean annual temperature, evaporation, and precipitation either from the landfill's on-site weather station or from the data available on the Bureau of Meteorology (BOM) website[18].

The NGER Measurement Determination requires on-site weather measurement data to be used, where possible, to ensure that the data is most representative of site conditions. On-site weather measurements must be recorded at the landfill by a meteorological station that is established and maintained in accordance with the Guidelines for the Siting and Exposure of Meteorological Instruments and Observing Facilities (Observation Specification No. 2013.1) (January 1997)[19]. If on-site data cannot be used or is incomplete but considered suitable, the landfill operator should, as necessary, use BOM data from BOM's weather station directory[20] that is located closest to the landfill facility, to complete records of weather for the preceding 10 years (NGER Measurement Determination ss 5.14(7)).

BOM provides data on mean maximum and mean minimum temperatures over the entire time-series of weather station data. The mean annual temperature can be estimated by averaging the mean maximum and mean minimum temperatures. Mean annual precipitation is available directly from BOM weather station (closest to the landfill) data, with no additional calculations needed to derive this value. Where BOM records are missing for any of the preceding 10 years, landfill operators may use the average of the available data for the preceding 10 years to fill in data gaps to undertake the required calculations.

Reporters with landfills in 'temperate' zones additionally need to estimate mean annual evaporation to determine k values. Mean annual evaporation data are available from certain BOM weather stations. Under section 5.14 of the NGER Measurement Determination, mean annual evaporation data should be obtained from the closest BOM weather station to the landfill for which evaporation records exist. No additional calculations are required to derive this value.

Section 5.14 of the NGER Determination specifies how to use the climate data to determine the landfill facility's climate region, and hence its k values (ss 5.14(6) NGER Determination). If the landfill operator uses k values based on climatic zone (that is, the k values in ss 5.14(6)), then it must keep using the same climatic zone for each subsequent reporting year (ss 5.14(4) NGER Determination) unless the landfill climate zone classification changes. If the landfill operator chooses to select k values from the table in ss 5.14(6), the landfill operator must first obtain climatic records of mean annual evaporation, precipitation, and temperature for the 10-year period immediately prior to the reporting year (ss 5.14(2) NGER Measurement Determination) to work out the landfill classification applicable to the landfill.

4.6.2 Using state or territory defaults

If the landfill does not have suitable measuring equipment on-site or BOM data is unsuitable, default k values, based on state or territory data, can be used (ss 5.14(5) NGER Measurement Determination).

[18] www.bom.gov.au
[19] http://www.bom.gov.au/climate/cdo/about/observation_specification_2013.pdf
[20] http://www.bom.gov.au/climate/data/stations/

Note: The SWC automatically applies k values specified in subsection 5.14(5) of the NGER Measurement Determination according to the state/territory or climate zone (identified by the reporter entered in the 'Inputs and data checks' tab of the SWC).

4.7 Collection efficiency limit of landfill gas

The maximum collection efficiency of landfill gas is calculated using the areas (m^2) for the following categories of landfill capping and gas management:

- **A2**: areas without active gas collection.
- **A3**: areas with daily soil cover and active gas collection.
- **A4**: areas with active gas collection and an intermediate cover in place or a final phytocap.
- **A5**: areas with active gas collection and final capping in place (excluding phytocaps) as approved under applicable State or Territory legislation.

For **A4**, the intermediate cover in place must be consistent with:

(a) applicable guidance issued by the State or Territory in which the landfill is located; or

(b) if no applicable guidance has been issued by the State or Territory in which the landfill is located:

(i) the document entitled *Siting, design, operation and rehabilitation of landfills* (Publication 788.3), published by the Environment Protection Authority Victoria in August 2015, as in force or existing from time to time; or

(ii) the last published version of the document referred to in subparagraph (i), if that document is no longer published.

The collection efficiency limit for a landfill is calculated using the following formula:

$$Collection\ efficiency\ limit = ((\mathrm{A3}\ \times 60\% + \mathrm{A4}\ \times 75\% + \mathrm{A5}\ \times 95\%))/((\mathrm{A2} + \mathrm{A3} + \mathrm{A4} + \mathrm{A5}))$$

Where a landfill operator is unable to specify the areas for the factors A2, A3, A4 and A5, the collection efficiency limit for the landfill is 75%.

Follow the instructions in the 'Subfacility' worksheets in the SWC to estimate the collection efficiency limit of the landfill.

Read section 5.15C of the NGER Measurement Determination for more information.

4.8 Estimate landfill biogas combusted

4.8.1 Landfill biogas types

The reporter must understand the existing landfill biogas management systems currently implemented at the site. More specifically, the reporter (or the contracted landfill biogas manager) must where applicable measure the quantity of CH_4 in landfill biogas during the reporting year of the following:

- the quantity of CH_4 in landfill biogas captured for combustion (Qcap)
- the quantity of CH_4 in landfill biogas flared (Qflared)
- the quantity of CH_4 in landfill biogas transferred out of the landfill (Qtr)
- if biogas is managed by a landfill biogas manager, the landfill biogas must be reported by the landfill operator as transferred out of the landfill (Q_{tr}), as per the example below.

Reporting methane in landfill biogas flared, captured or transferred out of the landfill

Example 1

A landfill operator has installed a flare and a generator to produce electricity. The landfill operator must measure the quantity flared and combusted in the generator separately and report as Q_{flared} and Q_{cap} respectively (see relevant columns in the SWC and in the matters to be identified (MTBI) in EERS).

Example 2

A landfill operator engages a landfill biogas contractor to manage the flare and generator (a separate facility under the operational control of the contractor). In this case, the landfill operator reports the quantity flared and combusted in the generator as Q_{tr} (see relevant columns in the SWC and in the MTBI in EERS). The landfill biogas manager would be responsible for metering the quantity flared and combusted and providing that quantity to the landfill operator.

Additionally, if you capture landfill biogas and generate electricity from it, you need to report the following activities:

- energy production for the gas captured
- fuel combustion for electricity generation, this activity is used to report the energy consumed through the combustion of landfill biogas
- production of electricity for use on site, reporting this activity will automatically generate the associated activity in EERS which reports the consumption of electricity produced on site
- production of electricity for use offsite on a network (if the electricity is sent to grid)
- production of electricity for use offsite not on a network (if the electricity is not sent to grid).

Alternatively, if you capture landfill biogas and flare it, you need to report the following activities:

- energy production for the gas capture
- flaring of landfill biogas, selecting '28 – Landfill biogas that is captured for combustion (methane only)' so that the energy consumption for this activity is recorded.

4.8.2 Landfill biogas measurement

How is landfill biogas volume measured?

- Methane in landfill biogas must be measured in cubic metres and at standard conditions (STP).

The selection of the measurement method depends on whether the acquisition of the landfill biogas involves a commercial transaction (s2.29 NGER Measurement Determination), as follows:

- if the acquisition involves a commercial transaction, either Criterion A, AA or AAA may be used. Normally the landfill biogas manager has a contract with the landfill owner or operator to collect and combust the landfill biogas, without paying for the biogas or involving a direct commercial transaction, so this option is not usual
- if the acquisition does not involve a commercial transaction, then Criterion AAA or BBB may be used, as described below:
  - » Criterion AAA: The measurement during the year of a landfill biogas fuel combusted from the operation of the facility. The measurement must be undertaken using appropriate biogas measuring equipment at the point of combustion[21]
  - » Criterion BBB: The estimation of landfill biogas fuel in accordance with industry practice if the measuring equipment used to estimate consumption of the fuel does not meet the requirements of criterion AAA.

Measuring landfill biogas using Criterion AAA

- Separate flow meters are normally installed for flares and combustion devices (including engines/generators used to produce electricity). These are normally installed at the point of combustion.
- Flow meter accuracy is specified for orifice plate meters only (s2.31 NGER Measurement Determination), based on the maximum daily quantity of biogas combusted (ss 2.31(4) NGER Measurement Determination). There are other equipment standards that apply to gaseous fuels, including landfill biogas (s2.32 NGER Measurement Determination) and to different types of flow meters:
- CER expects that the flow metering equipment should meet the accuracy requirements specified (s2.32–2.37 NGER Measurement Determination)
- equipment standards are only specified for orifice plate, turbine, and rotary type meters. Equipment standards are not specified for other types of flowmeters commonly used for landfill biogas such as mass flow meters. Flow meters, where gas combusted is greater than 3500 gigajoules per day, should have +/- 1.5% accuracy.

Measuring landfill biogas using Criterion BBB

- Criterion BBB may be used where the metering equipment does not meet the accuracy requirements of criterion AAA. In addition, if landfill biogas is combusted to produce electricity, then the volume of

[21] If Australian Carbon Credit Units are claimed for combustion through a flare, engine or combustion device, then Criterion AAA must be used.

landfill biogas may be back-calculated from the electricity produced and an engine electricity efficiency (manufacturer's specification or default of 36%) and the energy content of landfill biogas (ss 2.38(2) NGER Measurement Determination). In this case, the energy content factor for *28. Landfill biogas that is captured for combustion (methane only)*, from Schedule 1 of the NGER Measurement Determination is the applicable fuel.

The requirements for criterion AAA and criterion BBB are summarised in Table 4.

Table 4 - Landfill biogas combusted.

Parameter	Definition	How to measure it
Qcap	Volume of methane in landfill biogas captured for combustion in m3 at STP. Combustion occurs at the landfill and does not include landfill biogas flared (single facility as shown in Reporting Obligation case study 1 and 2, see chapter 2.1.1 of this guideline). Qcap is usually combustion for useful energy e.g. electricity generation.	Direct measurement using systems in accordance with s2.31–2.37 (criterion AAA), or Direct measurement using industry practice in accordance with s2.38(1) (criterion BBB), or Derivation from electricity generated from combustion of landfill biogas, and using the energy content, in accordance with s2.38(2) (criterion BBB).
Qflared	Volume of methane in landfill biogas flared in m3 at STP. Flaring occurs at the landfill (single facility as shown in Reporting Obligation case study 1 and 2, see chapter 2.1.1 of this guideline).	Direct measurement using systems in accordance with s2.31–2.37 (criterion AAA), or Direct measurement using systems which comply with s2.38(1) (criterion BBB).
Qtr	Volume of methane in landfill biogas transferred out of a landfill in m3 at STP Includes landfill biogas flared or combusted outside of the landfill (at a separate facility as shown in Reporting Obligation case study 3 and 4, see chapter 2.1.2 of this guideline).	Direct measurement using systems in accordance with s2.31–2.37 (criterion AAA), or Direct measurement using systems which comply with s2.38(1) (criterion BBB).

How is methane in landfill biogas volume measured?

- Q_{cap}, Q_{flared} and Q_{tr} is the methane quantity in landfill biogas only (and equals the landfill biogas quantity x methane content measured as a proportion of total gas volume).
- Methane content may be measured online (such as by a gas chromatograph or infrared analyser) or by laboratory analysis of representative samples. Methane gas analysers are usually installed since they are required for process control and efficient operation of engines/generators. Standards are not specified for measuring methane content in landfill biogas; however, it is expected that landfill biogas composition should be measured in line with the general requirements described in s1.13 and s2.23 of the NGER Measurement Determination:
  - » a sample should be derived from a composite of amounts of the landfill biogas

- samples must be collected on enough occasions to produce a representative sample (minimum monthly)
- samples must be free of bias so that any estimates are neither over nor under-estimates of the true value
- the value obtained from the samples must only be used for the reporting period for which it was intended to be representative.

- occasionally there may be no methane analyser for a flare. If methane content is not measured, the methane content of landfill biogas can be estimated as 50% (industry practice default).

4.9 Estimation of legacy and non-legacy waste emissions

Legacy waste means waste deposited at a landfill before 1 July 2016. Non-legacy waste means waste deposited at a landfill on or after 1 July 2016.

Subsection 5.3(4) of the NGER Measurement Determination stipulates that if the total amount of scope 1 emissions from the operation of the facility during the year is more than 100,000 tonnes CO_2-e, reporters are required to separately estimate legacy and non-legacy landfill waste emissions in accordance with Division 5.2.7 of the NGER Measurement Determination. In this case the reportable MTBIs from Part 6 of Schedule 4 of the NGER Measurement Determination include:

- legacy emissions from the decomposition of waste
- emissions, other than legacy emissions, from the decomposition of waste
- the tonnes of methane (CO_2-e) captured for combustion that are legacy emissions
- the tonnes of methane (CO_2-e) captured for combustion that are not legacy emissions
- the tonnes of methane (CO_2-e) captured and transferred offsite that are legacy emissions
- the tonnes of methane (CO_2-e) captured and transferred offsite that are not legacy emissions
- the tonnes of methane (CO_2-e) flared that are legacy emissions
- the tonnes of methane (CO_2-e) flared that are not legacy emissions
- the tonnes of methane (CO_2-e), other than legacy emissions, that would be emitted if emissions were not captured, and oxidation did not occur, calculated as:

$$NLCH_4 = \frac{non\text{-}legacy\ emissions}{1\ -\ OF} + CH_4\ recovery$$

Where:

- 'NLCH4' is the tonnes of methane (CO_2-e), other than legacy emissions, that would be emitted by the facility if emissions were not captured, and oxidation did not occur.
- 'Non-legacy emissions' is the emissions (CO_2-e), other than legacy emissions, from the decomposition of waste.
- 'OF' is the oxidation factor (0.1) for near surface methane in the landfill.
- 'CH_4 recovery' is the sum of the tonnes of methane (CO_2-e), other than legacy emissions, that are captured for combustion, or captured and transferred offsite, and flared.

Where scope 1 emissions from the operation of the facility during the year is 100,000 t CO_2-e or less, reporters can report the combined total of landfill waste emissions without allocation between legacy and non-legacy emissions. In this case the reportable MTBIs from Part 6 of Schedule 4 of the NGER Measurement Determination include:

- emissions from the decomposition of waste
- the tonnes of methane (CO_2-e) captured for combustion
- the tonnes of methane (CO_2-e) captured and transferred offsite
- the tonnes of methane (CO_2-e) flared.

The SWC separately calculates and displays emissions from legacy and non-legacy wastes automatically. Reporters are advised that they should input all of the SWC outputs into EERS which will then automatically incorporate MTBIs required for their final NGER report.

Note: No non-legacy emissions were produced in 2016–17, due to the delay in decomposition of wastes. non-legacy emissions are produced from 2017–18 onwards.

4.9.1 Sub-facility zones

Sub-facility zones can be used to apportion emission production and emission abatement more accurately between legacy and non-legacy sources. Division 5.2.7 of the NGER Measurement Determination outlines the rules for establishing sub-facility zones and apportioning emissions between sub-facility zones. Some key points are:

- a landfill can have up to four sub-facility zones that receive waste (or more if only inert waste)
- each sub-facility zone must cover at least one hectare and be a single area within the landfill
- there must be no biogas flow between sub facility zones
- it must have a uniform composition of waste mix types
- For landfill facilities with emissions greater than 100,000 t CO_2-e, it is recommended to use a separate SWC for each sub-facility zone, and then sum the results.

4.10 Review emissions released during the reporting year

As a final step to estimating emissions at the facility, the reporter should undertake a review of the parameters and inputs used in the emission estimation process. This is to minimise errors and ensure accurate reporting. The checklist in Appendix A may be used (the reporter could customise the checklist to its own situation).

Note: The reporter must review the EERS upload worksheet in the SWC. The worksheet provides a table of the information to be manually uploaded in the EERS.

Once the emissions from the landfill have been calculated in the SWC, these can then be compared to the reporting threshold. Emissions from the landfill do not need to be reported if they are less than 10,000 t CO_2-e for the reporting year (ss 5.2(2) NGER Measurement Determination).

Note: Section 8.10 of the NGER Measurement Determination states that the aggregated uncertainty level for solid waste disposal on land is 35%. Using this percentage, an emission estimate of 100 kt CO_2-e +/- 35% at the 95% confidence interval means that the true value lies between 65 kt CO_2-e and 135 kt CO_2-e with a probability of 95%. A 95% confidence level does not mean that the estimate needs to be within 5% of the true value.

4.11 Estimate emissions from biological treatment of solid waste

Section 5.22 of the NGER Measurement Determination sets out Method 1 for emissions released from the biological treatment of solid waste by either composting or anaerobic digestion.

If the biological treatment of waste is applicable to the facility, the reporter must report the mass of organic waste to calculate the total emissions generated from these processes, whether by composting or anaerobic digestion. The mass of organic waste can be estimated using weighbridges or other industry estimation methods. All information used in estimating emissions from composting should be documented and retained for future reference.

The amount of methane in recovered biogas (from anaerobic digestion only) can be subtracted from the methane emissions generated to estimate the net annual methane emissions if applicable.

Note: The SWC automatically calculates the total emissions using Method 1 for emissions released from the biological treatment of solid waste based on the mass of organic waste treated by each process. The SWC does not account for methane in recovered biogas, so this must be subtracted manually.

For the 2016–17 reporting period onward, biological treatment of solid waste must be reported, whether it occurs at the landfill or at another facility. Biological treatment is an occurrence of a source of emissions and is reported separately from solid waste disposed of at a landfill. However, MTBIs relating to biological treatment of solid waste are still reported with the MTBIs relating to solid waste disposed of at a landfill (if both activities are part of the same facility).

4.12 Estimate emissions from landfill biogas combustion

4.12.1 Emissions from landfill biogas combustion

Emissions from the combustion of landfill biogas by any means other than flaring are estimated in the same manner as any gaseous fuel as per s 2.19 of the NGER Measurement Determination and can be estimated using Method 1, 2 or 3.

Method 1 is the most straightforward and involves multiplying the quantity of landfill biogas combusted by emissions factors selected from Schedule 1 of the NGER Measurement Determination. If using Method 1, only the quantity must be estimated, as the emissions calculations are automatically factored into EERS. The quantity of methane in landfill biogas is calculated in the same manner as described in chapter 4.8.2 of this guideline.

Emissions from landfill biogas combustion are only reported if methane in landfill biogas is above the threshold of 1,000 m^3 (s 2.18 NGER Measurement Determination).

Which organisation must report on landfill biogas combusted?

The company that has operational control of the facility that includes the combustion activity must report on emissions.

4.12.2 Emissions from flaring

Emissions from flaring can be estimated using Method 1, 2 or 3 (s 5.19–5.21 NGER Measurement Determination). The method reported depends on the biogas sampling and analysis used:

- Method 1 uses a fixed methane gas fraction of 50%

- Method 2 uses methane determined by sampling and analysis conducted according to Subdivision 2.3.3.2
- Method 3 uses methane determined by sampling and analysis conducted according to Division 2.3.4.

In all methods, the landfill biogas volume is determined from Division 2.3.6. No reporting threshold exists for flaring, as the NGER Measurement Determination treats it as a fugitive emission that has no threshold.

- The NGER Measurement Determination does not require the reporter to use the same manner of estimating the methane fraction in landfill biogas flared used in section 5.4 (for emissions from landfills) and that used for flaring in sections 5.19–5.21 of the NGER Measurement Determination.

The quantity of methane in landfill biogas flared can be reported using Method 1 and a 50% methane content. In the example at chapter 4.8.2 of this guideline, the reporter can elect to report methane in landfill biogas as either:

- 154,612 m^3 x 50% = 77,306 m^3 using Method 1
- 78,711 m^3 using Method 2 or 3 (assuming the sampling and analysis of methane proportion undertaken meets the requirements of Method 2 or 3)
- A common error is the landfill operator or landfill biogas manager reporting the quantity estimated using Method 2 or 3 but reporting in EERS as estimated using Method 1. It must be noted that if Method 2 or 3 are used in one reporting year, the reporter must continue to report by that method in the future (for four reporting years) – that is, a NGER reporter cannot revert to reporting by Method 1 or a lower order method (ss 1.18(2) & (3) NGER Measurement Determination).

Which organisation must report on landfill biogas flaring?

NGER Measurement Determination Division 5.2.5 'Solid waste at landfills — Flaring' applies to all facilities that flare landfill biogas, whether at the landfill or at a facility operated by a landfill biogas contractor/manager. The company that has operational control of the facility that includes flaring activity (normally the company that operates the flare) must report on emissions.

A common error includes the landfill biogas manager claiming the biogas flared is excess biogas produced by the landfill operator and under the operational control of the landfill operator. It does not matter how landfill biogas emissions have been reported in the past or whether there is a contract indicating one party will report – the only test is whether the flaring activity (that is, the physical equipment) is part of the landfill facility or a separate landfill biogas management facility.

4.13 Emissions associated with biomethane

Biomethane is reportable under NGER for the first time in NGER reporting year 2022–23. Emissions may be associated with the process of upgrading landfill biogas into biomethane, that is emissions from biogas or biomethane combusted for stationary energy purposes, as well as the flaring or combustion of biomethane. See the Reporting blended fuels, other fuel mixes, bitumen and explosives guideline[22] for more information on how to report emissions associated with the production or consumption of biomethane.

5. Reporting energy consumption and production

[22] https://cer.gov.au/document_page/reporting-blended-fuels-other-fuel-mixes-bitumen-and-explosives-guideline

This guideline reflects the estimation and reporting of energy consumption and energy production at the date of publication. Reporters must ensure they report energy consumption and energy production in accordance with the requirements of the NGER legislation at the time of reporting. If there is any doubt regarding obligations for the estimation and reporting of energy consumption or energy production, or the currency of this guideline, contact CER.

5.1 Energy production

5.1.1 Landfill biogas energy production

What must be reported?

Fuel and other energy commodities that are produced, as listed in Schedule 1 of the NGER Regulations and Schedule 1 of the NGER Measurement Determination, need to be reported. This includes 'Landfill biogas that is captured for combustion (methane only)'.
The definition of 'captured for combustion', under 1.03 of the NGER Regulations, includes the term 'injected into a pipeline'. CER expects that if force is applied to create differential pressure to capture landfill biogas in a pipe, then it is considered to have been 'injected into a pipeline'. Where this occurs:

- it meets the definition of 'captured for combustion' in 1.03 of the NGER Regulations
- it is a fuel or other energy commodity listed in Schedule 1 of the NGER Regulations
- it meets the definition of 'energy' in NGER Act Section 7
- it meets the definition of 'production' in 2.25 of the NGER Regulations.

Force can be applied to create a differential pressure by use of a machine such as:

- a compressor
- extraction fan
- blower
- pump.

Where is the point of energy production for landfill biogas?

CER considers the point where landfill biogas is 'injected into a pipeline' as the point at which energy is 'produced', irrespective of any downstream uses, whether captured for combustion, flared or transferred. This point is at the capture point (landfill cell gas wells). As soon as landfill biogas is drawn into the landfill cell gas wells by an extraction fan/blower/compressor, it becomes 'energy' as it meets the definition of 'captured for combustion' under 1.03 of the NGER Regulations, and definition for 'production' under 2.25 of the NGER Regulations; and is a fuel or other energy commodity listed in Schedule 1 of the NGER Regulations.

This point of energy production is particularly relevant when landfill biogas is collected and sent to another facility for flaring/electricity generation.

All landfill biogas that is flared or combusted in any manner after injection into the pipeline, is considered energy produced. This aspect of energy reporting has been clarified for application to the 2017–18 reporting year and onwards.

There is no reporting threshold for energy production from landfill biogas.

Who must report energy production for capture of landfill biogas?

The reporter for energy production is the operator of the facility that includes the collection pipe work at the landfill cell gas wells as part of its production process. The biogas is considered to have been 'injected into a pipeline' at the point that it enters the collection pipe work. This aspect of energy reporting has been clarified for application to the 2017–18 reporting year and onwards. If the landfill waste management, gas capture, and gas combustion occur across two facilities, the operators of those facilities (typically landfill manager and landfill biogas manager) should reach agreement on which facility includes operation of the collection pipe work and is therefore responsible for reporting energy production. There are multiple potential configurations, including:

- landfill waste management, gas capture, gas combustion all at the same facility (the facility reports energy production)
- landfill waste management and gas capture at first facility, gas combustion at the second facility (first facility reports energy production)
- landfill waste management at the first facility, gas capture and gas combustion at the second facility (second facility reports energy production).

Note: CER expects energy production to be reported by one and only one facility when gas captured for combustion (including flaring) is 'injected into a pipeline'. Accordingly, where more than one facility could be considered to include operation of the landfill gas wells, the operators of those facilities are expected to agree which facility must report the corresponding energy production.

5.1.2 Biomethane energy production

Biomethane is reportable under NGER for the first time in NGER reporting year 2022–23. See Reporting blended fuels, other fuel mixes, bitumen and explosives guideline[23] for more information on how to report energy from the production of biomethane.

5.1.3 Electricity production

Electricity production also must be reported as energy production, if above the threshold. The applicable reporting threshold is the generating unit capacity is greater than 0.5 megawatts and the unit generates greater than 100,000 kilowatt hours of electricity in the reporting year (4.19(2) and 4.20(3) of the NGER Regulations). Some electricity generators at landfills may be below this reporting threshold. The threshold applies to each generating unit, not the combined capacity of the generating facility, as shown in the example below.

[23] https://cer.gov.au/document_page/reporting-blended-fuels-other-fuel-mixes-bitumen-and-explosives-guideline

Electricity production example

A landfill biogas manager has two generating units, with the following annual generation:

Table 5: Generating units and the annual generation

Unit	Capacity (MW)	Annual generation (kWh)
1	0.6	90,000
2	0.4	120,000
Total	1.0	210,000

The landfill biogas manager does not have to report electricity production, since neither unit is above both reporting thresholds. If, the following year, unit 1 generates greater than 100,000 kWh, it would have to be reported as electricity production.

A summary of reporting required for emissions, energy consumed, and energy produced is shown in Figures 6 and 7.

5.2 Energy consumption

All energy consumed by combustion must be reported if above the reporting threshold of 1,000 m^3 for methane content of landfill biogas (s 2.18 and s 6.4, Note 3 NGER Measurement Determination). The definition of 'consumption' in 2.26 of the NGER Regulations includes 'disposal of energy from the operation of the facility'.

Energy from landfill biogas consumed by combustion is automatically calculated in EERS from the quantity entered in the emissions section, including for flared quantities. In this case the reporter should select the fuel type '28 - Landfill biogas that is captured for combustion (methane only)' in EERS.

Energy consumption from other fuels used at the facility, such as diesel or gasoline, must also be reported.

Figure 6 – Emissions and energy reported as one facility.

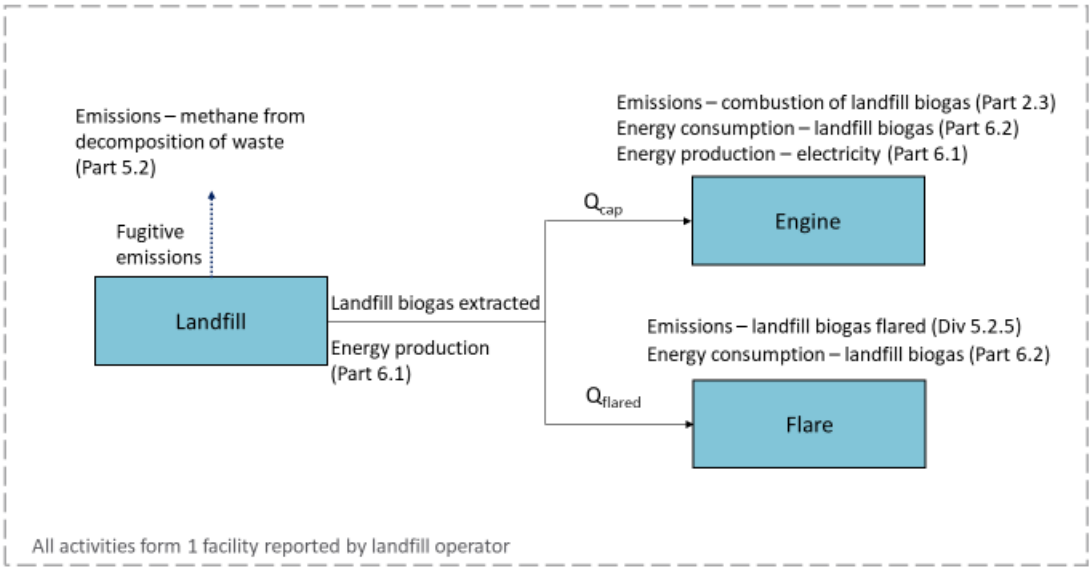
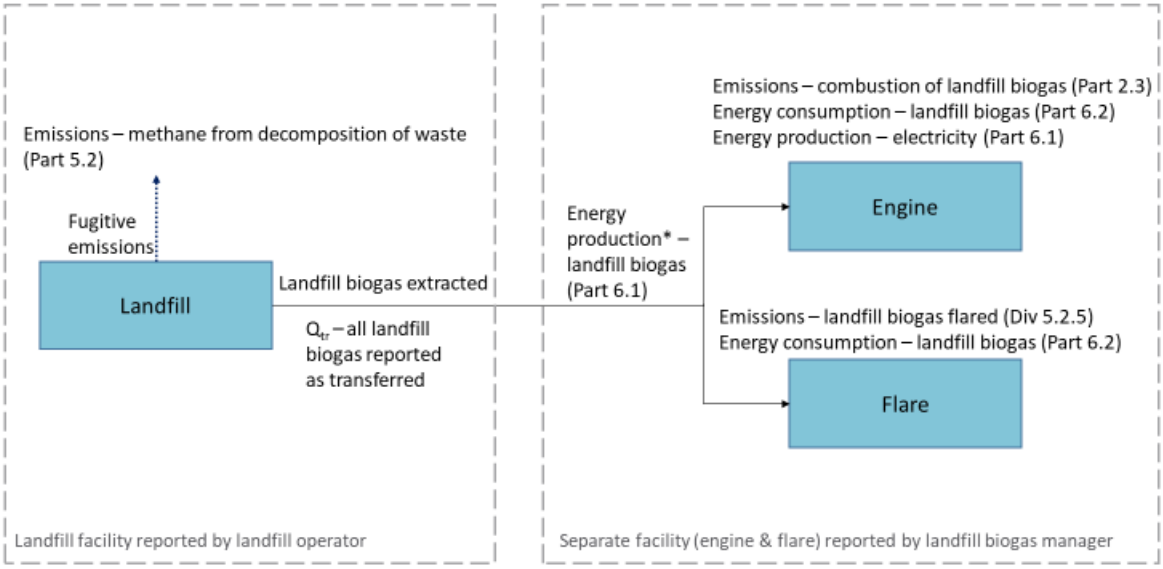


Figure 7 – Emissions and energy reported as separate facilities.



Note: Reporting of energy production will depend on whether the gas collection wells are part of the landfill facility or the landfill biogas management facility.

More information and references

This guideline has been developed by CER for use by landfill operators and landfill biogas managers, to assist in the consistent accounting and reporting of greenhouse gas emissions, energy consumption and energy production using the NGER legislation.

More information

For more information, please contact CER.

Email: cer-nger-reporting@cer.gov.au

Phone: 1300 553 542 within Australia

Web: www.cer.gov.au

See NGER Reporting Guides[24] for guidance on:

- defining a facility
- operational control
- measurement criteria
- reporting energy production and consumption
- reporting uncertainty.

[24] https://cer.gov.au/schemes/national-greenhouse-and-energy-reporting-scheme/report-emissions-and-energy/nger-reporting-guides

Appendix A – Checklist for landfill emissions

Check undertaken	Guideline Chapter	Y/N/NA
Waste received at the landfill (over the weighbridge) has been reported, not waste disposed of in the landfill	4.1 and 4.4	
Waste streams are split into MSW, C&I and C&D where required under legislation, or if they can be reasonably estimated	4.2	
Homogenous waste is reported separately from general waste streams	4.2.3	
Only AWT residue, shredder flock and inert waste have been reported as homogenous waste	4.2.3	
Receival of MSW class I, class II or both has been recorded	4.3.1	
Waste mix types have been estimated, if defaults are not used	4.3	
Licence restrictions on wastes received at the landfill have been considered	4.3.2	
If shredder flock is reported, the breakdown of waste mix types have been estimated	4.3.3	
Wastes that are recycled or reused on site have been recorded	4.4	
Tonnes of organic wastes that are sent to biological treatment are measured	4.4 and 4.11	
The technique used for estimating the opening stock of degradable organic carbon has been specified	4.5	
Historical records are available or estimated for all years prior to the first NGER reporting year	4.5	
If non-default k values are used, records of climatic data are maintained	4.6	
If non-default k values are used, climatic data has been checked (for the previous 10 years)	4.6.1	
The collection efficiency amount for the landfill is calculated (or default value used)	4.7	
The methane only component of landfill biogas has been used (not the landfill biogas quantity)	4.8	
All biogas flowrates have been adjusted to standard and pressure	4.8.2	

Methane analyser fractions are in volume/volume per cent	4.8.2
If non-default data is used, methane volume is the sum of [landfill biogas flow x methane %], measured at least monthly (or over a shorter time period)	4.8.2
Operational control for each activity/facility has been reviewed	2
Records of all of the above have been retained	1.2
Key decisions and assumptions have been documented	1.2