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Landfill Gas Management

Final Report

On behalf of the Ministry for the Environment

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Report For

Ministry for the Environment

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Executive Summary

This report examines the operation of landfill gas (LFG) management in New Zealand and internationally and sets out recommendations for a robust, transparent, and effective LFG capture regulatory framework in Aotearoa. The work also presents options to improve organic waste management that would reduce emissions from landfilling and presents the results of modelling the estimated costs and benefits of making these changes.

The current landfill gas management regime was initially established in 2004 through the NES-AQ and further developed through the NZ ETS (with Class 1 landfills being required to participate from 2013). Aotearoa New Zealand's first and second *emissions reduction plans* include actions to address biogenic methane emissions from organic materials in landfills.[1] The *Second Emissions Reduction Plan (ERP2*) states that "*in 2022, the waste sector produced an estimated 3.5 Mt CO2-e (about 4.5 percent) of New Zealand's gross greenhouse gas emissions*." 93.3 percent of these emissions were in the form of methane and overall, 81 percent of waste sector emissions were attributed to solid waste disposal.[2]

Regulatory Framework Improvement Options

New Zealand's LFG regulatory regime consists of several components that interact but do not necessarily provide a cohesive approach in respect of LFG. The key components are:

- The National Environmental Standards for Air Quality under the RMA – which is applied by regional councils,
- The NZETS and the associated regulations, administered by the EPA,
- The Climate Change Response Act, administered by the MfE which sets emissions budgets and through the ERP identifies actions to meet carbon budgets, and
- The waste disposal levy, administered by the MfE. The levy does not directly address LFG but acts as a tool to disincentivise waste to disposal and, through the application of levy funds provides support for activities that could reduce emissions from disposal.

The current approach, while broadly functional, has led to several areas where there is potential for improvement. These include:

- Organic waste is in effect being treated differently depending on its destination, with Class 1 facilities being required to have leachate collection, gas capture, and facing higher waste disposal levy rates. This creates a perverse incentive to send material to Class 2-5 facilities, where the control of emissions is lower.
- The waste disposal levy is currently at a low to moderate rate compared to the best performing international examples. Application of an escalator to higher levels would provide clear signals to the industry an allow appropriate timeframes for investment.
- New Zealand is relatively unique in that the key instrument around minimising LFG emissions is an emissions trading scheme. This creates the requirement to estimate generation and capture rates. Other jurisdictions without this type of instrument (for example UK and Australia), measure gas

[1] New Zealand Government (2022) Te hau mārohi ki anamata: Towards a productive, sustainable and inclusive economy, Aotearoa New Zealand's first Emissions Reduction Plan
[2] New-Zealands-second-emissions-reduction-plan-202630.pdf

captured and provide incentive payments based on the total quantity of LFG captured and destroyed, which can be measured and calculated with reasonable accuracy.[3]

- There is no established national best practice standard or guidance for operation of LFG systems.
- There is no established national best practice standard or guidance for measurement of on-site emissions.
- Current reporting arrangements have resulted in some landfills claiming high instantaneous gas capture rates, which may not reflect actual gas capture rates (due to organic loading), and which do not reflect lifetime gas capture rates.
- There is a disconnect between the instantaneous LFG capture rates reported for the purposes of the NZETS and gas capture rates used for the purposes of policy and for GHG inventory reporting.
- While the NZETS has incentivised high gas capture rates amongst some landfills, the effect has been uneven, with larger facilities able to claim high rates, while smaller facilities generally do not.
- There is limited transparency as to how LFG generation calculations are made by operators when submitting claims for the ETS payments.

The LFG regulatory regime should present a consistent framework that takes a holistic approach and offers appropriate controls and incentives directed towards the desired outcomes of reducing emissions from landfills and improving gas capture. The recommended changes are intended to enable the industry to make investment and operational decisions that fairly and transparently reflect the risks and benefits of the various approaches to management of organics (i.e. landfills with and without gas capture, energy from waste, anaerobic digestion, composting etc.).

Importantly, these improvements can be made within the existing regulatory framework, and to deliver improved outcomes primarily requires some adjustments to current settings.

Potential key changes include:

- **Increasing the cost of landfilling through changes in waste disposal levy rate and ETS**. This, in turn, is anticipated to reduce the relative cost of recycling and composting and make it more competitive compared to landfill, thereby encouraging diversion. Although the value of NZUs is subject to market fluctuations, by making changes to how ETS obligations are calculated (noted below), the effective rate per tonne of material landfilled under the ETS could be increased. This would mean that a lower levy rate would be necessary to achieve comparable levels of diversion.
- **Organic disposal restrictions**. These can be achieved either via a ban on sending certain organic waste streams to landfill, or by a requirement to sort organic waste streams, such as food waste. In the New Zealand context, this policy option is considered within the analysis undertaken here for the Class 1 landfills, which are the sites where most organic material is sent. The analysis also considers the implications of banning organics from Class 2-4, and for Class 1 sites without LFG capture (i.e., that leakage of organics into other land disposal options is mitigated). It is noted that the banning of specific streams from landfill is, in practice, difficult to police by operators, since mixed loads will be arriving at the site continuously and the operator will be unable to inspect them in sufficient detail to ensure that no banned material enters the site. It is for this reason that effective implementation of a ban typically requires actions upstream from the

[3] While simply incentivising gas capture could create an incentive to landfill more organics, it tends not to in these jurisdictions because organic waste diversion is incentivised through high landfill levy rates.

landfill to occur, supported by sufficient regulatory control to ensure operators and waste generators are compliant with the ban / regulation.

- **A requirement for all Class 1 landfills to have landfill gas capture systems**. For very small sites, this includes the use of improved passive gas capture techniques (since these sites are likely to be too small for the engineered capture systems based on wells to be effective).

- **Improvements in landfill gas capture infrastructure** over the landfill lifetime for the remaining Class 1 sites that currently have gas capture systems in place. This includes meeting best practice well-spacing guidelines, improving the use of capture systems when the site is operational and the utilisation of best practice aftercare techniques.

- **Improve LFG measurement and reporting by allowing operators to claim, as close as possible, their actual lifetime gas capture rates** where the evidence can be presented, while allowing some lower level of lifetime gas capture to be claimed where partial evidence is available. This could involve removing the ceiling on LFG capture rates and having different emissions factor tiers linked to different standards of evidence. The higher the gas capture level that is claimed, the higher the standard of evidence required to support it (within defined tiers).

- **Improve the mass balance methodology used for compliance with the NZETS by requiring lifetime rather than instantaneous gas capture rates to be calculated.** The mass balance methodology was chosen as the basis for the current approach under the NZETS as all lifetime emissions are essentially accounted and paid for in the same period as the waste is deposited, avoiding issues with liabilities in respect of future emissions for this tonnage. With this as the rationale, it requires the use of a lifetime gas capture rate to be consistent. In other words, the emissions attributed to deposited waste needs to reflect the emissions profile from the time of deposition to when emissions effectively cease, rather than, as is the case at present, the emissions for the disposal facility in the year in which the waste is deposited. This adjustment would also have the added benefit of better aligning figures calculated for the purposes of compliance with the NZETS, with calculations made for the purposes of policy.

- **Update the mass balance approach through using a standard LFG generation model for all operators**. Under this approach MfE or EPA would operate an LFG model and would simply require operators to input/update the parameters. Once set up the model would only have to be updated with parameters that had changed. This solution would give Government greater insight and control of calculation, as well as confidence that the outcomes of the system were equitable and uniformly reliable. Government can also refine and update calculations over time. By taking on the responsibility for modelling of outcomes, Government would also reduce the time and cost burden for operators to comply with the regime.

Impact of Class 1 Landfill Emission Reduction Options

Building on the understanding gained about the current market and regulatory landscape in Aotearoa, policy options to reduce landfill emissions were defined and the economic, waste minimisation and carbon impacts quantified. The focus here was Class 1 landfills, as the main destination for residential, commercial, institutional, and industrial wastes. Stakeholder engagement with site operators, alongside close liaising with MfE, supported the short-listing of policy options to:

1. increase Class 1 landfill **diversion** (through increasing the cost of Class 1 landfills and restrictions on organics disposal);

2. improve landfill **gas capture infrastructure**; and

3. improve landfill **gas capture measurement**.

The first policy option relates to a potential set of policy tools that can **increase diversion from Class 1 landfill**. It includes a combination of levy and ETS increases (to make Class 1 disposal more expensive) and organic disposal restrictions to Class 1. These may trigger other tools and related outcomes such as a requirement to sort, separate collections (of organics), recycling targets (and related fines), promotion of home composting, etc. The exact combination of policies, their implementation and their enforcement is not yet clearly defined in legislation. Instead, a higher-level assessment of the implications of having greater or lower levels of policy intervention was assessed.

The BAU flow of waste to different destinations was established from which low, medium and high levels of policy intervention result in increasing levels of diversion from Class 1 landfills – with that diversion shifting waste to recycling, composting, and AD treatment options. A small portion is assumed lost to Class 2-5 landfills, monofills, etc.

Achieving high levels of diversion quickly, based on international examples, is challenging to achieve. However, given enough time and resources, almost 30 percent diversion of all wastes sent to Class 1 by 2050 is forecast in even the medium intervention scenario. Lower diversion – occurring due to fewer tools being used and/or those being less-well implemented - is estimated to half the overall level of diversion in 2050, from about 30 percent to 15 percent.

The GWP100 benefits under high intervention scenario in 2050 range between just over 800 to just under 1,000 kt CO_2e, depending on the level of capture infrastructure in place. A 0.8-1Mt CO_2e reduction in 2050 represents about 24-28 percent of the current reported emissions from the waste sector (an estimated 3.5 Mt CO2-e in 2022). The low intervention scenario is forecast to reduce GWP100 by around 400ktCO_2e compared to the BAU tonnage levels per destination (i.e., 10-12 percent of current emissions).[4]

The high intervention scenario shows about two times lower damage costs compared to the low scenario. Compared to no intervention at all (i.e., compared to BAU), the high intervention scenario leads to a result that has four to twelve times lower damage costs, depending on the level of baseline capture in use.

As the level of intervention increases, the costs of collection, recycling and composting/AD also increase. However, these additional costs are eclipsed by the forecast savings from avoided landfilling costs and additional revenue from recycling. The benefits are further realised when incorporating avoided damage costs. Simply put, although implementing higher levels of intervention costs more, the benefits are forecast to outweigh the costs.

A key sensitivity in this assessment is assuming almost all diverted waste is sent for treatment (recycling/composting/AD). If the waste is instead sent to other land disposal options that do not have gas capture (Class 2-5 landfills, etc.), then the environmental benefits do not stack up. Environmentally, diversion from Class 1 to other land disposal is a worse outcome than no diversion at all. Therefore, it is important to mitigate leakage to other land disposal options when implementing policies on Class 1 landfills.

The estimated **improvements to landfill gas capture infrastructure** show that by solely improving Class 1 landfill gas capture, from the current lowest estimated level to a higher future level, GWP100 could reduce by over 500 kt CO_2e, and the damage costs are forecast to reduce by as much as about $0.1bn in 2050.[5] The 'current lowest estimated level' is one of two landfill gas capture baselines, which are both considered due to the uncertainty in current gas capture data. This shows there is value in investing in improving gas capture infrastructure, as well as improving its measurement and reporting.

The assessment of **improvements to landfill gas capture measurement** was qualitative, due to the current uncertainties in the data being collected from landfill operators. This highlights the importance of having

[4] New-Zealands-second-emissions-reduction-plan-202630.pdf
[5] Cost shown is undiscounted, in 2023 real terms.

more accurate data with which to drive performance of landfill gas capture. The degree of the potential uplift in gas capture arising from the implementation of the improved measurement actions is outside the scope of current work to estimate. Estimates of the cost needed to upgrade the infrastructure developed under Option 2 suggest that the financial investment needed to improve the capture for each site is relatively small in comparison to the ETS cost needed to be paid if infrastructure is not improved. This study therefore recommends that there is value in investing in improving gas capture measurement and reporting.

Conclusions

In summary, this project has sought to understand in some detail how landfill gas is managed in Aotearoa New Zealand and identify practical opportunities for improvement, including reduction of emissions. The work found that, compared to international best practice, there are a range of areas where practices can be improved within the country. While the best performing Class 1 landfills in New Zealand compare reasonably well to overseas examples in terms of LFG management, there appear to be a wide range of practices here based on the data obtained thus far from operators. Thus, there is opportunity for more guidance and standards in relation to best practice.

New Zealand's use of the NZETS as a key tool for incentivising gas capture has had some success but brings with it challenges, particularly around how gas generation rates are calculated and reported. In most other countries this is not an issue, as LFG capture incentives tend to be based on actual quantities captured. There is scope to amend the current regulatory regime to better reflect actual lifetime gas capture rates and thus enable better alignment of practice with the intended outcomes of the existing NZETS incentive.

When the potential impact of implementing the key recommendations for improvement were modelled, it was found that interventions could reduce LFG emissions by up to approximately 30 percent. Although implementing these changes would be more costly in waste management terms, these additional costs are eclipsed by the forecast savings from avoided landfilling and additional revenue from recycling. The benefits are further extended when incorporating avoided damage costs.

Glossary

Key terms used in this document include the following:

Term	Definition
CH_4	Methane
CO_2e	Carbon dioxide equivalent
DEF	Default emissions factor
Disposal facility	Has the meaning under the Waste Minimsation Act 2008: disposal facility means any facility, including a landfill,— (a) at which waste is disposed; and (b) at which the waste disposed includes waste from a household that is not entirely from construction, renovation, or demolition of a house; and (c) that operates, at least in part, as a business to dispose of waste; but (d) does not include a facility, or any part of a facility, at which waste is combusted for the purpose of generating electricity or industrial heat
FOD	First order decay
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LFG	Landfill gas
NZ ETS	New Zealand Emissions Trading Scheme
NZU	New Zealand Unit. An NZU represents one tonne of carbon dioxide equivalent (CO2e) as traded under the NZETS
UEF	Unique emissions factor
UEFwc	Unique emissions factor from waste composition
UNFCCC	United Nations Framework Convention on Climate Change
Waste participant	A disposal facility operator that is a participant means a person who is a participant in the NZ ETS under section 54 of the Climate Change Response Act 2002

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1.0 Introduction

1.1 Project Overview

Chapter 15 of *Te hau mārohi ki anamata: Towards a productive, sustainable and inclusive economy, Aotearoa New Zealand's first Emissions Reduction Plan* (ERP1) includes a several actions to address management of organic waste including biogenic methane emissions from organic materials in landfills.[6] On this basis the Ministry for the Environment (MfE) commissioned Eunomia Research & Consulting Ltd (Eunomia) to provide an evidence base to support these activities, thereby supporting policy development and emissions reductions activities

Subsequent to the commissioning of this project and during the work, the second emissions reduction plan (ERP2) was released[7]. ERP2 continues to support the intent around management of organics and landfill gas with a specific action to investigate ways of improving organic waste disposal and landfill gas capture

This document reports on the analytical process followed through the project, and sets out recommendations for a robust, transparent, and effective landfill gas (LFG) capture regulatory framework in Aotearoa. The work also presents options to reduce emissions from landfilling -and modelling providing estimated costs and benefits of making these changes. The reduction in emissions can stem from improving the coverage and efficient of gas capture and from reducing the organics waste sent to landfill (i.e., increasing landfill diversion). The project outputs aim to build on existing knowledge and regulations and provide clear recommendations for addressing any gaps in the current LFG management system, as well as outlining options for increased landfill diversion.

There were two phases to the work as follows:

Phase 1: Improvements towards a robust, transparent, and effective landfill gas capture regulatory framework in Aotearoa New Zealand

- Review of current gas capture practices in New Zealand
- Review of regulatory framework in New Zealand
- Review of international approaches and best practices
- Updated landfill gas modelling – the project made updates to the existing GHG Inventory model in New Zealand to improve the estimates of gas capture, taking into account best practices in modelling this type of emissions
- Recommended changes to the regulatory framework in Aotearoa New Zealand

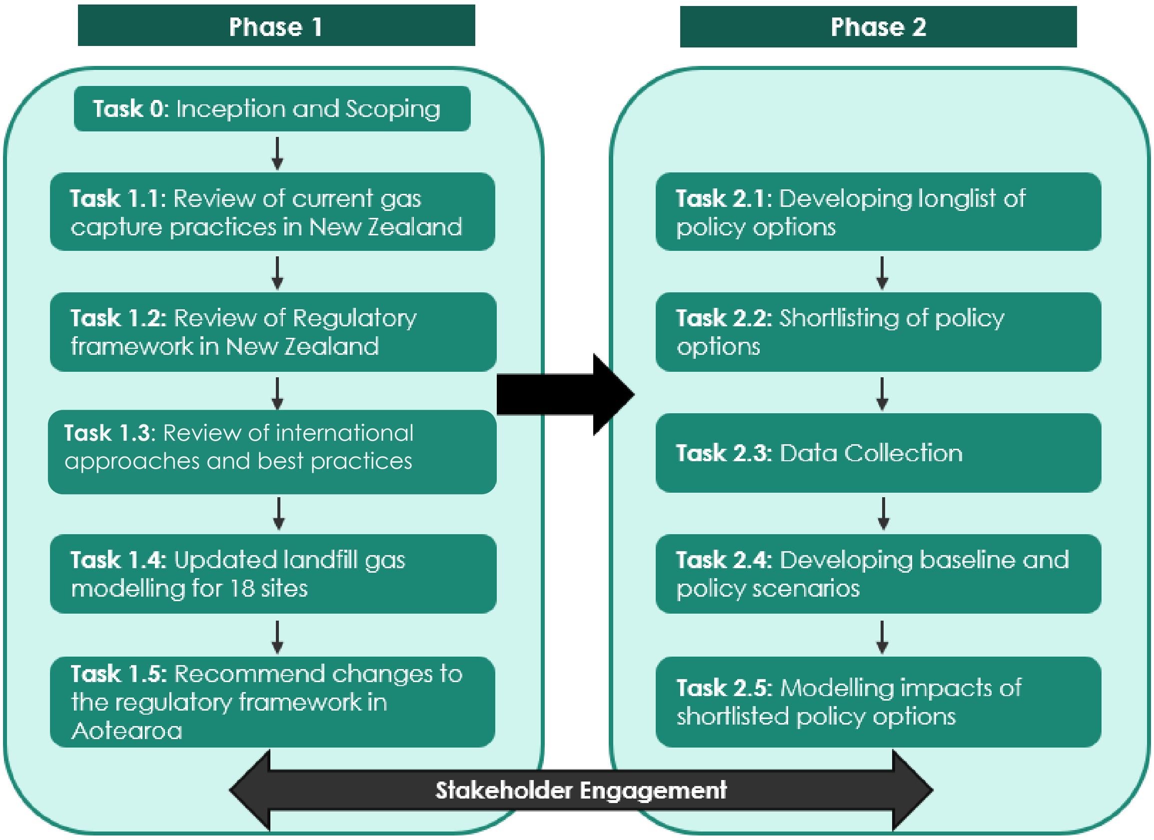
Phase 2: Further options to reduce emissions from landfilling

- Stakeholder Engagement – including surveying current New Zealand site operators to establish current landfill gas management practices
- Longlist policy options

[6] New Zealand Government (2022) Te hau mārohi ki anamata: Towards a productive, sustainable and inclusive economy, Aotearoa New Zealand's first Emissions Reduction Plan

[7] New Zealand Government (2024) Our Journey Towards Net Zero: New Zealand's second emissions reduction plan 2026–30. Tā Aotearoa mahere whakaheke tukunga tuarua

- Shortlist policy options
- Data Collection
- Developing Baseline and Policy Scenarios
- Modelling Impacts of Shortlisted Policy Options



This report is the final consolidated report that brings together and summarises all of the different elements of the project and presents the outcomes of the modelling.

There have been a range of interim progress reports generated throughout the project and submitted to MfE. The key interim reports that feed into the content of this report are:

- Review of International Best Practice in Landfill Gas Management
- New Zealand Landfill Gas Legislation and Regulation Review
- Marginal Abatement Cost Curves Peer Review Report
- Stakeholder Engagement Plan
- Landfill Operator Survey
- Policy Options Stakeholder Survey & Interviews
- Policy Options Stakeholder Survey Report
- Long List Policy Options

1.2 Background

1.2.1 Government Objectives

The Government's objective in relation to biogenic methane emissions is as stated as follows:

> *Emissions abatement of -0.8 Mt CO2e as committed to in the second emissions reduction plan, through:*
>
> - *The reduction of organic waste generated and sent to landfill*
> - *Improving the coverage and efficiency of landfill gas capture systems*
>
> *Improving the quality of our organic waste data and reporting is an essential component to achieve the objective by enabling more accurate estimates and monitoring of the sector's emissions and measuring the effectiveness of policy interventions.*[8]

The second emissions reduction Plan (ERP2) states that "in 2022, the waste sector produced an estimated 3.5 Mt CO2-e (about 4.5 percent) of New Zealand's gross greenhouse gas emissions." 93.3 percent of these emissions were in the form of methane and overall, 81 percent of waste sector emissions were attributed to solid waste disposal.[9]

Reducing emissions from landfill disposal is therefore a key area to target in terms of overall emissions from the sector. The ERP2 identifies the following actions to address emissions from landfill:

- encourage diversion of organic materials from landfill
- determine which landfill types accept which types of organic waste, and the impact on the waste disposal levy
- review the scope of landfills that require LFG capture systems
- improve settings to raise the average LFG capture efficiency
- extend the New Zealand Emissions Trading Scheme (NZ ETS) to a wider range of landfills
- improve data and evidence to support LFG capture efficiency calculations and reporting, and accurate NZ ETS accounting.

The ERP2 also states that the Government has committed to waste minimisation investment priorities for the Waste Minimisation Fund (WMF) that will also help reduce emissions, including during the second emissions budget (EB2) period. A proportion of the WMF will target infrastructure projects and systems that reduce organic waste and emissions (and other waste streams)[10]

In addition, the New Zealand Waste and Resource Efficiency Strategy[11] identifies as one of the key outcomes "Minimising emissions and environmental harm from waste and litter". This is supported by the MfE work programme 2024-2026 which has reducing waste emissions as a focus area, and references actions in ERP2.

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[8] MfE via email 04 April 2025
[9] New-Zealands-second-emissions-reduction-plan-202630.pdf
[10] New-Zealands-second-emissions-reduction-plan-202630.pdf page 80
[11] new-zealand-waste-strategy.pdf

1.2.2 Problem Statement

The problem definition in relation to management of organic waste that the Ministry is working to is as follows:[12]

Further emission reductions are needed from the waste sector

- A significant amount of organic waste is sent to landfill. It is estimated that 42.7 percent of the waste disposed of to Class 1 managed landfills, and 18.7 percent of waste disposed of at Class 2-5 unmanaged landfills, is organic waste.
- The portion of organic waste that is diverted from landfill disposal is small. However, the total amount of organic waste that is diverted within the waste system is uncertain.
- Organic waste produces biogenic methane emissions when it breaks down in the anaerobic landfill environment.
- While biogenic methane emissions from the waste sector are trending downward, further reductions are needed to help meet New Zealand's domestic and international targets.

There are gaps within our landfill gas capture (LFG) system

- Class 1 managed landfills with a total capacity of at least 1 million tonnes are required to have LFG capture systems. The efficiency rate of these systems varies greatly, ranging from about 20 to 90 percent.
- Class 2-5 unmanaged landfills are a source of emissions but not equipped with LFG capture systems.

We have significant data and evidence gaps which is impacting our ability to estimate the sector's emissions and monitor the effectiveness of actions to reduce emissions from organic waste:

- We do not have robust estimates of the composition and volumes of organic waste being diverted and disposed of to landfill.
- We do not have robust estimates of the composition of the waste streams which make up organic waste.

1.2.3 Key Issues

The current landfill gas management regime was initially established in 2004 through the introduction of a National Environmental Standard for Air Quality which applied a capacity threshold by which landfills would be required to install landfill gas capture. This was further developed through the establishment of the New Zealand Emissions Trading Scheme (NZ ETS) and a requirement for Class 1 landfills to participate from 2013. In addition, the Government is required to monitor and report LFG emissions for the purposes of the GHG Inventory which is used for reporting to the UNFCCC.

The difficulty with reporting LFG emissions is that the ability to identify how much LFG sites are producing is indirect. While gas that is captured can be measured directly, the proportion that this represents of total production is based on modelling. This modelling infers generation based on a range of inputs including waste composition, and landfill management practices such management of leachate, moisture ingress, waste depth, cover material and depth etc. How best to address the uncertainty around generation rates and how they can be measured and accounted for is one of the central issues discussed in this report.

The current regulatory regime[13] has resulted in increasing levels of reported gas capture. However, possible issues have arisen that suggest there is potential to further improve the effectiveness of the

[12] Correspondence with Kara Lok, 04 April 2025

[13] The current regulatory regime has evolved over time, but its current form largely took shape with the introduction of the NZETS and the associated regulations in 2009 and 2010.

scheme's operation. In brief, some of the issues noted (which are discussed further in this report) include:

1. **Organic loading.** Organic loading refers to where a higher organic fraction is disposed of in landfill, relative to what has been assumed in LFG modelling and calculations (through the use of default emissions factors (DEF)). This may lead to higher gas capture efficiency being able to be claimed by operators relative to what is actually occurring. Past submissions suggest that this may be incentivised by the current regulatory framework.

2. **Use of DEFs.** The ability to use a DEF when calculating LFG emissions for the NZ ETS may have reduced the accuracy of claimed emissions and led to disconnect between claimed emissions and assumed emissions if using different (potentially more accurate) methodology (actual emissions are not known). Since 2022 the DEF specified for the purposes of calculating a UEF has been based on a waste composition that has lower levels of organics than a majority of landfills, resulting in fewer operators choosing to undertake waste composition audits to calculate a UEF.[14]

3. **Class 2 landfills receiving organic waste but not being subject to ETS.** Composition analyses undertaken on a number of Class 2 facilities suggest that relatively high levels of organics (notably timber and textiles) are deposited at these sites.[15]

4. **Variation in quality of LFG capture.** There is significant variation in the levels of LFG capture reported by Class 1 facilities under the ETS. Anecdotally, and through survey data received, it is apparent that that the quality and operation of LFG capture systems across the country is variable. While some facilities (notably the larger ones) have good quality systems and processes, there is room for improvement across many sites. The current regime has not been sufficient to lift performance across all sites.

5. **Discontinuity between NZ ETS reporting and reporting for GHG inventory and UNFCCC purposes**. The LFG capture and destruction calculations and figures produced for ETS reporting are different to those used for the purposes of reporting to UNFCCC (the GHG inventory) with ETS LFG capture figures significantly higher. Ideally these figures should be consistent in terms of the underlying methods of calculation.

GHG Inventory versus NZ ETS Methods

The GHG Inventory uses methods prescribed by the IPCC to calculate emissions from waste. The core of the IPCC methodology for estimating CH_4 emissions from landfills is based on the First Order Decay (FOD) method. "*This method assumes that the degradable organic component (degradable organic carbon, DOC) in waste decays slowly throughout a few decades, during which CH_4 and CO_2 are formed. If conditions are constant, the rate of CH_4 production depends solely on the amount of carbon remaining in the waste. As a result, emissions of CH_4 from waste deposited in a disposal site are highest in the first few years after deposition, then gradually decline as the degradable carbon in the waste is consumed by the bacteria responsible for the decay*".[16] Calculating emissions over time therefore is a combination of multiple years of calculations for a given site.

The method used for calculating emissions for the purposes of the NZ ETS is known as the 'mass balance' method. This accounts for all emissions generated over time in the year the waste is deposited in landfill. It estimates potential, rather than actual, emissions based on a standard emissions factor for waste deposited in the landfill in the period.

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[14] Climate Change (Unique Emissions Factors) Regulations 2009, Section 23C(g)
[15] Waste composition studies commissioned by MfE on Class 2 and 3-4 fills. Reported in Eunomia (2024) New Zealand's National Recycling Rate Issues and Options. Report for Ministry for the Environment
[16] V5_3_Ch3_SWDS.pdf

1.2.3.1 How the Project Addresses the Issues

This work aims to support policy decisions on the above range of actions, by providing evidence for key potential policy actions.

The outputs of this contract relate most specifically to:

- Potential policy options to reduce organic waste to landfill and its impact
- Potential policy options to improve the capture of landfill gas
- Potential policy options to improve measurement of landfill gas
- Potential policy options to improve reporting of landfill gas capture.

This report aims to develop insights and evidence to aid in the potential design of regulations for landfill gas capture at municipal landfills and preliminary investigations into options for managing and reducing emissions from organic waste disposal. This includes specific requests to fill information gaps identified in preliminary scoping, including:

- Testing the feasibility and risk of 'organic loading' based on prior independent advice to the Ministry that indicates this is possible under the current regulatory framework.
- Investigating the use and potential application of Unique Emissions Factors (both landfill gas capture volume and waste compositional based factors) for eligible landfilling activities under the New Zealand Emissions Trading Scheme.

Work done during this project helped inform the development of policy for the second Emissions Reduction Plan, which was published in December 2024.

This work also provides analysis and evidence that helps to inform New Zealand's country-specific values on CH_4 recovery efficiency rates as recommended by a UNFCCC expert review team in September 2022[17] (currently assumed as 68 percent for open landfills and 52 percent for closed landfills), which will contribute to improving New Zealand's Greenhouse Gas (GHG) Inventory models.

This project has been completed in two parts to best support the policy development process and Emissions Reduction Plan timelines.

1.3 Document Structure

This report starts with summaries of key contextual information on the following areas:

- Current Regulatory landscape in New Zealand, including that relating to carbon management and how this relates to landfill gas specifically, and;
- Review of international best practices.

This leads into the analysis for improving regulation in New Zealand, resulting in a long list of recommendations for improving (and reducing) landfill gas capture and its reporting. A short list of

[17] Emissions Trading Scheme: Landfill Gas Technical Advice 2016 – Prepared by Tonkin & Taylor. Unpublished.

recommendations is then defined. Impacts on the amount of waste sent to Class 1 landfills, the resulting environmental impacts, and monetary costs are assessed, and conclusions drawn.

Technical details can be found in the appendices.

1.4 Documents and Systems Reviewed

The full methodology and details of the documents reviewed can be found in:

- For long-list of legislation and regulation reviewed, appendix A.2.0
- For stakeholder engagement, appendix A.3.0.
- For quantitative analysis, appendices A.4.0, 0, and A.6.0.

2.0 New Zealand's Regulatory Approach to Landfill Gas

2.1 Overview of Landfill Gas Legislation Administration and Implementation

This section provides a high-level overview of the key actors and systems currently involved in administering the landfill gas (LFG) legislation. More detailed presentation and discussion of the legislative requirements is contained in Appendix A.2.0.

LFG is regulated through two primary mechanisms in New Zealand – through National Environmental Standards for Air Quality and through participation by disposal facilities in the New Zealand Emissions Trading Scheme. These are outlined briefly below and then discussed further in the following subsections.

National Environmental Standards for Air Quality.

Under the Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (NES-AQ), disposal facilities that are over 1 million tonnes total capacity, hold at least 200,000 tonnes of waste and accept waste with 5 percent or more biodegradable material must have LFG capture systems in place that meet minimum specifications. The regulations are made under the Resource Management Act 1991, and regional councils are responsible for ensuring compliance.

New Zealand Emissions Trading Scheme (NZ ETS)

The NZ ETS is a system that requires participating organisations to measure and report their greenhouse gas emissions, surrender one 'emissions unit' (known as a New Zealand Unit or NZU) for each tonne of carbon dioxide equivalent (CO_2e) emissions they emit, and limits the number of NZUs that are available to the scheme.

Landfills which meet the definition of a disposal facility under the Climate Change Response Act 2002[18] are mandatory participants (waste participants) in the NZ ETS. Operators of Class 2-5 facilities are not currently NZ ETS participants. Disposal facility operators are responsible under the NZ ETS only for methane emitted through the biodegradation of organic waste in their facilities, and not for other gases.[19]

Participating facilities in the waste sector (waste participants) are required to record information about the gross tonnage and diverted tonnage of waste entering their landfill facility in a year and submit this as part of their annual methane emissions return.[20] This figure is then multiplied by an emissions factor that estimates the emissions per tonne of waste to give a total emissions figure. Once an emissions return has been completed, a waste participant will be required to surrender NZUs corresponding to the total emissions from the activity reported to the NZ ETS.[21]

Entities that emit GHGs must purchase units from the market to meet their obligations. Entities that obtain units for removals or via free allocation can sell their units. Conversely, those that emit less than

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[18] The definition under the CCRA 2002 is currently the same as in section 7(1)(a) of the Waste Minimisation Act 2008
[19] Waste | EPA
[20] Section 4(1) of the Climate Change (Waste) Regulations 2010
[21] Section 5(2) of the Climate Change (Waste) Regulations 2010

their allowances can sell their surplus units. This system theoretically creates a financial incentive for entities to reduce their emissions.

When calculating their obligations, waste participants can use a 'default emissions factor' (DEF), which is set by the government using data from landfills around the country. If a waste participant believes that the emissions factor for their landfill is different than the default factor, they may apply to the EPA for a 'unique emissions factor' (UEF) which reflects the actual emissions from their facility.[22] These UEFs can be based on waste composition and/or gas capture.

While the NES-AQ requires gas capture at qualifying landfills, the incentive to maximise gas capture comes through the NZ ETS mechanisms. These mechanisms include the following:

- **Gas capture and destruction**: To minimise emissions and meet their emissions obligations, landfill operators can implement gas capture and destruction systems. These systems collect methane emitted from the landfill and either burn it (flaring) or use it for energy generation. By capturing and destroying methane, landfills can reduce their emissions and potentially lower their NZ ETS liabilities.
- **Reduction of degradable organic carbon**. Disposal facility operators can also reduce their obligations by reducing the amount of methane generated. This can be done by reducing the amount of organic matter deposited in the facility.[23]
- **Offsetting and credits:** Landfill operators can also participate in offsetting activities within the NZ ETS. For example, they may establish or manage forests on their land to absorb carbon dioxide, thereby offsetting their emissions from landfill operations. This can earn them credits, which they can use to offset their NZ ETS liabilities.

Overall, the NZ ETS is intended to incentivise methane emission reductions in waste management by placing a financial value on these emissions and providing mechanisms for offsetting/reducing these through activities such as gas capture, reduction of organic material disposed of in the facility, and forestry.

2.2 Summary of Key Legislation

There are three key pieces of legislation that govern landfill gas capture in Aotearoa. These are supported by three climate change regulations around waste, emissions, and exemptions, and regulations under the Resource Management Act around fugitive emissions from sites. Additionally, there are guidelines to practically help in waste management and emissions calculations. n in depth review of NZs legislative approach can be found in Appendix A.2.0

Legislation

- Climate Change Response Act 2002
- Resource Management Act 1991 (RMA) – Section 43 (Proposed National Environmental Standard to Control Greenhouse Gas Emissions from Landfills)
- Waste Minimisation Act 2008 (WMA)

[22] Waste | EPA
[23] Disposal facility operators can also deploy other methods for reducing landfill gas generation, such as limiting the moisture in the waste mass in order slow down anaerobic decomposition and reduce the generation of methane.

Regulations[24]

- Climate Change (Waste) Regulations 2010 (SR 2010/338)
- Climate Change (Unique Emissions Factors) Regulations 2009 (SR 2009/286)
- Climate Change (General Exemptions) Order 2009 (SR 2009/370)
- Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (sections 25-27)

Standards & Guidelines

- Solid Waste Analysis Protocol 2002.

2.3 Key Roles

The key responsibilities of the different parties involved in management of LFG in NZ are noted in this section. Key parties include:

- **The Ministry for the Environment**. Responsible for climate change and waste policy legislation and advice. Gathers waste levy and activity source data.
- **The Climate Change Commission**. Provides advice to Government on the preparation of emissions reduction plans, and oversight on progress towards emissions targets
- **The Environmental Protection Authority**. Receives data from disposal facility operators and calculates emissions obligations from the information supplied. Ensures NZUs are surrendered, by waste participants and prepares NZ ETS reports on emissions reported by waste participants
- **Recognised verifiers**. Verifiers' key role is to review measurements and confirm they have been carried out in accordance with the Regulations[25], and verify the resulting UEFs
- **Regional Councils**.[26] Regional councils are responsible for consenting facilities under the RMA, and subsequently monitoring of LFG fugitive emissions and taking compliance action if necessary
- **Disposal facility operators**. Design, build and operate facilities; calculate ETS obligations and choose whether to use a UEF or the DEF. They operate LFG collection and destruction systems, gather data, and calculate and report LFG capture performance and purchase NZUs to ensure compliance with the obligations under the ETS. They also are responsible for monitoring and reporting of LFG fugitive emissions to regional councils under the RMA.

Further information on each of the key agencies and their responsibilities is provided in the Appendix A.1.0.

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[24] Other indirectly related regulations that are not covered here include: Waste Minimisation (Information Requirements) Regulations 2021 (LI 2021/69), which contain activity source definitions (Schedule 3), and the Waste Minimisation (Calculation and Payment of Waste Disposal Levy) Regulations 2009 (SR 2009/144) which contain the definitions of disposal facility types (Section 3B)

[25] Climate Change (Unique Emissions Factors) Regulations 2009 (SR 2009/286)

[26] Including unitary authorities.

2.4 New Zealand's Carbon Management

This subsection explores in more detail how New Zealand manages its carbon emissions, which provides the context within which LFG management occurs.

2.4.1 Emissions Reduction Plans

Section 5ZG of the Climate Change Response Act 2002 requires the Minister of Climate Change to "prepare and make publicly available a plan setting out the policies and strategies for meeting the next emissions budget". Two emissions reduction plans have been published, the first in 2022 and the second in 2024.

The first emissions reduction plan (ERP) was published in May 2022 by the Ministry for the Environment. It set out a range of actions for the first emissions budget period (2022 to 2025). The waste chapter includes a range of actions to reduce the generation of greenhouse gas emissions from the sector, such as:[27]

- Reducing generation of organic waste by households and businesses
- Increasing the amount of organic waste diverted from landfill
- Increasing diversion of construction and demolition waste from landfill
- Exploring bans to organic waste to landfill by 2030
- Increase the capture of gas from municipal landfills

The proposals include potentially requiring all Class 1 landfills to have LFG capture systems by 31 December 2026. Sites without LFG capture could be banned from receiving organic waste. The ERP states that "The Government intends to enact this requirement by lowering the threshold and related provisions under the National Environmental Standards for Air Quality[28] (or its equivalent under new resource management legislation) or potentially using new tools under revised waste legislation."[29]

It is also proposed to investigate whether it would be feasible and practical to extend the LFG capture requirement to other classes of facilities that receive smaller amounts of organic waste.

More recently, in December 2024 (during the period of this project) the Government released the Second Emissions Reduction Plan (ERP2) ERP2 notes the following actions:

"…Investigate how we dispose of and manage organic waste streams in order to:

- encourage diversion of organic materials from landfill
- determine which landfill types accept which types of organic waste, and the impact on the waste disposal levy
- review the scope of landfills that require LFG capture systems

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[27] Waste | Ministry for the Environment

[28] The present standards require landfills above 1 million tonnes capacity to have LFG capture systems – refer section **Error! Reference source not found.**). Exemption provisions provided through the Climate Change (General Exemptions) Order 2009 may also have to be reviewed.

[29] Waste | Ministry for the Environment

- improve settings to raise the average LFG capture efficiency
- extend the New Zealand Emissions Trading Scheme (NZ ETS) to a wider range of landfills
- improve data and evidence to support LFG capture efficiency calculations and reporting, and accurate NZ ETS accounting.[30]

2.4.2 New Zealand Emissions Trading Scheme -

A vital consideration relating to the drivers for LFG capture and destruction in New Zealand is the cost of meeting the liability for the gas that is emitted. The higher the cost, the greater the incentive to reduce the liabilities associated with these emissions. This cost is determined by the way the carbon market operates within the framework of the NZ ETS.

The NZ ETS in New Zealand provides a mechanism for pricing and trading NZUs; and is intended to incentivise emissions reductions, promote carbon abatement activities, and facilitate the transition to a low-carbon economy.

The NZ ETS puts a market price on the carbon associated with LFG emissions. This means that the price varies over time depending on the operation of the market. At the time of writing the price is $62.75 per tonne and it has been stable at around this price since 2023. It has however been as low as $2 per tonne and as high as $90. This has been driven primarily by changes in how the scheme has been operated.

Summarised below are some key features of the NZ ETS that impact on the price of NZUs over time:

- **Cap-and-Trade System:** The NZ ETS is a cap-and-trade system designed to limit greenhouse gas emissions from participating sectors. The government sets a cap on the total amount of emissions allowed within the scheme and allocates NZUs to participants.
- **Emissions units**: Each NZU represents one tonne of carbon dioxide equivalent (CO2-e) emissions. Participants in the NZ ETS, such as industrial facilities, energy producers, and landfill operators, must surrender NZUs equal to their emissions at the end of each compliance period.
- **Market trading**: NZUs can be traded on the NZ ETS market, allowing participants to buy and sell emissions units to meet their compliance obligations or for speculative purposes. The NZ ETS market provides liquidity and price discovery for carbon units, allowing market participants to efficiently manage their emissions portfolios. There is no expiry on an NZU so, once NZUs have been purchased, they can be held until the participating entity chooses to surrender them to meet their obligations. Some organisations therefore choose to purchase when they perceive the market price is favourable and hold these or sell them on the secondary market when they want to realise their value.
- **Price discovery**: The carbon price in the NZ ETS is determined by market supply and demand dynamics. Factors such as government policy changes, international market conditions, economic factors, and technological developments influence the carbon price. The price of NZUs fluctuates over time based on these factors.
- **Compliance obligations**: Participants in the NZ ETS have compliance obligations to surrender emissions units equal to their emissions. Failure to meet compliance obligations may result in financial penalties or other enforcement measures.

[30] New-Zealands-second-emissions-reduction-plan-202630.pdf , Chapter 13

- **Offsets and forestry**: The NZ ETS allows for the use of offsetting activities, such as forestry, to generate emissions units that can be used to offset emissions from other sectors. Landowners can earn credits by establishing or managing forests that absorb carbon dioxide from the atmosphere, providing an additional source of emissions units within the scheme.

- **Government oversight**: The New Zealand government plays a significant role in regulating the carbon market and administering the NZ ETS. It sets emission caps, allocates emissions units, establishes compliance requirements, and controls the supply of NZUs. Regulating the supply of NZUs on the market is a mechanism for providing some price stability. This is done through a quarterly auction process (discussed below).

Further discussion of the NZETS and pricing is contained in Appendix A.2.4A.2.4

2.4.3 Disposal Facilities in the New Zealand Emissions Trading Scheme

While the NES requires gas capture at qualifying landfills, the incentive to maximise gas capture comes through the NZ ETS (which requires NZUs to be surrendered).

Since 2013, Class 1 landfill operators have been required by the Climate Change (Emissions Trading) Amendment Act 2008 (and associated regulations) to surrender emission units to cover methane emissions. The Act also requires emission units to be surrendered to cover greenhouse gas emissions from the incineration of household wastes.[31]

The number of emissions units that need to be surrendered is based on a calculation of how much methane is generated from a tonne of waste (after accounting for oxidation through the landfill cap). As a starting point, landfills use a default emissions factor (DEF)[32] for waste (the methane assumed to be generated by each tonne of waste) which is currently set at 1.023 tonnes of CO2-e (CO2 equivalent) per tonne of waste.[33]

Landfill operators can reduce their liabilities under the NZ ETS by applying for one or both of two types of UEF:

- a composition UEF which allows methane generation to be calculated for that landfill specifically based on the composition of waste at that landfill; and/or

- a gas capture UEF, which allows the rate of methane capture at the landfill to be calculated, and the facility's liabilities under the ETS to be adjusted accordingly relative to the default.

Using these UEFs the landfill operator can then apply to the EPA for their NZ ETS liability to be adjusted (usually lowered). The calculation and application of the DEF and UEFs are discussed further in Section A.2.2.

One of the impacts of the NZ ETS on the landfilling sector has been to incentivise waste to move from smaller[34] (usually council-owned) landfills to larger (usually privately or joint public/privately owned)

[31] Entities that are in emissions intensive and trade exposed industries, notably agriculture and some industrial operators, receive a free allocation of units. The waste sector does not receive an allocation of units because disposal facility operators are not internationally trade-exposed and are able to pass the costs of their ETS obligations on to their customers. Waste | EPA
[32] A DEF is specified in regulation and is calculated by assuming an average composition for landfills, based on national waste audit data. The DEF has been updated a number of times as new waste audit data is compiled.
[33] Climate Change Waste Regulations 2010 (amended in 2022 by the Climate Change (Emissions Trading Scheme and Synthetic Greenhouse Gas Levies) Amendment Regulations 2022. However, a figure of 0.91 is used in Climate Change (Unique Emission Factors) Regulations 2009.
[34] With the exception of landfills that are exempt under the Climate Change (General Exemptions) Order 2009.

regional landfills, particularly in some regions such as central North Island. Smaller landfills are usually older sites and often do not have LFG capture and destruction systems fitted. This means that, if they are to be used, they must be retrofitted; often at significant capital cost relative to the size of the landfill. These retrofitted systems on smaller sites do not have the same capture and destruction efficiency as can be achieved at the larger sites. At a recent NZU value of approximately $65 a tonne, for example, landfills that can claim a 90 percent gas capture rate (i.e. the large landfills), have a price advantage of around $60 a tonne. At typical industry bulk haul rates this is equivalent to transporting a tonne of waste approximately 150km. In effect this means that a large landfill can extend its catchment area a further 150km and not be at a cost disadvantage.

2.5 New Zealand's Approach to LFG Measurement under the NZ ETS

How LFG emissions are calculated under the NZ ETS is established through regulation.[35] See A.2.2 for further details.

New Zealand takes a 'mass balance' approach to measuring and reporting LFG for the purposes of compliance with the NZ ETS. The mass balance method estimates potential rather than actual, emissions based on a standard emissions factor for waste deposited in the landfill in the period.

When options to control LFG emissions were being reviewed in 2010, two other approaches for measuring LFG were considered.[36]

1. **Direct measurement.** This involves direct measurement and recording of surface emissions. This approach was noted as being potentially the most accurate as it measures actual emissions, but there is not an internationally accepted method of measurement. This option was considered likely to have significant ongoing compliance costs.

2. **First order decay method.** This involves estimating and recording actual emissions based on the waste that has been deposited in the landfill and applying assumptions regarding decay rates. Participants then use a model to estimate their emissions It is worth noting that the GHG inventory uses the IPCC First Order Decay model (Tier 2) rather than the mass balanced approach, to estimate emissions.[37]

It was considered that both the direct measurement approach and the first order decay method would create policy issues in that emissions are arising from waste already disposed of with no mechanism to recover costs from those responsible for depositing the waste, and that gas released after closure would be responsibility of the Government.

The mass balance approach was preferred and progressed. It was seen as having lower compliance costs, and because emissions are essentially accounted and paid for in the same period as the waste is deposited, it avoids issues with liabilities for past and future emissions. The mass balance approach was also identified as the preferred method by an expert stakeholder group.[38]

The legislation and regulations examined in the following sections therefore reflect the implementation of this mass balance approach.

[35] Specifically the Climate Change (Waste) Regulations 2010 and the Climate Change (Unique Emissions Factors) Regulations 2009

[36] Cabinet Economic Growth and Infrastructure Committee: Emissions Trading Scheme Regulations for Solid Waste Disposal Facilties, 2010.

[37] the IPCC Guidelines strongly discourage the mass balance because it produces results that are not compatible with the FOD method which produces more accurate estimates of annual emissions.

[38] Report of the New Zealand Emissions Trading Scheme Waste Technical Advisory Group. March 2010

2.6 New Zealand Waste Disposal Market Impacts on LFG Management

A further factor that impacts on how LFG is managed in New Zealand relates to the operation of the waste disposal market.

Historically landfills were owned and operated by local councils and were small and largely unregulated with no liners, no (or minimal) leachate control, or gas capture systems. The introduction of the Resource Management Act 1991 (RMA) resulted in tighter controls being placed on landfills and the progressive replacement of older style landfills with fewer, more modern, landfills. Because of the higher capital costs associated with landfill construction under the RMA, there was a move towards larger, more highly engineered, regional landfills which provided economies of scale. Local councils were not well placed to develop and operate these regional facilities and lacked the technical expertise to upgrade and run existing facilities to a higher standard. These factors meant that the private sector became the primary player in the ownership and operation of landfills.

This historical context has resulted in the current situation where there are a number of large well-engineered modern regional landfills (some owned in partnership between local councils and private sector (e.g. Kate Valley, Northland Regional Landfill), and a larger number of smaller legacy landfills owned by local councils but operated by private sector contractors. The local council landfills generally have lower rates of landfill gas capture compared to the larger private facilities, usually because these have not been engineered to optimise gas capture from inception.

This change is shown by the number of operational landfills: A 1987 Department of Health survey identified 462 landfills, while MfE's 1995 *National Landfill Census* identified 327 landfills. [39]. As of the time of writing MfE reports that there are 40 open Class 1 landfills, and 167 open landfills of other landfill classes.[40]

Two overseas-owned companies, WM (formerly Waste Management NZ Limited) and Enviro NZ, are the dominant players in the New Zealand waste disposal and collections sectors, particularly in the North Island. Currently WM and EnviroNZ either wholly or partly own the six largest Class 1 landfills in New Zealand, which accountfor an estimated 73 percent of all waste to Class 1 landfills.

Although the movement towards fewer, larger landfills has slowed, it is likely that the drivers towards larger regional landfills will continue. These factors include:

- High costs of establishment including consenting processes. This incentivises maximising the size where it is possible to establish a landfill
- Larger landfills, although having a high capital cost, generally have much lower costs per tonne.
- Landfills may compete with one another where their catchments overlap (and generally speaking, the larger the landfill the lower the cost of disposal and so the larger the effective catchment).
- For the large waste companies that are 'vertically integrated' (i.e. they own/operate all parts of the collection and disposal value chain), there is financial incentive to have access to low-cost disposal as this enables them to be competitive in the residual waste collection market.

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[39] Ministry for the Environment (MfE), *1997 National Waste Data Report*. Ministry for the Environment, Wellington
[40] Waste facilities and disposal | Ministry for the Environment

There are therefore economic incentives towards larger landfills with high reported rates of gas capture. Larger landfills with higher capture rates are able to offer lower gate fees and therefore be competitive in the market. Even if the carbon price is high, high LFG capture rates in effect serve to widen the level of competitive advantage over smaller, local facilities, as well as recovery options.

These same commercial drivers that incentivise high rates of gas capture however also incentivise operators to maximise rather than minimise organics in landfill. This is because:

- Large modern landfills have been designed as ‘bioreactors’ to optimally function with a certain level of putrescible waste, and gas generation.
- Maximising tonnes to landfill also maximises income and payback on the capital invested
- Organics, particularly putrescible wastes, degrade relatively quickly in landfills, meaning that once degraded, this airspace can be resold, improving profitability
- Under current regulatory settings, disposal facilities are able to increase their claimed rates of gas capture by generating more gas (which is not accounted for in the ETS gas capture calculations – refer Appendix A.2.2 for further detail and discussion).

For more detailed discussion of the local disposal market factors refer to Appendix A.2.5.

3.0 International Practices Review

This section provides a review of how other countries have chosen to manage LFG and how it is measured and reported. It focusses on where good practice has been implemented that may provide lessons for improving LFG management in New Zealand.

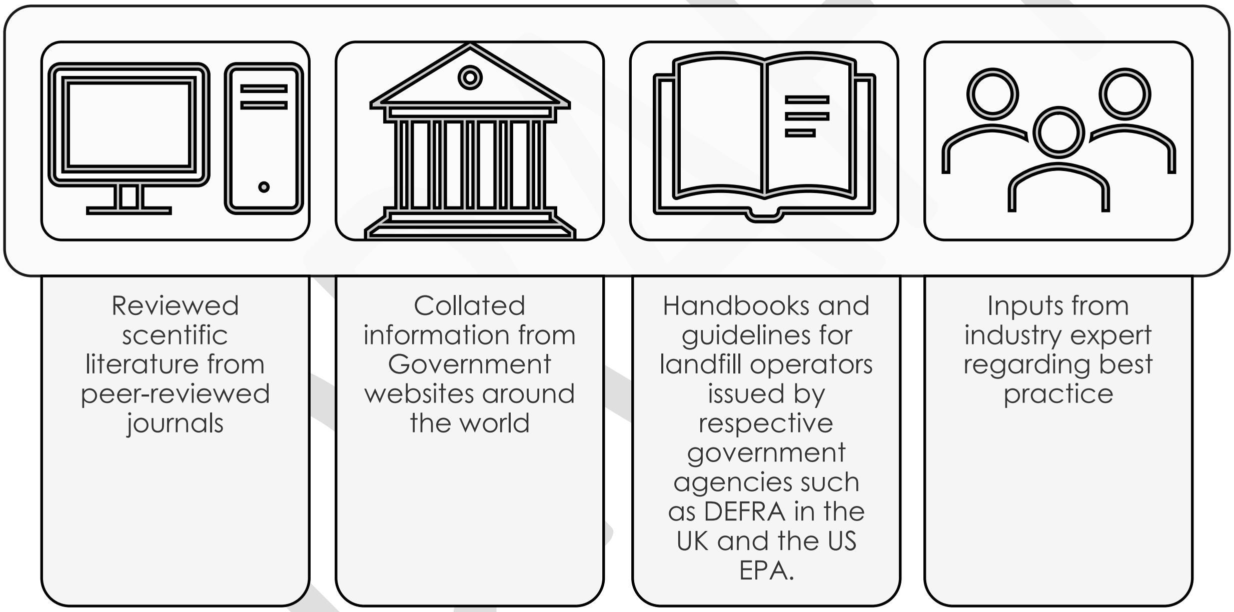
3.1 Research Methodology

The research considered various aspects of landfill gas management around the world, focussing on several key themes:

- Existing relevant policies affecting gas management practices – including policies such as financial incentives for gas capture (e.g. those promoting renewable energy);
- The different models in use in different countries to estimate methane emissions from landfills;
- Guidelines for landfill operators, including when gas capture systems are switched off;
- Literature on gas capture rates.

The research used various methods for identifying source material; these are summarised in Figure 3-1.

Figure 3-1: Methodology used for International Practices Review



The review focussed on countries where practice is generally reasonably good and there is documentation readily available on practices. This includes the UK, the USA, France, Germany, Ireland, Denmark, Australia and Canada, as well as the EU more broadly.

3.2 Regulatory and Policy Requirements

All countries considered in the review had policy in place mandating gas capture for larger sites at a minimum, although (like New Zealand) smaller sites are exempt for some (this is the case in the US for example). These countries often also have incentives for energy generation from landfills. Where energy incentives are in place, countries monitor the amount of landfill gas captured, collected and exported for energy generation. New Zealand is unusual in requiring operators to participate in the country's emissions trading scheme. Sites in other countries are not generally required to calculate a landfill gas capture rate and often do not need to regularly provide composition data.

Other key points from the research into policy and regulatory requirements include the following:

- Some countries recommend sites to undertake on-site methane measurements – this is the case in Germany for example – although this is not mandated. Other countries have undertaken research projects to capture site specific methane measurement data, which has fed into analysis of the country's gas capture performance – this is the case for the UK and US. In both cases, the research suggested that models had overestimated gas capture values in the site-based gas generation models. Walking surveys are also used in the US – these are designed to flag emissions hotspots.
- Activities aimed at improvement in gas capture towards the end of the life of the landfill are also a feature of regulation in some countries such as Denmark, but this is not a clear focus in most others, which are more focussed on collecting the gas at high flow rates - at which point it is more cost effective to do so. Good management practice for low flow rates of methane includes the use of low calorie flares, installation of biofilters and the use of bioactive covers.
- In some countries such as the UK, the regulatory bodies provide operators with relatively detailed guidance on how to design a site to maximise the capture of landfill gas, including details such as specifications on well spacing, and guidance on when to put in place vertical wells. This is incorporated into the requirements that operators must meet to obtain an operating permit. This is anticipated to generally improve consistency of performance in respect of the gas capture systems in place.
- Organic waste bans have been in place in some countries such as Denmark for some time; in countries such as Germany and Belgium waste to be sent to landfill must have a low degradable organic carbon content. These countries also have significant incineration and MBT capacity. Environmental benefits from incineration compared to landfill vary making comparisons complex, but the use of biostabilisation on organic waste streams is generally likely to be beneficial in reducing environmental impacts.
- In other countries, requirements to sort specific waste streams are in place: the UK has mandated food waste collections from 2025 for households and businesses, meaning that all households must be offered a separate food waste collection and businesses over a certain size are required to have food waste separately collected. Alongside this, diversion from landfill in the UK was historically boosted by high landfill tax rates, which formed part of the UK's implementation of the EU Landfill Directive. This has increased over time; the standard rate from April 2025 (converted to New Zealand $) will be $277 per tonne.

3.3 Landfill Gas Generation Models

Countries use a range of models to estimate gas generation. There is a mixture of site based and country-based tools in use – with the site-based ones requiring more operational requirements for the site to be input. The tools have different purposes – site-based tools may be designed for operators to assess landfill gas liabilities (or financial rewards due from capture) whereas the country-based tools are used by policy makers to estimate national emissions or the benefits from specific policies designed to mitigate landfill emissions. Country based modelling is also used by government agencies to comply with statutory international GHG reporting (Paris Agreement- UNFCCC).

All tools identified follow the first order decay approach and are generally aligned with the IPCC approach for modelling methane emissions, although there is some variation in some parameters (particularly in respect of the application of carbon content values to waste streams).

Key points include the following:

- The UK operators use GasSim whereas national emissions modelling is undertaken using MELMod;

- Some US operators use the relatively simplistic LandGEM. The US EPA has developed the model WARM, (Waste Reduction Model) which is a comparative tool used to estimate benefits in changing waste management; it includes landfill modelling. There are also state based tools such as the California Air Resources Board Landfill Gas Tool aimed at site operators.

The review identified no instances for a specific country where the national and site-based tools were aligned in terms of assumptions used and calculation methods, although this is generally likely to get the best alignment between the outputs from the various calculations needed by operators and policy makers.

3.4 Estimates of Gas Capture from Other Countries

Capture rates are dependent on the coverage of site wells and are also strongly influenced by where the landfill is in its lifecycle. When sites are actively accepting waste, coverage of wells is reduced, and the capture rate that can be achieved through those wells is also lower, reducing capture rates accordingly. Permanent caps achieve the highest rates of landfill gas capture, but these can only be put in place in areas where the site is no longer accepting any waste.

A distinction is made between instantaneous and lifetime capture rates. Lifetime rates need to take into account the higher emissions rate that typically occurs at the start of the landfill's life (the use of permanent or temporary caps cannot be used over parts of the site), and the reduced ability for landfill gas capture systems to function at very low flow rates towards the end of the lifetime. The highest instantaneous rates are expected to occur when the landfill is no longer actively accepting waste and has been fully capped. Most rates that are published are instantaneous rates, but rates published across all sites in a country may be akin to a lifetime rate for that country, as a result of this data capturing a range of sites at different points in the landfill life cycle.

A review of gas capture rates for various countries by Duan et al gave a range of such rates – ranging from 30 percent for Iceland and 36 percent for the Netherlands, to rates above 60 percent for the US, the UK and Finland (the latter has the highest rate, at 69 percent).[41] However, the literature confirms that there is often wide variations in capture at individual sites: the same paper confirms that in Demark, the country average was 50 percent but the variation ranged from 13-86 percent. Site based data in the UK collected in 2014 – and calculated in part through the use of site-based measurements – suggested the range of collection efficiency for all closed landfill sites was 23-85 percent with a mean of 75 percent and a median of 70 percent, whilst the range for operational sites was found to be 26-91 percent.[42]

The WARM model provides data on rates at different points in the landfill's lifetime: this is shown in Table 3-1. It is noted that this data does not provide an indication for what the capture rate will be at the point in which low flow rates mean the capture system fails to operate. But the data does help in illustrating the variation in performance that arises from changes in the capture rate occurring over the site lifetime.

Table 3-1:: Collection Efficiency Data in WARM Over Landfill Lifetime

Collection Efficiency	Years
0 %	0-4

[41] Duan Z, Kjeldsen P and Scheutz C (2022) Efficiency of gas collection systems at Danish landfills and implications for regulations, Waste management, 139, pp269-278

[42] Department of the Environment, Food and Rural Affairs (2014) Review of Landfill Methane Emissions Modelling

50 %	5-9
75 %	10-14
82.5 %	15-20
90 %	Final cover

Source: US EPA WARM v15

Data on capture rates from the best practice reviews and other operational information was used develop estimated capture rates which were then used to provide an updated estimate of New Zealand's national lifetime landfill gas capture rate. Details on the assumptions used to calculate these rates is provided in Appendix A.5.2.1.

3.5 Summary of International Best Practices

International best practices for landfill management can be summarised as follows:

- Policies to incentivise landfill gas capture, typically through some form of financial incentive for energy generation from captured landfill gas;
- Regulatory bodies that provide site design guidance covering key infrastructure requirements such as well spacing;
- Particularly when flow rate is high, a requirement for regular monitoring of gas generation and emissions, backed up by on-site methane measurements where appropriate. These requirements are often linked to the need by operators to demonstrate how much gas has been captured when filing the claim for the financial incentive, as detailed above;
- Use of low-calorie flares, biofilters, and bioactive covers when the flow rate is low towards the end of the landfill sites lifetime;
- Education of landfill operators on what is needed to ensure best practice capture systems are in place;
- Use of landfill bans or requirements to collect food waste separately, or bans on any waste stream being sent to landfill that has a significant degradable organic carbon content, where appropriate alternatives to landfill are in place for residual treatment.

Ideally site-based models and the GHG inventory models are aligned for best results when modelling but there are no clear examples of this taking place amongst the countries researched as part of this project.

4.0 Analysis of Areas for Improvement in New Zealand Practices

This section provides an analysis of where New Zealand's practices could be improved based on the review of international practices and New Zealand's current approach, and taking account of issues already noted in section 1.0 that prompted this study.

4.1 Diversion

A significant proportion of organic waste is sent to landfill in New Zealand at present, particularly from the household and commercial waste streams. Organic waste makes up approximately 20% of all waste and 50% of household kerbside. Food scraps make up approximately 54% of all organic waste and garden waste 36% (other organics make up 10%). When other degradable organic waste (such as paper and timber) is included the total proportion of degradable material in landfill is estimated to be approximately 45%.[43]Although some separate collection of garden waste is taking place (with such collections accounting for approximately 20 percent of total garden waste – in addition a further approximately 25% is taken to transfer stations for separate recovery, with the rest sent to disposal), there is relatively little separate collection of food waste (in the order of 10-12 percent of household food waste is estimated to currently be diverted through kerbside collections). Recycling rates for other material streams such as paper - which also have an impact on landfill emissions - are also relatively low in comparison to international standards, at 64 percent[44]. Improved diversion from landfill – by policies which aim to increase the proportion of separate collection – could therefore have a significant impact on future landfill emissions.

4.2 Other Residual Treatment

New Zealand currently sends all its residual waste to landfill, with no uptake of other forms of residual waste treatment such Mechanical Biological Treatment (MBT) or as incineration at a municipal scale to date.[45] Alternative residual waste treatment technologies could therefore be considered. The emissions benefit associated with alternative residual treatments will depend on the type of treatment. The extent to which alternative residual treatment technologies might result in emissions mitigation is not always clear: this is particularly the case for incineration facilities generating mostly electricity operating in countries where the electricity grid has already significantly decarbonised, such as is the case in New Zealand.

4.3 Landfill Gas Capture

The stakeholder engagement element of this project included undertaking an in-depth survey of New Zealand landfill operators to establish landfill gas capture practices. The survey included questions on site design, well spacing, the use of different types of wells (sacrificial, horizontal, vertical) and practices related to gas capture during the active (operational) stage of landfilling when waste is still being accepted on site. Additional information included the use of temporary and permanent caps at different stages in the landfill lifecycle. Further details on the survey are included in Appendix A.3.1. The survey outputs were used to inform the estimates of instantaneous and lifetime landfill gas capture rates for the country.

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[43] New Zealand's National Recycling Rate: Options and Estimates | Ministry for the Environment
[44] Eunomia (2024) New Zealand National Recycling Rate Issues and Options. Report for Ministry for the Environment
[45] It is noted that there are currently two energy from waste EfW plants that have applied for resource consents that are under consideration at the time of writing: Project Kea, in Waimate in the South Island, and Paewira, near Tokaroa in the North Island.

The survey outputs confirm a wide range of performance in landfill gas management particularly on the smaller sites.

- Very small sites are not currently required to have any gas capture equipment. However, the tonnage for these sites is small, at 138 thousand tonnes per annum (spread across 21 active sites). This accounts for 4 percent of the total volume of landfilled waste across the Class 1 sites.
- For some small sites there was historically no capture equipment in place: this has impacted the overall aggregated lifetime gas capture figure for sites with capture in place. Data received by some small sites through the survey suggests that instantaneous gas capture performance is lower for some of these sites due to lower levels of temporary and permanent caps on these sites whilst they are still actively accepting waste.
- The two largest sites have reasonably good capture performance, although one of the large sites – Hampton Downs - could improve its operational site well coverage.

There is also no requirement in place for any landfill gas management once capture systems fail towards the end of the life of the landfill.

Across the data provided by the operator survey, estimates of instantaneous gas capture for individual sites range from 32 percent to 76 percent, with variation being due to the proportion of temporary and permanent caps in place. Detailed data on capture equipment coverage was only provided for seven sites, out of a total of 27. The data that was obtained, however, includes information for the two largest sites, and these two sites alone accounted for 41 percent of the total waste stream in 2021. Site specific data was provided in total for 66 percent of landfilled waste for that year (with the latter total including that from the very small sites with no capture). This gives a degree of certainty to estimates for gas capture across the overall landfilled waste stream for the country.

The data suggests there is some potential for landfill gas capture to be improved. It is difficult to be sure of the scale of benefit that might be obtained by such improvement due to the lack of data on the remaining smaller sites and the considerable potential for variation, as seen across the sample of data provided to date. As a result of this uncertainty, during the GHG inventory process undertaken in 2022 aimed at submission to the UNFCCC, New Zealand was advised by peer reviewers to use the IPCC default gas capture rate for sites with no data, which is 20 percent capture.[46] This is expected to underestimate the actual capture rate in the country for most of those sites, but the figure has been used as a lower benchmark for performance of these sites in analysis undertaken for this project.

4.4 LFG Measurement and Reporting

The key issues noted with New Zealand's current approach to LFG measurement and reporting include the following

- New Zealand is relatively unique in that the key instrument around minimising LFG emissions is an emissions trading scheme. This creates the requirement to estimate capture rates. Other jurisdictions without this type of instrument (for example UK and Australia), measure gas captured and provide incentive payments on the basis of the total quantity of LFG captured and destroyed, which can be measured and calculated with reasonable accuracy.

- There is no established national best practice standard or guidance for operation of LFG systems.

- There is no established national best practice standard or guidance for measurement of on-site emissions.

[46] Report on the individual review of the annual submission of New Zealand submitted in 2022. Note by the expert review team

- Current reporting arrangements have resulted in some landfills claiming high instantaneous gas capture rates, which may not reflect actual gas capture rates (due to organic loading) and which do not reflect lifetime gas capture rates.

- There is a disconnect between the LFG capture rates reported for the purposes of the NZETS and gas capture rates reported to UNFCCC.

- While the NZETS has incentivised high gas capture rates amongst some landfills, the effect has been uneven, with larger facilities able to claim high rates, while smaller facilities generally do not.

- While there is no suggestion that facilities do not comply with regulations, there is limited transparency as to how calculations are made. In particular, the regulations require LFG generation to be estimated using models, which can have a large impact on the overall outcome, and the precise inputs and calculations in these models (while subject to some independent verification) are not transparent to government and may not be consistent.

5.0 Long-list of Recommendations for Improving Landfill Gas Capture and Reducing Emissions

5.1 Decreasing LFG Emissions via Increased Landfill Diversion to Alternative Destinations[47]

Reductions in LFG emissions can be achieved by sending less waste to landfill, focussed in particular on waste that can decompose – such as food waste, garden waste, paper and wood. Therefore, the options listed here target these 'active waste' streams. Although their level and speed of degradation, and thus their level of emission production, varies between streams, targeting all active waste is recommended. Conversely, inactive wastes (such as rocks, rubble, soil, ceramics, and ash) do not degrade, do not contribute to LFG emissions, and, in the context of reducing emissions from landfill do not need to be targeted for landfill diversion[48]. Indeed, landfill is considered a reliable destination for inert waste streams.

Landfill diversion policies can only be applied to 'new' waste, which has not yet been sent to a final disposal/treatment destination. Thus, the policy levers below will not affect any waste currently sitting in landfills; these tools will not mitigate any of their emissions. Emissions savings will stem purely from diverting 'new' wastes to alternative destinations.

Alternative destinations can include recycling, composting, anaerobic digestion (AD) and so on. Therefore, policies that promote recycling and composting also promote landfill diversion. Similarly, a route for improving recycling and composting rates is to improve sorting of collected waste – removing active wastes from the residual stream that would otherwise be sent to landfill.

Other alternative destinations can also include other residual waste treatment options. Policies would need to promote any alternatives, whilst Government ensures that these alternatives do indeed exist, and are practically accessible and economically competitive. For example, policy options here would likely require government funding to support investment in additional infrastructure (e.g., an incinerator). These alternatives would also need to be assessed as to whether they would result in the overall reduction waste emissions – in line with the emissions reduction plan.

Overall, the policies below – individually or in combination - can help reduce future LFG emissions via:

1. Landfill diversion due to **waste reduction**;
2. Landfill diversion due to **increased recycling and organic waste recovery**; and
3. Landfill diversion to **other residual treatment** destinations (e.g., incineration or export).

[47] NOTE: It has been agreed that Eunomia will focus less on the Phase 2 policy options for reducing organic waste to landfill.
[48] Recognising that there are lifecycle carbon impacts from the production of some of these materials

5.1.1 Policies for Landfill Diversion via increased Recycling and Composting

The policies below can be implemented to achieve the high-level ambition of increasing recycling and composting rates, thus reducing new waste sent to landfill.

- **Recycling (recovery) rate targets,** which are commonplace in Europe and are good goals to have in legislation. However, they are only as strong as their implementing tools – recycling does not increase simply due to the existence of a target. The target helps allow for the creation of additional levers to promote recycling (improving collection systems, investment in infrastructure, public communications and education schemes, etc.), and consequences for missing the targets (e.g., fines). Overall, targets – if implemented alongside robust tools - should result in an increase the nation's recycling and/or composting rates, thus diverting waste from landfill. This could be supported by other actions such as those set out below to consider organic waste.

- **Organic waste recovery targets** could be implemented, to promote organic materials being source separated and sent to alternative destinations – such as composting and AD. Policy can **mandate separation** of organic waste (also known as a requirement to sort waste) for households and businesses, with the output being sent for **composting, anaerobic digestion** or other organic waste recovery.

- Other tools that could be used to deliver/support targets or mandates include:

    - Promoting food waste reduction (such as through the Love Food Hate Waste programme)

    - Promoting home composting and other similar technologies and techniques (e.g. bokashi, worm farming, kitchen dehydrators/composters etc.). This can include education, composting courses, provision of subsidised bins/units, options to opt out of kerbside systems if official compost bins purchased and courses attended etc.[49]

    - Promoting and funding/supporting sector level agreements and initiatives (such as the Kai Commitment)

    - Setting sector level industry targets and or requiring the development of sector waste reduction plans (similar to the now discontinued industry transformation plans).

    - Promoting and supporting food rescue. There are already a range of schemes in New Zealand to divert surplus food from supermarket and other outlets to foodbanks[50]. These schemes could be expanded, or other related tools could be explored in this area to promote achieving a recycling/composting target. There are examples in the US of policy levers promoting food surplus being sent to foodbanks, such as a requirement for supermarkets to send surplus edible food to food rescue.[51]

- Organic material disposal **bans or limits** to landfill, either for an entire stream (e.g., all organics in all MSW) or for specific streams only (e.g., only food from businesses) can be introduced. This would reduce the amount of new LFG-producing material being sent to landfill.

[49] In sink disposal units are also an option that can be considered, however their benefit is contingent on biosolids having a beneficial use, so while there is some food waste diversion potential here, it is a more complex question, as to whether it should be promoted.
[50] Love Food Hate Waste
[51] https://www.vanguardrenewables.com/organic-waste-bans

- It would not be practical to simply impose bans on landfill operators and expect them to uphold specific bans on mixed waste arriving on site. The 'bans' would need to become part of the landfill's acceptance criteria, so they could be policed through contracts and consent compliance. Any ban or limit would, however, need to be primarily implemented as a **requirement to sort** waste prior to arriving to landfills placed on waste generators and/or collection services, not just on the landfill operators. Any 'ban' would need to allow for exceptions - such as in emergencies, incidental amounts, or for contaminated streams that are not possible to recover. Such a measure is very similar, in practice, to what may be needed to support the meeting of recycling targets. So, any ban should work in tandem with other drivers to increase recycling and composting.

- In addition, any such ban would have to cover all landfills. It should not just be applied to Class 1 landfills. Similarly, to achieve this lever in practice, alternative treatment destinations for the organic material is needed. For this, investment would be needed for new infrastructure, or expansion of existing infrastructure.

- If only certain streams are targeted, there will still be some organics being sent to landfill. The lower levels of emissions stemming these non-targeted steams may be harder to capture, due to capture technology's lower effectiveness at lower gas capture flow rates. Therefore, a ban or limit is anticipated to best reduce CH_4 emissions if all streams are targeted (and/or all limits are strict).

Current examples of different types of bans/limitations from around the world

Sweden banned all municipal organic waste being sent to landfills in 2005 (following a ban on sorted combustible waste in 2002). [52]

Scotland has legislated a ban on biodegradable municipal waste to landfill from 31 December 2025.[53]

The US has a more varied approach that only targets specific streams in certain locations:[54]

- Geographical specificity: only certain states (or even, only certain cities within a state) have bans in place

- Stream specificity: many of the bans are food-only, some are all organics

- Source specificity: some bans cover all businesses, others are for only large enough businesses; some target food-enterprises only, or higher education & research institutions; some bans cover all persons and business entities.

- Destination specificity: Most landfill bans include limitations on the allowed alternative destinations. The allowed destinations can vary. For example, some landfill bans allow for diversion to incineration, others do not.

- **Waste levy** is a cost added on top of any normal landfill fees that can be charged by weight. New Zealand's current levy regime sets one fixed rate for all waste being sent to a particular class of landfill. However, particularly for the construction and demolition sector (which produces much rubble and other inert wastes and currently represents about a third of all waste being sent to Class 1 landfills), a flat rate for all waste to Class 1 may be seen as not adequately distinguishing between the LFG generating potential of different materials. An

[52] https://www.eea.europa.eu/publications/managing-municipal-solid-waste/sweden-municipal-waste-management
[53] https://www.sepa.org.uk/regulations/waste/landfill/biodegradable-municipal-waste-landfill-ban/
[54] https://www.vanguardrenewables.com/organic-waste-bans

alternative is to set different levy rates depending on the materials. For instance, a **differential waste levy** can set different rates for 'active' and 'inactive' materials – allowing inactive materials to still be landfilled whilst discouraging emission-producing wastes. This type of regime could replace the current regime of different rates for different classes. In other words, the levy rate would be the same whichever class of landfill material is disposed at (recognising that the rate for 'active' waste would only apply to facilities that are consented to accept this material)

Countries such as the UK currently have this type of differential levy. A key feature of any levy is that the price be set high enough to make recycling, composting and other recovery options comparatively financially beneficial. Thus, this option – if implemented robustly – can help promote recycling and composting. If, however, other forms of residual treatment exist then the differentiated levy may not increase recycling if the other form of residual treatment is now cheaper than landfill.

A consideration in setting a levy rate is how it interacts with the effective costs imposed by the NZETS. Other jurisdictions that have levies generally do not also have an ETS. In terms of one of the primary purposes of the levy being to raise the cost of disposal, it should therefore be considered in conjunction with the effects of the ETS, which, can have the impact of raising the cost of disposal. The impact of the NZETS is however, variable depending on the level of gas generation or capture and destruction that is claimed by the waste participant. If lower rates of gas capture were to be claimed (as a result for example of changing the methods of measurement and calculation employed), then this would have the effect of raising the cost of disposal.

- **The use of pay-as-you-throw** (PAYT) schemes can incentivise recycling. In the better performing recycling systems in place in Europe, there is a significant differential between fees applicable for waste that is recycled, compared to waste that is sent for disposal. The design of such schemes is an important factor in determining success, and many approaches are possible in practice.

    - In New Zealand, there are already PAYT schemes. However, in recent years, councils have been moving away from these schemes, due to losing market share to the private sector. The convenient services offered by the private sector (notably, large wheeled bins) result in higher waste generation. Where council PAYT schemes are operated households can seek alternatives to the council services, and many tend to choose the larger wheeled bins can negate any waste reduction from those who do participate in the PAYT service. This makes the current PAYT schemes an ineffective tool for reducing the amount of waste sent to landfill. Removal of alternative forms of collection would be necessary for the schemes to function more effectively.

    - Other forms of PAYT incentives have been seen to reduce residual waste (and promote recycling) in other parts of the world. Financial disincentives are applied in some authorities in Wales, for example, to residents that exceed the amount of residual waste that is permitted to be disposed of per household. Another PAYT lever to support a recovery target could be the reduction of disposal fees for businesses and households that participate in composting or organic waste recycling programs.

    - If new PAYT schemes are to be introduced based on successful international examples, further detailed assessments of their specific applicability to the New Zealand market would be needed, as well as work to ensure stakeholder buy-in.

5.1.2 Policies for Landfill Diversion to other Residual Treatment Destinations

The policies below can be implemented to achieve reducing new waste being sent to landfill. However, the policies' implications and potential benefits for the reduction of total emissions from waste would need to be further assessed.

- **Landfill phase-out**, which would see the eventual closure of Class 1 landfills. This would result in complete diversion of municipal waste. However, alternative disposal option(s) would be needed, and the alternatives' shortcomings also would need to be assessed. It is not a foregone conclusion that an alternative would – from an emissions standpoint – perform better than Class 1 landfills (especially if other policy interventions were to improve the Class 1 landfills' performance). Alternative options may include:

- **Incineration:** Currently, New Zealand does not have any large-scale municipal waste incinerators (although there are a number currently proposed with two going through consenting processes). One alternative to landfill could be to build incineration plants. Incineration is not a solution for all waste streams – only for combustible streams such as plastic, paper, textiles, etc.[55]

    - Incineration should not be introduced to the detriment of recycling ambitions. Incineration capacity could be purpose built for New Zealand, with the expectation of increases in recycling and composting reducing current levels of residual waste over time.

    - New incineration capacity may require some waste to travel farther than it might otherwise have to for landfill or other disposal/treatment options. This would add additional expense to a market that may have minimal competition. So, regulations may be needed to keep pricing fair.

    - Incinerators do also produce emissions. For the waste sector as whole to achieve lower emissions, in-depth LCA are key to guide decision-making.

    - New Zealand's electricity grid is already low carbon and emissions are anticipated to be reduced further. To fully utilise an incinerator's benefits, heat would also need to be produced and used (i.e., utilisation of combined heat and power, 'CHP' technology). This would limit the location of plant(s) to wherever a symbiotic venture could be planned. It would also increase the overall capital cost of the project(s).

    - Similarly, to minimise the impact of emissions, the carbon capture, utilisation and storage (CCUS) potential should be assessed. Examples are now being trialled in Europe and the US, after years of planning:

        - Multiple incinerator CCUS plans are being announced in the UK[56], stemming from a wider industrial net zero push from the UK Government that includes notable financial support and has been in the works for years.

        - Norway's project, 'the Longship', involves capturing carbon from waste incineration (as well as from heavy industry) that will then be transported and stored in the North Sea. The first phase of the work is completed, with the second

[55] For further discussion of incineration in the New Zealand context please refer to a report produced by Eunomia in 2024: [Waste to Energy Technology Implications in the Aotearoa New Zealand Context | Eunomia Consulting]
[56] https://resource.co/article/uk-efw-operators-vying-launch-first-ccs-installations

phase being currently underway. To provide a sense of timescales, the government FEED assessment was published in 2016.[57]

- The US is leading the charge on carbon capture, with investments across many sectors.[58]

- **Class 2-4 landfills:** Only small quantities of degradable waste is sent to other classes of landfills. Part of any Class 1 phase out should include further stipulations of waste not being diverted to other classes. Class 2-4 landfills should not be seen – or be allowed to be utilised – as an alternative destination for active wastes.

- Mandate the implementation of high performance **MBT biostabilisation** before landfill. Biostabilisation techniques, when applied to residual waste, effectively require the application of an in-vessel composting process to residual waste, to ensure that degradation of organic materials takes place in a controlled fashion prior to such material being sent to landfill. Providing the composting process is effectively managed – and is of sufficient duration – the resulting output is of low degradability and as such methane emissions in landfill are significantly reduced. Italy, Austria and Germany historically implemented variations on such a policy, whereby residual waste containing organic materials could not be landfilled unless it had been through a biostabilisation process. Sample outputs were tested to confirm they were below the threshold limit of degradability prior to being landfilled. The processes can be combined with high performance sorting equipment for recyclables, which aim at increasing the recycling of materials such as plastic film, which are otherwise less likely to be captured effectively for recycling through kerbside systems.

  Where performance of biostabilisation processes is of a sufficiently high standard, there is less need for reliance on sophisticated landfill gas capture systems as methane emissions in landfill are significantly reduced. As such, landfills in Germany and Austria operate only passive landfill gas capture systems. Variations of such a policy exist – it is also possible to combine the application of biostabilisation with reduced levies or taxes for landfilled waste that has been through such a process.

5.2 Improving Management of LFG emissions from existing landfill waste

Alongside policies to reduce organic waste in landfill, the regulatory environment needs to ensure that:

a) organic waste that does go to landfill is well managed and capture and destruction of the emissions is maximised; and,

b) landfill emissions are calculated and accounted for as accurately as practicable. This will enable not only correct accounting for actual emissions and ensure that that current tools such as the ETS are effective, but provide key data for decision making about where effort is best focused - including how capture and diversion solutions are deployed.

While management and measurement of LFG does not directly impact diversion of organics from landfill and hence the amount of LFG produced (they either seek to measure it or capture it), they are critical in enabling the application of other policy tools, in particular the NZETS.

As such, these policy options should be considered in context with other policies. Improving LFG management and measurement in isolation may have some positive impact if it results in higher overall

[57] https://norlights.com/about-the-longship-project/ ; https://ccsnorway.com/the-project/
[58] https://about.bnef.com/blog/us-is-set-to-expand-global-lead-in-capturing-carbon/

rates of capture but (given the limits on lifetime capture rates), this alone will not enable New Zealand to achieve the aspirations set out within the first emissions reduction plan. However, doing nothing to improve the measurement tools would limit the ability to assess progress and mitigate the emissions impacts of historic waste and residual active waste that gets landfilled in the future. As per the diversion policies, creating a policy landscape that tackles LFG emission reduction holistically is key.

5.2.1 Longlist Policies for Increasing LFG Capture

The longlist of **emission capture policy** options includes:[59]

- Require all Class 1 landfills to have LFG capture systems.[60]
    - Class 1 landfills without LFG capture could be banned from receiving organic waste.
    - Extend this to Class 2-4 landfills (depending on further investigations)[61]
- Require all Class 1 landfills to be operated as bioreactors. A bioreactor landfill is a Class 1 type facility in which the biological degradation of the waste mass is accelerated. The increase in waste degradation and stabilisation is accomplished through the addition of liquid and air to enhance microbial processes. Processes can either be aerobic, anaerobic or hybrid.[62]
- Extend the ETS requirements to Class 2-4 disposal facilities.
- Landfill **site design guidelines** to improve capture – both for new sites and for making updates to existing sites (where practicable)
    - E.g., Mandating the use of **horizontal sacrificial gas wells** in new sites during the active landfilling stage. This could also be combined with sacrificial vertical wells. In combination these actions could collect around 50 percent of the landfill gas generated in these areas which would otherwise be lost to the atmosphere.
    - E.g., The Ireland EPA recommends placing **physical barriers** to control landfill gas migration, in the form of cement/bentonite slurry cut-off trench. To improve effectiveness, a geomembrane should be incorporated into the trench. A horizontal barrier can be formed as well, by jet grouting or chemical grouting.[63] Similar approaches have been used on sites in other countries, e.g. Canada.[64]
- Moving to **larger regional landfills**, and away from dispersed smaller sites, with lower levels of gas capture. This could be achieved via a policy stipulation that existing small sites would not be allowed to accept tonnage at a certain point in the future, and that only facilities above a certain size threshold/LFG capture efficiency could be opened in the future (noting existing sites' resource consent conditions will vary, so there would likely be considerable lag in implementation)

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[59] Note: There are various government initiatives that could incorporate multiple policy options such as the Emissions Reduction Plan and National Adaptation Plan.
[60] Noting that the current national standards largely only require landfills of 1 million tonnes or above to have LFG capture systems.
[61] It is worth noting that the NES for Air Quality 2004 applies to any 'landfill' that accepts 5% or more of organic waste. Technically speaking therefore this NES could already apply to Class 2 facilities that accept large quantities of construction wood waste, and it may therefore simply be a case of enforcing this.
[62] Bioreactor Landfills | US EPA
[63] Environmental Protection Agency Ireland (2000) Landfill Manuals – Landfill Site Design, https://www.epa.ie/publications/compliance--enforcement/waste/EPA_landfill_site_design_guide.pdf
[64] https://bmross.net/project-profiles/stanley-landfill-slurry-trench-cut-wall

- The operational area compared to the total capped area is proportionally smaller on larger sites; the smaller the proportionate operating area, the lower the emissions from the site.
- Larger landfills are more cost effective overall and easier to manage emissions from.

- Options to **concentrate biodegradable materials** into specific landfills.
  - Diluting the biodegradable wastes will make it more costly to recover landfill gas and tends to lead to lower capture rates overall.
  - New Zealand already somewhat supports this by concentrating C&D wastes (considered to be inert) into specific landfills. This could be extended within existing Class 1 landfills. Such approaches are complicated by the need to consider the fines fractions that result from pre-processing – and which also generate landfill gas.
- Financial support or incentives (or disincentives/fines) to install more efficient capture systems

5.2.2 Longlist Policies for Better Measurement of LFG Emissions

The longlist of **emission measurement policy** options includes **additional monitoring requirements** in line with the European legislation.

- There is relatively little guidance on on-going landfill gas monitoring requirements for New Zealand landfills. In Europe, procedures for demonstrating the effectiveness of LFG controls include monitoring soil gas outside the landfill, monitoring fugitive emissions, assessing landfill gas conditions within the site. Example requirements can be found here Guidance on Landfill Gas.[65] Comparable requirements are also documented for UK landfills.

Other options are focussed on **fixes to the existing regulations:**

- **Have different emissions factor tiers linked to different standards of evidence**. For example:
  - A disposal facility can claim up to 20 percent gas capture if they use the DEF. This would essentially be using the same method as currently provided for in regulation
  - If a disposal facility wants to claim over 20 percent but less than (for example) 75 percent, they must use a unique emissions factor from waste composition (UEFwc) (as provided in section 23D)
  - If claiming over 75 percent gas capture, in addition to using a UEFwc the facility operator would also have to have a full history of waste composition for the first order decay calculation, undertake annual composition audits, and annually recalculate UEF (rather than just when there is ‘significant change in composition’.

    This approach would mean that where high levels of gas capture are claimed - which provides commercial benefit for a facility - a higher standard of evidence is required. This approach could also be linked to a removal of any ceiling on claimed gas capture rates, as the higher rates could only be claimed with very high standards of evidence that provide confidence of a high-level accuracy in the calculation. This could be an important consideration in incentivising disposal facility operators to continue to innovate and pursue the highest possible level of gas capture.

[65] https://ec.europa.eu/environment/pdf/waste/guidance on landfill gas.pdf

- **Align current measurement calculations with best practices** and produce an accepted methodology (which could be tailored to each site/ emissions factors tier, as needed). This might include the following:
    - Align the rate of waste degradation (i.e. k values) with rainfall and evapotranspiration using the IPCC methodology for a potentially more accurate picture of gas generation.
    - Have different tiers linked to different standards of evidence.
    - Post closure gas capture consents. These would require better landfill gas management practices to be put in place when conventional gas capture systems begin to fail after closure (at lower gas generation levels).
- **Adjust the 90 percent capture limit to be more in line with international experience as to what is technically feasible.** Under Section 23D of the Climate Change (Unique Emissions Factors) Regulations 2009 (SR 2009/286) regulations, the maximum level of gas capture that a disposal facility operator can claim is 90 percent. From the latest gazette notice it can be calculated that 10 out of 19 disposal facilities report 90 percent gas capture and destruction efficiency.[66] In addition, as has been noted, some operators have suggested that their gas capture rates are in excess of 90 percent and have argued that the cap limits them claiming their full level of capture.

  However, as our research has shown, when properly calculated, international best practice suggests that the best possible rates are less than 90 percent, with best case instantaneous capture being likely to be no higher than 85 percent. Lowering the maximum rate that can be claimed in relation to the ETS so that it is better aligned with rates achieved by international best practice would add credibility to the scheme, by ensuring that no-one is able to claim rates that are higher. It is also important to note in this context that lifetime capture rates will likely be lower still – and arguably it is those that should be used, given the need to consider emissions over the full lifetime of the landfill. This is further discussed in subsequent policy options.

  On the other hand, high rates of landfill gas capture are desirable, and operators should be incentivised to push the boundaries of the technology to maximise gas capture. If the cap of what can be claimed is set too low, then operators will not be incentivised to invest in the highest performing landfill gas systems or to innovate to improve capture. Such a risk can be mitigated by ensuring that the ceiling reflects realistic current best practice for capture rate.
- **Require the use of a EUFwc.** This would require a change in the regulations to require disposal facility operators applying for a landfill gas capture UEF to also use a composition UEF (UEFwc). This would involve a change to 23C of the Climate Change (Unique Emissions Factors) Regulations 2009 (SR 2009/286); instead of being able to use a default value, they would have to use a UEFwc calculated in accordance with section 23B.

  The advantage of this change would be that it would ensure that the gas capture UEF more accurately reflects actual gas generation at the disposal facility. It avoids the situation where operators use one set of composition data to calculate the first order decay, and a different set of data when making the calculation for the purposes of the ETS.

  The primary disadvantage of this change would be that it would impose an extra cost for operators that wish to claim a gas capture UEF. Undertaking composition analyses that comply with 23B of the Regulations can cost in the order of $70-100,000[67]. This could be a significant

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[66] Notice of Approval of Unique Emissions Factors - 2023-au3444 - New Zealand Gazette

[67] Personal Communication with Bruce Middelton Waste Not Consulting

cost for smaller facilities. Given that operators stand to gain substantial financial benefit from a lower UEF, the operator will need to consider whether the cost of obtaining a UEF is worth the gain from it. Although the cost of the composition analysis is relatively high, at present for most sites where the composition is not deemed to have changed significantly, this is a one-off cost.

- **Review how the DEF is calculated.** The DEF currently is based on a calculation of the average composition of landfills in NZ. Each class of material (e.g. garden waste, wood waste etc.) is assigned an emissions factor. The DEF is then a function of the different proportions of each material times each material emissions factor.

  The issue with this approach is that there can be substantial variation between landfills in terms of composition, rainfall, gas and leachate management etc, that means that few landfills will actually be close to the 'average'. Therefore, most landfills using the DEF will be using an inaccurate number for their situation.

  The level of accuracy could be improved by having several defaults rather than a single default. Options for these different defaults include the following:

  - Differentiation of DEF by landfill size. Larger landfills are generally able to have higher rates of gas capture as they have a greater volume to surface area and can invest more in sophisticated gas capture systems. The disadvantage of this approach is that landfills of a similar size could still have very different gas generation rates (depending on rainfall, composition, landfill management etc.)
  - Differentiation of DEF by location/rainfall zone. The country could be divided into different rainfall zones with adjusted DEFs for each zone. This would provide some compensation in the DEF for the impact of average rainfall. However, it would not provide any compensation for other factors.
  - Differentiation by quantity of soil/rubble/inert. Waste composition data suggests that the largest impact on composition and therefore gas generation is the amount of soil disposed of at a landfill site. This would be a relatively simple adjustment to make as it would simply mean adjusting the DEF by subtracting the default inert tonnages and adding in the specific tonnages for each landfill. Landfills would have to record the quantities of soil and other inert material deposited in order to make this calculation.
  - A further variation could be to have a series of DEFs by Activity that generated the waste. As disposal facilities and transfer stations now have to record the Activity of their tonnages received, it would then be a matter of multiplying the Activity.
  - The EF applied to each material classification could be reviewed and updated more regularly (and potentially put in a more readily updateable form than regulation – for example referenced in regulation and be gazetted). The intention would be to ensure that the EF can change when the scientific consensus changes – such as when the GWP of methane is updated.
  - Similarly, the DEF(s), rather than being specified in regulation, could be referenced in the regulations as the being the latest figures published by Government, such as via gazette. This would enable more regular and easy updates to the DEF and help ensure that situations such as where two different regulations contain different DEFs (because they were updated at different times) does not occur.
  - The final option in respect of the DEF is to have some combination of the above. Having a combination, particularly if there are multiple elements, starts to move away from the concept of a default, and into the realm of developing UEFs. This approach of essentially applying a formula based on a series of relevant factors is a hybrid between a DEF and a UEF. The advantage of this approach however is that it would allow a degree of customisation that would likely capture most of the variation that would occur between sites, without requiring extra measurement or cost for facility operators.

- **Update the Climate Change (Unique Emissions Factors) Regulations 2009** to utilise the latest DEF figure (1.023). This would remove the discrepancy between this regulation and the Climate Change (Waste) Regulations 2010 (SR 2010/338). Updating this regulation with the latest figure would reduce the incentive for disposal facility operators to choose the DEF. We understand that this change is already in progress.

- **Apply DEF to current tonnage only.** At present the waste composition DEF can be applied to all historical tonnage when calculating a landfills gas capture UEF. A further option to adjust this calculation is to require the DEF to be applied only to tonnage deposited in the landfill for the period for which that DEF is active. In other words, the current DEF could not be applied to all historical tonnage. This would reduce the impact of the current DEF relative to how it is presently calculated but would not otherwise increase the accuracy of the calculations.

- **Improve the mass balance methodology. Improve the mass balance methodology.** As noted earlier in the report, New Zealand has elected to take a 'mass balance' approach to measuring and reporting LFG for the purposes of compliance with the NZ ETS. The mass balance estimates the potential - rather than actual -emissions based on a standard emissions factor for the waste deposited in the landfill in the specified period. One of the key rationales for this approach was that, because all lifetime emissions are essentially accounted and paid for in the same period as the waste is deposited, it avoids issues with liabilities in respect of future emissions for this tonnage. However, given this rationale, the calculations for gas capture should utilise the lifetime landfill gas capture rates (which are likely to be around 60 percent) rather than the instantaneous gas capture rate as is currently used (these can be much higher – up to 85 percent). In other words, the emissions attributed to deposited waste needs to reflect the emissions profile from the time of deposition to when emissions effectively cease, rather than, as is the case at present, the emissions for the disposal facility in the year in which the waste is deposited. Lifetime gas capture rates account for losses prior to gas capture being installed as well as when gas capture systems are no longer functioning (e.g. at the end of a landfill's aftercare period). In order to apply a lifetime gas capture rate to landfills, the likely lifetime gas generation would have to be modelled taking into account time before gas extraction, and aftercare plans. This would be more complex and would have to deal with uncertainty around future management of the landfills (including likely site closure dates and aftercare plans) but is likely to more accurately reflect the reality of gas generation and capture, compared to using the instantaneous gas capture figure.

- **Direct measurement.** Utilise the latest in drone, surface and satellite technology to develop a comprehensive monitoring regime for detecting actual emissions from landfill. With the recent advances in satellite and drone capabilities there is greater potential for this method to be utilised than when the landfill gas regulations were conceived. The regime could for example entail each landfill having a periodic (for example every 3 years) comprehensive direct measurement of fugitive emissions, supplemented by ongoing monitoring of indicators. A UEF could then be applied to the waste disposed of annually based on direct measurement. This could then be combined with the direct measurement of the captured gas and adjusted for the tonnage disposed of which would give a capture rate.

  The main issue with this approach is that it would produce an instantaneous gas capture estimate, and this would not adequately account for future emissions (post closure). However, this could still improve on the current situation by providing a more robust benchmark of current capture performance than is the case with the present system. Ideally, models should be designed to be relatively conservative. In such an environment, a robust benchmark of actual capture performance could therefore be beneficial to the operators. The ideal system might therefore be to pair direct measurement with a tiered approach to evidence provision for gas management as is set out in one of the options in Section 5.2.1.

- **Update the first order decay model approach through using a standard model for all operators**. One option for improving the first order decay model approach is, rather than have the operators (and/or their consultants) calculate the gas generation themselves using their own (potentially variable) models, there is a standard model operated by MfE or EPA used to calculate emissions from the data submitted by operators. The data provided by the operators is verified by the independent verifier, and MfE/EPA finalises the calculations and informs the operator what its liability is. The purpose of this approach would be to introduce more transparency and consistency in how gas generation is modelled. This approach would entail more work for Government, but if it is set up so data entry was all online, the model could do most of the calculations automatically, and once in place, effort mostly relates to updating existing figures.

6.0 Short-list Policy Recommendations

This section presents key organics management and LFG emissions policy options that it is recommended be taken forward for further consideration.

6.1 Approach to Shortlisting

The shortlisting of policy options was arrived at through a series of consultations and discussions with the final shortlist being agreed between MfE and the project team.

6.1.1 Stakeholder Engagement Outcomes

Stakeholder input was sought through a stakeholder engagement exercise (refer stakeholder engagement report – Appendix A.3.2). A targeted group of stakeholders were engaged with consisting of landfill owners and operators and technical experts. Views were sought on LFG policy generally and specific policies were not identified in the questionnaires. The stakeholder engagement provided for free-form answers to a small number of questions relating to policy and practice around LFG capture and measurement and management of organic waste. The engagement was not designed to determine a quantitative measurement of views but to elicit in-depth discussion and response. There were a range of views expressed by the stakeholders. The following key points were put forward:

General Organic Waste Management

- Respondents, in particular councils, indicated broad support for the principles of the waste hierarchy.

- A policy and regulatory regime should take account of the complexities of cost and benefits of different approaches to organic waste management (including GHG impacts, soil health, circular use of materials etc.) rather than characterising certain technologies or methods as 'good' or 'bad'.

- Organic management options should be evaluated on a case-by-case basis, taking account of local/regional conditions, and that disposal to well-engineered Class 1 landfill is a legitimate the option to be considered.

Application of the Waste Levy and ETS and other regulation

- There should be consistent requirements for all types of disposal facilities accepting organics and/or organic waste should not be permitted for disposal in Class 2-5 type facilities.

- Moving from a levy regime based on landfill type to a flat rate or to a levy rate based on material type would help avoid issues with material being incentivised to be disposed of at less well engineered Class 2-5 facilities.

- Any change to regulation or policy needs to be justifiable and not simply impose greater administrative burden or costs for minimal improvement. A relatively common view among private operators was that while flawed, the current regime has led to marked improvements in gas capture rates.

- Stricter regulation and or higher costs on Class 1 disposal without corresponding measures on other forms of disposal (or even recovery) could have perverse consequences by incentivising material to go to less well managed sites or processes.

- Blanket 'bans' for material to Class 1 are not realistic as there will be some streams of material that have no practical alternative (such as biosecurity waste, disaster waste, or contaminated material). Any ban would have to have exceptions and practical ways of monitoring and enforcement that were not onerous and did not put unrealistic requirements on landfill operators (such as inspecting every load).

- Alternative measures that incentivise higher LFG capture rates should be considered (such as the Australian ACCU scheme.

Measuring and Reporting

- Greater standardisation around how LFG is measured and reported, including training and upskilling and implementation of standards nationally - for practitioners and regulators.

- There was some support among landfill operators for removal of the 90 percent gas capture cap to incentivise maximising LFG capture.

- Improve the DEF and associated processes to enable a low-cost compliance option that more accurately reflects local situations.

- Consideration should be given to improving alignment between the NZETS measurements and reporting and IPCC guidance

- Introduce a mechanism to allow LFG to be accounted for over the life of the landfill to smooth annual fluctuations in quantities and capture rates.

Other Comments

- Changes could have unintended consequences and should be introduced with plenty of lead in time to allow industry time to adapt and/or for there to be a course correction if there are issues.

- Consideration should be given to how biosolids that go to monofills are managed and reported on within the NZETS and GHG reporting regimes, as this material is not currently accounted for.

- Class 1 landfills are designed to accept a certain amount of organic wastes, and reducing the quantities significantly could impact their ability to capture and destroy carbon emissions over time.

6.1.2 Shortlisting

A long list of policy options was presented to MfE in a workshop and a range of considerations taken into account in identifying short list policies to take forward to modelling. These included:

- Use of the policies in international contexts and their effectiveness,

- Practicality of application to the New Zealand context including interaction with existing policy instruments such as the waste levy and the NZETS, and

- Views of stakeholders including potential cost of compliance and ease of implementation.

6.2 Short-list Recommendations of Policies for Decreasing LFG Emissions via Diversion

As described in Section 4.1, New Zealand currently has relatively low rates of recycling and biowaste treatment for organic waste streams, and no alternative residual waste treatment systems in place. This suggests that actions to increase the diversion of these waste streams from landfill would have a relatively large impact on future emissions, particularly on sites that do not have good capture systems in place.

At the time of analysis, uncertainties associated with the cost and performance of alternative residual waste treatments – such as incineration and MBT systems – were such that stakeholders did not feel that these options should be short listed. The short list therefore focuses on diversion based on changes to rates of recycling and biowaste treatment, since such practices are already underway.

International best practice for landfill diversion includes the use of instruments such as taxation to increase the cost of landfilling, and legislative restrictions imposed on organic waste streams being sent to landfill. Short-listed options in these categories were the following:

- **Increasing the cost of landfilling through changes in waste levy rate and ETS**. This, in turn, is anticipated to reduce the relative cost of recycling and composting and make it more competitive compared to landfill, thereby encouraging diversion. An improved implementation of the New Zealand ETS (discussed in Section 6.4) would be expected to increase the cost of meeting ETS obligations for operators that do not provide sufficient data to justify the high capture rates they are claiming, or for those who do not currently have in place good capture systems. This, in turn, might mean that the increase in the waste levy rate could be more modest to achieve the same degree of landfill diversion. There are various ways this could be achieved, including the application of differential levy rates by material stream, or a higher flat rate across all landfill classes. We have explored this in the analysis through consideration of variations in the overall rate for the ETS cost and ley combined.[68]

- **Organic disposal restrictions**. These can be achieved either via a ban on sending certain organic waste streams to landfill or by a requirement to sort organic waste streams such as food waste. In the New Zealand context, this policy option is considered for the Class 1 landfills which are the sites where most organic material is sent. Analysis also considers the implications of banning organics from Class 2-4, and for Class 1 sites without LFG capture. It is noted that the banning of specific streams from landfill is, in practice, difficult to police by operators, since mixed loads will be arriving at the site continuously and the operator will be unable to inspect them in sufficient detail to ensure that no banned material enters the site. It is for this reason that effective implementation of a ban typically requires actions upstream from the landfill to occur, supported by sufficient regulatory control to ensure operators and waste generators are compliant with the ban / regulation.

Rationale for short-listing these policies: The nature of landfill sites is such that landfill gas is difficult to manage well throughout the sites lifetime. Given this, policies that divert organic waste from landfill are used in other countries to assist in reducing emissions from landfill sites. Both types of options lead to similar outcomes, albeit with different levers being used. In both cases, it is the implementation of the option that leads to a differential performance. For the financial incentives, higher ETS costs would be expected to drive greater performance. For the ban implemented on sending organic waste streams to landfill, performance depends on the specification and method of implementing the ban, including the degree to which site performance is monitored. Requirements to sort waste are similarly somewhat dependent upon enforcement. The analysis explores the environmental impact of varying intervention

[68] For the purposes of this discussion, it is assumed that waste levy funds continue to be hypothecated (at least to a substantive degree), and are directed towards waste minimisation infrastructure and actions.

levels for these policies. At higher levels of performance, activities would be expected to include actions such as inspections of class 2 sites to ensure that no organic material is being diverted there in large quantity.

6.3 Short-list Recommendations of Policies for Improving Management of LFG

Rationale for short-listing these policies: There is currently a variation in landfill gas capture particularly amongst the smaller sites in the country. Very small sites have no capture whilst capture performance varies amongst other small sites that do have some capture systems in place, although due to a lack of site data, it is unclear what current overall performance levels are for this group of landfills. Action needs to be taken to address these deficits.

Shortlisted policy options in this category are the following:

- **A requirement for all Class 1 landfills to have landfill gas capture systems**. For very small sites, this includes the use of improved passive gas capture techniques (since these sites are likely to be too small for the engineered capture systems based on wells to be effective).

- **Improvements in landfill gas capture infrastructure** over the landfill lifetime for the remaining Class 1 sites that currently have gas capture systems in place. This includes meeting best practice well-spacing guidelines, improving the use of capture systems when the site is operational and the utilisation of best practice aftercare techniques.

Performance is modelled on the basis of good practice implementation seen in other countries, as discussed in the review of literature from international best practices. Passive gas capture systems are frequently used in Denmark, whilst the UK has many sites implementing good landfill gas capture systems. The largest Class 1 sites in New Zealand are already performing reasonably well, based on data obtained from operators in this project. The recommended action is therefore to improve the capture infrastructure in other, smaller sites, where performance in some cases does not meet these standards.

6.4 Short-list Recommendations of Policies for Better Measurement of LFG Emissions

The key considerations in identifying a short list of policies for better measure measurement of LFG emissions included the following:

- The measurement and reporting of LFG should be an appropriately accurate reflection of actual performance that provides opportunity to differentiate between the performance of different sites.

- The policies should support and incentivise operators and sites to adopt best practices and maximise gas capture.

- The basis of the calculations should be consistent, transparent and able to be readily verified.

- The regime should impose administrative or compliance requirements that are in proportion to the benefit achieved.

- The polices should support one another and present a cohesive integrated approach.

A key design principle of the new system was therefore for operators to claim actual LFG capture levels provided appropriate levels of evidence are presented that directly support that claim. It is put forward that claims of higher levels of gas capture should require higher levels of evidence, and that conversely it is important to recognise that not all sites or operators will be able to provide high levels of evidence, and that provision should be made for some level of gas capture to be claimed with lower standards of evidence.

The following **three policy amendments** are recommended to be implemented together as they are complimentary and in combination provide a comprehensive, evidence-based approach. The intention is to create a transparent, fair regime, and raise the standards of operation across the board. This means allowing operators to claim, as close as possible, their actual gas capture rates where the evidence is able to be presented, while allowing some lower level of gas capture to be claimed where the evidence is not available.

- **Remove the ceiling on LFG capture rates and have different emissions factor tiers linked to different standards of evidence**. For example:
    - A disposal facility can claim up to X percent gas capture if they use the DEF. This would essentially be using the same method as currently provided for in regulation. The default gas capture level could be set at the median level calculated from the modelling for small facilities or could be set at the 20 percent IPCC default.
    - If a disposal facility wants to claim over X percent but less than Y percent, they must use a UEFwc (as provided in section 23D of the Climate Change (Unique Emissions Factors) Regulations 2009 (SR 2009/286)). In this instance. Y is assumed to be the median level calculated for all facilities. [69]
    - If claiming over Y percent gas capture, in addition to using a UEFwc the facility operator would also have to have a full history of waste composition for the first order decay calculation, undertake annual composition audits, and annually recalculate UEF (rather than just when there is 'significant change in composition'.

  Rationale for Shortlisting this policy amendment: *The removal of a ceiling on high LFG capture rates is justified by the standard of evidence provided. If the operator is able to prove to a satisfactory level of confidence that their LFG emissions are what they claim, then they should be allowed to claim it. This could be an important consideration in incentivising disposal facility operators to continue to innovate and pursue the highest possible level of gas capture. It also provides the industry with a policy outcome they have been seeking while providing safeguards that the claims are accurate. Requiring different levels of evidence for different levels of claim is pragmatic as it recognises that not all facilities (in particular smaller ones) will be able or willing to provide the highest standard of evidence, but it is still reasonable to allow them to claim some level of elevated gas capture.*

- **Improve the mass balance methodology.** As noted earlier in the report, New Zealand has elected to take a 'mass balance' approach to measuring and reporting LFG for the purposes of compliance with the NZ ETS. The mass balance estimates the potential - rather than actual - emissions based on a standard emissions factor for the waste deposited in the landfill in the specified period. One of the key rationales for this approach was that, because all lifetime emissions are essentially accounted and paid for in the same period as the waste is deposited, it avoids issues with liabilities in respect of future emissions for this tonnage. However, given this rationale, the calculations for gas capture should utilise the lifetime landfill gas capture rates (which are likely to be around 60 percent) rather than the instantaneous gas capture rate as is currently used (these can be much higher – up to 85 percent). In other words, the emissions attributed to deposited waste needs to reflect the emissions profile from the time of deposition

[69] There are other variations possible in calculating a mid-tier gas capture claim that could be investigated. These include options outlined under section 5.2.2 such as for example Differentiation of DEF by landfill size, Differentiation of DEF by location/rainfall zone, Differentiation by quantity of soil/rubble/inert or Differentiation by Activity.

to when emissions effectively cease, rather than, as is the case at present, the emissions for the disposal facility in the year in which the waste is deposited. Lifetime gas capture rates account for losses prior to gas capture being installed as well as when gas capture systems are no longer functioning (e.g. at the end of a landfill's aftercare period). In order to apply a lifetime gas capture rate to landfills, the likely lifetime gas generation would have to be modelled taking into account time before gas extraction, and aftercare plans. This would be more complex and would have to deal with uncertainty around future management of the landfills (including likely site closure dates and aftercare plans) but is likely to more accurately reflect the reality of gas generation and capture, compared to using the instantaneous gas capture figure.

Rationale for Shortlisting: *This is potentially the most significant adjustment to the calculations. However, it is essential in that it aligns the justification for use of the mass balance methodology (that all LFG emissions are accounted for at the point and time of deposition in a landfill), with the calculation of all lifetime emissions. This adjustment would also have the added benefit of better aligning figures calculated for the purposes of compliance with the NZETS, with calculations made for policy purposes.*

- **Update the first order decay model approach through using a standard model for all operators**. One option for improving the first order decay model approach is to utilise a standard model, which would be operated by MfE or EPA to calculate emissions from the data submitted by operators. This would be instead of the current practice of operators (and/or their consultants) calculating the gas generation themselves using their own (potentially variable) models. In this option, the data provided by the operators would be verified by the independent verifier, and MfE/EPA would finalise the calculations and inform the operator what their liability is. The purpose of this approach would be to introduce more transparency and consistency in how gas generation is modelled. This approach would entail more work for Government, but if it is set up so data entry was all online, the model could do most of the calculations automatically, and once in place, effort mostly relates to updating existing figures.

  Rationale for Shortlisting: *This is not an essential component, but it would address one of the core issues with the present regime, which is that the calculation of LFG emissions essentially takes place in a 'black box'. This solution would give Government greater insight and control of calculation and confidence that the outcomes of the system were equitable and uniformly reliable. By taking on the responsibility for modelling of outcomes, central government would also reduce the time and cost burden for operators to comply with the regime, as operators would simply be required to submit the required information (relative to the level of gas capture they are claiming).*

- In summary the above three policy amendments work together as follows –

  - The tiered approach to claiming for LFG capture under the ETS enables operators to claim what the evidence supports, while allowing administrative requirements to be in proportion.

  - The use of a mass balance approach that takes account of lifetime gas capture aligns the rates able to be claimed under the NZETS with rates reported to UNFCCC, and ensures that actual landfill emissions are accounted for, and the costs internalised as closely as possible

  - Finally, the use of a standard first order decay model, seeks to ensure consistency in how capture rates are calculated across operators and reduce the direct costs and administrative burden for operators.

7.0 Method for Modelling Policy Options

This section presents the method that was applied to model the potential impact of the short listed policy options.

7.1 Summary of Modelled Policy Options

Table 7-1 summarises the policy options modelled in the analysis, together with key elements of the impact assessment approach model. Further details are provided in the following sub-sections.

Table 7-1: Summary of Modelled Policy Options

Option	Impact assessment approach	Option outcome
1 Increased landfill diversion: a combination of (a) levy / ETS increases and (b) organic disposal restrictions	Different impacts are considered in the modelling, depending on the degree of implementation[1]. Modelled indicatively through low, medium and high diversion rates, based on Eunomia's tipping points model.	Increased landfill diversion by increased dry recycling, anaerobic digestion and composting
2 Improvements to landfill gas capture infrastructure	Two landfill gas capture baselines are considered in the modelling[2]	Increased landfill gas capture
3 Improvements to landfill gas capture measurement	Qualitative assessment of impact only	ETS has more accurate data with which to drive performance of landfill gas capture

Notes

1. See Section **7.2** for more details
2. See Section **7.3.2** for more details
3. **See Section A.6.0 for more details**

Because there is some unpredictability in terms of how the landfill operators might choose to respond to changing ETS costs, option modelling considers separately – and jointly - both the impact of increasing landfill diversion and changes in landfill gas capture upon the overall emissions associated with waste management in New Zealand with regards to option 1.

7.2 Increased Landfill Diversion Modelling

Baseline modelling assesses the total amounts of waste generated, treated and disposed of in New Zealand from current levels into the future – to 2050 (i.e., business-as-usual scenario). The short-listed policy options are applied to modify that baseline to estimate the policy impact on waste flows, based on scale of intervention.

7.2.1 Current Situation of Waste Flows

Generation and destination tonnages for 2023 are derived from information held by Eunomia in relation to other work undertaken for the Ministry.[70] All generated waste is assumed to be collected and sent to a final destination. The sources of waste are: Residential (kerbside & drop-off); mixed industrial, commercial and institutional (ICI); and other streams (i.e., C&D and heavy industry wastes). The destinations collected waste can be sent to are Class 1 landfills, recycling plants, composting sites, and all 'other' disposal is grouped into one (i.e., class 2-5 landfills, monofills, farms, etc.)

These data were used to assess the current flow of materials through the nation in 2023. For example, the recycling rates were estimated at 24 percent for the residential stream, 20 percent for mixed ICI, and just over 2 percent for other streams (due to 94 percent of the stream comprising of inert materials, most of which was sent to 'other' disposal).

More information can be found in appendix A.4.1.

7.2.2 Growth Projections

Three scenarios were forecasted to assess the policy options and assessed against the business-as-usual (BAU) scenario.

For every projection, 2023 is the baseline year. Targets are applied to 2035, 2040 and 2050 to estimate growth, landfill diversion, and recycling and composting capture. Generation growth is assumed to be consistent across all scenarios. Growth assumptions are aligned with the GHG Inventory model assumptions on growth of tonnage sent to landfill, shown in Table 7-2

Table 7-2: Growth of Generation, from Baseline Year (2023)

	2023	2035	2040	2050
Growth from Baseline Year	0.00%	-0.29%	0.44%	4.66%

The BAU scenario assumes that there is no change in level of landfill diversion nor capture rates for **recycling and composting**. This, therefore, should result in the amount of waste being sent to Class 1 landfills being aligned with the other national (GHG Inventory) reporting.

7.2.3 Diversion Scenarios: High, Medium, Low Intervention

The assessed policies are assumed to divert waste from Class 1 landfills into other destinations. The BAU scenario is the starting point from which the level of policy intervention can be assessed. Each

[70] 70 Eunomia (2024) New Zealand National Recycling Rate Issues and Options. Report for Ministry for the Environment

intervention scenario is forecast using the same calculation methodology, with different input assumptions. The flow of material is as follows:

- **Waste generation** is forecast for 2035, 2040 and 2050 (per Table 7-2).
- Of that generated, the **proportion sent to Class 1 landfills** is known for 2023. For future years, the rates of diversion from the 2023 level are estimated. Three diversion rate scenarios are used to assess the level of potential effectiveness of policy intervention compared to the BAU scenario. The higher the level of intervention, the greater the diversion. The link between policy interventions and diversion rates is described in more detail below. Class 1 landfills' flow is handled first, as it is the primary focus of this study.
- Of the diverted material**, 95 percent** is assumed to be **sent to recycling, compositing** or anaerobic digestion (AD).
- The remaining 5 percent of material diverted from Class 1 is assumed to be destined for 'other' disposal (monofills, farms, Class 2-5 landfills etc.).

Landfill diversion is key to considering changes in New Zealand's waste management system occurring as a result of policy. The scenario modelling undertaken here describes a situation of increasing landfill diversion, linked to the progressively stronger implementation of policies. The impacts are indicatively modelled, with levels low, medium and high diversion being described, and a transition through the levels included within the modelling. Key things to note in this context are the following:

- The diversion scenarios are affected by increased landfill costs – mostly driven by increasing ETS costs, in combination with some background increases in the waste levy occurring in future decades. This, in turn, is assumed to occur to a certain extent through the improvements to the ETS measurement system occurring as part of Option 3. Under this option, it is assumed that disposal facilities obligations under the NZETS are calculated based on lifetime gas capture and that the methods of calculation are robust.
- **Low levels of landfill diversion** are assumed to occur in response to only slightly increases in landfill costs from the current situation. Although landfill bans have been put in place, these are not well implemented. There is a reliance on achieving regulatory compliance with the ban at the landfill sites (e.g. via site inspections), but no supporting policies - such as a requirement on waste generators to sort high- impacting waste streams (as far as landfill emissions are concerned) – have been put in place.
- **At high levels of landfill diversion**, the implementation of the ETS measurement changes has had a more significant effect on landfill operators' investment in capture infrastructure. To a certain extent the investment infrastructure drives some reductions in ETS costs, but landfill costs still remain high compared to current levels, so diversion from landfill also continues – and is further supported by additional policy activity such as a requirement to sort waste streams for recycling and composting / AD.
- The modelling assumes a relatively low level of leakage from Class 1 to Class 2 landfills. This is based on assuming a reasonably strong regulatory environment is achieved during implementation of the proposed policies. For example, as part of their enforcement, some current practices – such as where Class 1 sites open Class 2 areas on the same site – are no longer permitted to occur. Nevertheless, low levels of leakage of household waste from Class 1 sites is still anticipated. Similarly, there may be some shift of commercial waste into Class 2 landfills, and changes in how waste generated at farms is handled. Currently, the impact of future leakage levels has not been modelled, but potential impacts are discussed in the results section.

Since the above-described policies are anticipated to be mutually supportive, it is difficult to separate them out from one another in effect. A landfill ban implemented on its own is expected to only slightly improve landfill diversion but could achieve greater levels of waste system change if enacted in combination with supporting other policies, backed up with greater levels of regulatory support.

It is noted there is some flexibility to achieve diversion in respect of the precise policy mechanisms employed. It is understood there are no current plans to impose on waste generators a requirement to sort for recycling / biowaste treatment. Other policies may have a similar effect: for example, a requirement placed on landfill site operators to ensure that no high impacting waste streams are accepted for treatment at the site. If properly enforced, higher rates of diversion would occur – although this would increase the compliance burden on operators, along with placing additional administrative burdens on the regulator.

The sub-sections that follow detail the changes that are modelled for each of the key waste streams. . The diversion rate percentages per stream are derived from determining the financial 'tipping points' that drive diversion from Class 1 to alternative destinations (described more in appendix A.6.0; with the assumed diversion rates outlined in appendix A.4.2.1)

7.2.3.1 Sent to Class 1 Landfills

Figure 7-1 shows that about 3.5Mt was sent to Class 1 landfills in 2023. Projecting forward, without any intervention, this is set to rise to 3.7Mt by 2050. In the low intervention scenario, the orange-striped portion of waste would be diverted (a decrease of about 15 percent by 2050). In the medium intervention scenario, the yellow-striped portion of waste would additionally be diverted (a decrease of almost 30 percent by 2050. The high intervention scenario increases the scale of 2050 diversion by only a couple of percentage points compared to the medium intervention scenario, however, the high scenario does achieve more intervention earlier.

Figure 7-1: Cumulatively Increasing Levels of Intervention showing decreasing levels of Waste Sent to Class 1 (2023-2050,kt)

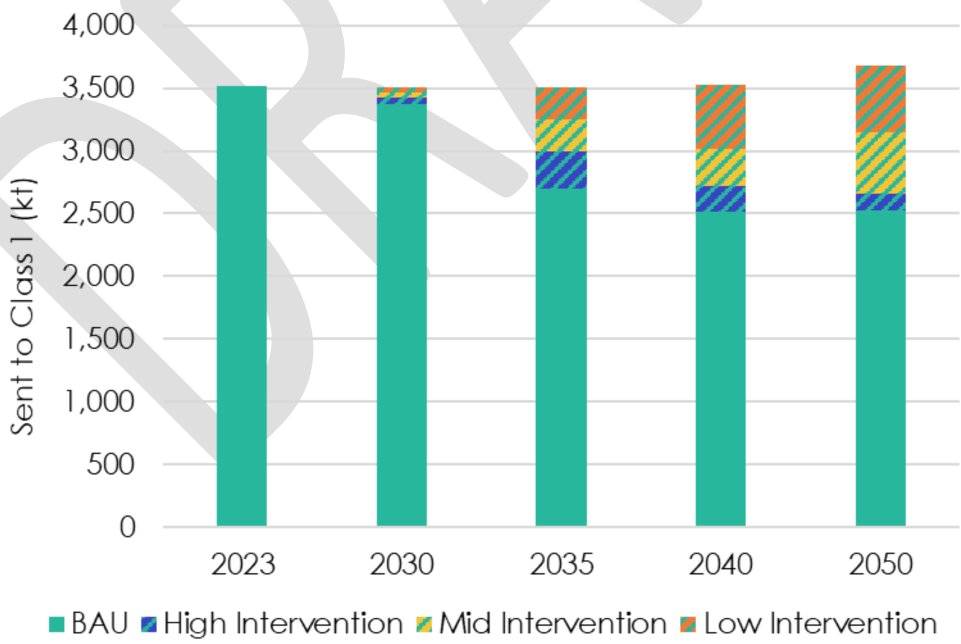
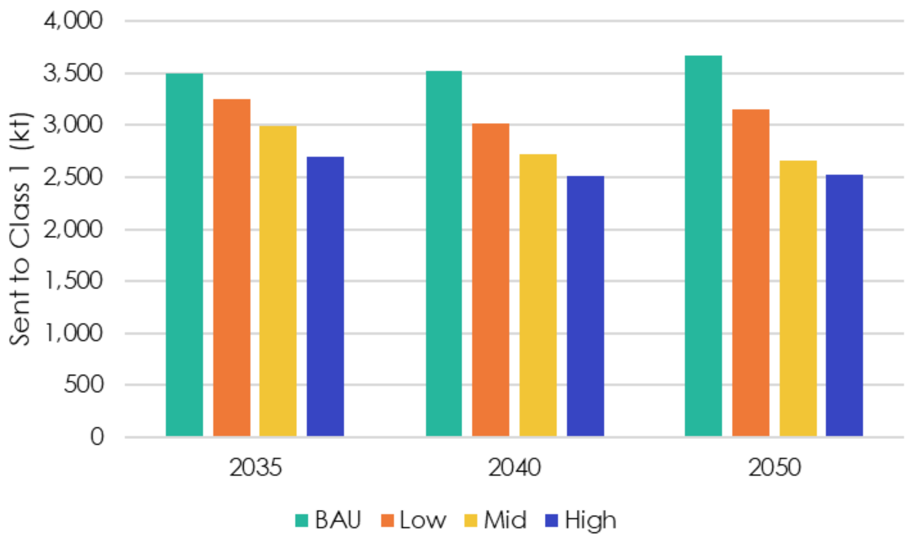


Figure 7-2 also shows the forecast amount sent to Class 1 landfills across the BAU and different diversion intervention scenarios. Under BAU waste tonnages gradually increase over the years, whereas diversion in the mid and high intervention scenarios results in progressively less being sent to Class 1 landfills. By

2050, the high scenario is forecast to have almost a third less waste being sent to Class 1 landfills compared to the BAU scenario. The low intervention scenario does not assume an increase in diversion from Class 1 landfills between 2040 and 2050. Therefore, there is a decrease in the total amounts diverted from 2035 to 2040, but an increase from 2040 to 2050 (as total generated increased and the diversion rates remain unchanged). Overall, the low scenario is forecast to have almost 15 percent less waste sent to Class 1 landfills in 2050, compared to BAU.

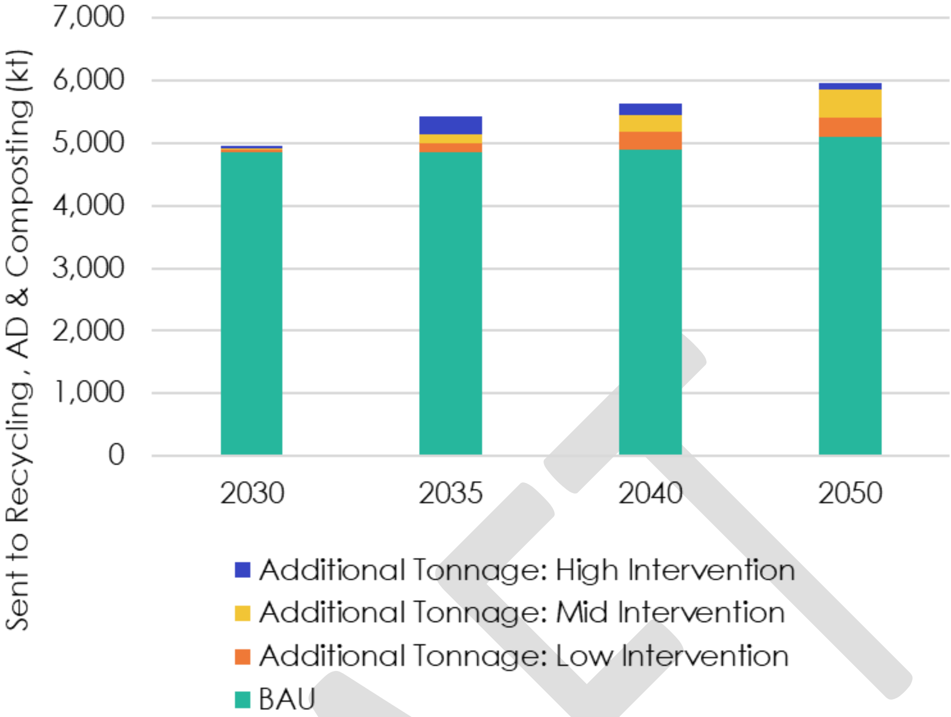
Figure 7-2: Total Forecast Amounts sent to Class 1 across scenarios



7.2.3.2 Sent to Recycling, Composting & Other Destinations

In 2023, 4.9Mt is reportedly sent to recycling, AD or composting. Within the BAU tonnage scenario, as a result of the growth of total waste generation, this amount increases to 5.1Mt by 2050. Within the low scenario, in 2050 there is projected to be an additional 306kt sent to recycling, composting or AD, as shown in Figure 7-3. The additionally treated tonnage is 752kt for the medium intervention scenario (orange and yellow bars) and 854kt for the high intervention scenario (orange, yellow and navy bars combined). A key difference of the high intervention scenario, as previously noted, is that more intervention is realised earlier. By 2035, it is estimated that the high scenario results in an additional 560kt of treated material, whereas medium scenario results in just less than 300kt and low in about 150kt. (Hence why the navy bar is comparatively thicker in 2035 compared to the increase realised within the other scenarios.)

Figure 7-3: Amount of Waste Sent to Recycling and Composting/AD (kt)



Any waste generated that is not sent to Class 1 landfills, recycling or composting/AD, is assumed to be sent to an 'other' destination (i.e., Class 2-5 landfills, monofills etc.). Within the analysis, of the waste diverted from Class 1, only 5 percent is assumed leaked into these other destinations.

However, when assessing the waste market in New Zealand, these destinations are important to consider. Most waste generated in New Zealand is sent to one of these destinations, as over half of all waste generated was from the construction and demolition (C&D) stream: 23.5Mt is C&D, out of a total of 40.4Mt generated (58 percent). Within the C&D stream, 95 percent (22.3Mt) is inert. As such, almost all of C&D waste (78 percent) is sent to Class 5 landfills. For this study, the destination of inert waste is not a focus. Nevertheless, 'other' destinations should not be completely ignored, as there are still low levels of degradable streams arriving to these destinations alongside the inert wastes – and the biodegradable wastes in those streams would contribute to GHG emissions. The contribution of the non-inert streams within 'other' destinations is shown in Section 8.1.1.

7.3 Environmental Modelling

7.3.1 Overall Approach to Impact Modelling

Environmental impact modelling considers both the changes in GHG emissions due to policy options as well as the impact on air quality from emissions such as NOx arising from the combustion of landfill gas combusted via a gas engine – and changes in these impacts as a result of changing landfill practices.

Environmental modelling was carried out, taking into account GHG emissions from all aspects of waste management in the country. GHG emissions factors were developed for each type of waste sent to landfill, for key dry recycling streams, and for source segregated organic waste treatment. These emissions factors were largely developed from existing methodologies, with amendments being made as discussed elsewhere in this report. Outputs from the modelling are expressed in tonnes CO_2e (with methane emissions being multiplied by the Global Warming Potential for methane). Alongside this, the models also estimate tonnes of other air quality pollutants such as NOx, using data from European facilities and life-cycle assessment databases.

Damage cost assumptions (in terms of $ per tonne of pollutant) can then be applied to the tonnage flows of pollutant.[71] For climate change impacts, the damage costs consider the likely future abatement costs of mitigating carbon emissions, in alignment with NZ Treasury advice – this uses a graduated carbon cost, starting at $256 between 2030-2050 and increasing to $463 beyond 2050.[72] It is noted that the cost of carbon abatement in the earlier years is relatively low compared to the comparable costs used in appraisals in other countries, such as the UK and Germany. The equivalent cost for abating GHGs in the UK currently is already $574, with costs similarly escalating over time.

For air quality impacts, the damage costs consider the impact on human health and the financial costs of those impacts. The cost assumptions advised by the NZ Treasury to be used for these impacts are higher than those in use in other countries, particularly for NOx pollution. For air pollution, the damage costs are applied to end of life impacts occurring within New Zealand's geographical boundaries. This method is of relevance when considering the recycling of materials – for which primary production and secondary production may take place outside New Zealand. Air pollution impacts for recycling are excluded for materials that are largely manufactured outside its boundaries and / or typically reprocessed for recycling overseas (e.g. plastics and metals). This issue is not relevant for disposal impacts which do take place within New Zealand's geographical boundaries and which are therefore included within the impact assessment.

Environmental impacts within the scope of the analysis – other than landfill – are recycling and biowaste treatment. More detail on the approach taken to model the emissions and environmental impacts from these waste management activities is provided in Appendix 0.

7.3.2 Modelling Landfill Methane Emissions

7.3.2.1 Updating the GHG Inventory Model

New Zealand's methane generation model for landfills - used as part of its GHG inventory reporting to the UNFCCC - contains data on waste tonnage, waste composition and decay characteristics for every Class 1 landfill in the country. It reports annual methane emissions for each of those sites, taking into account historic waste acceptance practices. The model also provides projections for future landfill impacts, taking into account site closures and changes in overall waste generation.

The potential impact on methane emissions of the short-listed policies was modelled by modifying this model. Updates to the GHG Inventory model were made in alignment with international best practices, notably:

- the amendment of the material-specific decay rates;[73]
- the inclusion of site-specific waste composition data obtained via an operator survey carried out as part of this project (Appendix A.3.0) and SWAP audits;
- the inclusion of site-specific characteristics, notably:

[71] The use of damage cost data is an alternative to the use of lifecycle assessment impact factors which are typically used to compare one type of environmental impact to another. The damage cost approach seen here combines lifecycle GHG impacts with emissions of air pollutants that have an impact on human health, such as NOx and PM

[72] Emission Impossible (2022) Health and Air Pollution in New Zealand 2016 (HAPINZ 3.0): He rangi hauroa he iwi ora – Volume 2 Detailed Methodology, report for Ministry for the Environment, Ministry of Heath, Te Manatu Waka Ministry of Transport andWaka Kotahi NZ Transport Agency

[73] These are now aligned with IPCC assumptions following peer review feedback received during the IPCC submission process

- the proportion of each site cover type: operational, temporarily capped, and permanently capped obtained via the same operator survey;
- how these vary over a site's predicted life cycle;
- the gas capture rates associated with each site cover type.

A key aspect of the modelling was the development of a revised estimate for landfill gas capture for New Zealand landfill sites, taking into account the updates of data in the GHG Inventory model set out above. The amendments to the GHG Inventory model produced updated instantaneous gas capture rates for each site, which were then fed into the GHG inventory's existing calculations to provide year-on-year methane generation and methane captured masses. These year-on-year results were used to calculate each site's predicted lifetime capture rates.

Where site-specific data was not available for the instantaneous rates, default values were applied. Two baselines were developed for Class 1 landfills, with the overall approach being as follows:

- **Low baseline for instantaneous capture rate**: As was discussed in Section 4.3, following engagement with peer reviewers during the GHG inventory process, sites that did not provide survey data were given the IPCC default landfill gas capture assumption of 20 percent as part of the lower baseline. This is expected to be an underestimate of actual performance of many Class 1 New Zealand sites. For sites where data was provided (which includes the larger sites), assumptions are derived from survey information and other default assumptions on capture (the latter being described in Appendix A.5.2).

- **Higher baseline for instantaneous capture**: Default level assumptions for sites that did not provide survey data were developed with these being derived from the survey returns, with the default approximating the median capture of those sites that provided data. This is aimed at setting the upper bound of current practices.

Given that increases in the levy and ETS could result in some diversion of waste from Class 1 landfills to the other classes, impact modelling for landfills in Classes 2-4 has also been undertaken. These sites do not have any gas capture equipment installed, and so emissions are higher than is the case for the majority of Class 1 sites, since the modelling assumes zero gas is captured.

7.3.2.2 Developing Landfill Emissions Factors

The GHG Inventory model described in Section 7.3.2.1 was used to develop an overall estimate of the lifetime gas capture rate aggregated across all of New Zealand's landfills. This – along with the key assumptions from the GHG Inventory model on decay rate characteristics – was fed into Eunomia's policy-oriented landfill model. This is used to develop GHG emissions factors for the different types of waste (food, paper, etc) sent to landfill, such that these could then be directly incorporated into the Cost Benefit Analysis (CBA) model for this project. The emissions factors are directly applied to the waste flows described in Section 7.2.1. In this way, impacts to landfilled waste arising from policy options such as changes in recycling can be calculated in alignment with the GHG Inventory model assumptions.

This step is important for the project analysis to be able to model future changes to landfilled waste in an explorative and systematic way, alongside analysis of financial impacts necessary for a cost benefit analysis to be undertaken.

7.4 Forecasting Current State of Environmental Impacts

This section considers the emissions associated with the BAU tonnage scenario, assuming that there are also no major changes in the landfill gas capture occurring at the country's sites. Table 7-3 shows BAU scenario (i.e., no diversion intervention) modelled with a 20 percent capture rate for all landfill sites that did not provide survey data, from the present day up to 2050 (i.e., the current (lower) gas capture level). Impacts associated with recycling make a significant contribution to the overall impacts associated with the end of life stage. These impacts show as net-negative, since there are significant avoided emissions associated with there no longer being a need to produce materials from primary raw materials where materials are produced using a recycling process. The material and resources sector operates in international commodity trading markets with impacts taking place in various countries to produce the materials, and to recycle them. The net-negative figure is a feature, in part, of the focus in this project on the end-of-life stage only. If the system boundary were to be extended to include the impacts associated with producing the original materials that have become waste, the overall system would show a net contribution to climate change associated with each scenario (i.e., all values would be positive for the scenarios). Those impacts would, however, be the same for each scenario, so it is appropriate to ignore such values in the overall assessment.

It is also important to note that much of the recycling GHG benefit shown in this table, will not directly impact on New Zealand's territorial emissions inventory, since a lot of this benefit occurs outside of the country's borders. Furthermore, recycling impacts are not included with the "waste" sector of the GHG territorial inventory which only considers disposal emissions and emissions from composting and AD facilities (the latter excluding any GHG benefits from energy generation and digestate use).

Table 7-3: GHG Emissions, kt CO_2e per year – Current (lower) gas capture with BAU scenario

Year	Net GWP100 impact	Class 1 landfills	Other land disposal	Recycling	Composting	AD
Current	**154**	732	1,516	-2,164	76	-5
2035	**144**	730	1,512	- 2,158	72	-11
2040	**145**	735	1,523	-2,417	73	-12
2050	**151**	766	1,587	-2,265	76	-12

Table 7-4 shows the current (higher) emissions by assuming the capture situation in the current day is somewhat better for sites that did not provide survey data. This results in a relatively significant decrease in the impacts for Class 1 landfills. Similarly to the previous table, the BAU scenario (that assumes no policy intervention) is used as to forecast the tonnage being sent to each destination. These outcomes therefore indicate the forecast environmental impacts if there is no additional policy intervention. Total waste system impacts are shown as net negative GHG emissions, since the recycling and AD impacts have net negative emissions associated with avoided emissions.[74]

Table 7-4: GHG Emissions, kt CO_2e per year – Current (higher) gas capture with BAU scenario

Year	Net GWP100 impact	Class 1 landfills	Other land disposal	Recycling	Composting	AD
Current	**-105**	473	1,516	-2,164	76	-5
2035	**-114**	472	1,512	- 2,158	72	-11
2040	**-115**	475	1,523	-2,417	73	-12
2050	**-120**	495	1,587	-2,265	76	-12

The BAU results also confirm the significant contribution made to waste management's GHG impacts from other land disposal – i.e., the landfill sites which do not have gas capture installed. Current impacts look to be around three times the impact associated with the Class 1 sites in the current (higher) gas capture. This suggests that government should also consider the installation of such infrastructure on other sites to mitigate waste sector emissions.

7.5 Cost Modelling

7.5.1 Overall approach to cost modelling

The overall approach for costs was to determine costs per tonne for each stage and destination of handled waste, as much as possible. This includes:

- **Collection costs**, including residual residential, kerbside recycling, mixed ICI collections, and an average collection cost for 'other' waste (derived from costs from C&D and landscaping collections).
- **Treatment costs**, including recycling (sorting, shipping, revenues) and organics (containers, liners, processing, communications, composting gate fees and AD gate fees).
- **Disposal costs**, including the Class 1 gate fees, and the combination of additional costs from increasing levy and ETS rates.

[74] For recycling, avoided emissions are related to a reduced requirement to manufacture materials from primary feedstocks, e.g. plastic polymer, since materials can instead be produced from re-processed materials. For AD, this relates to benefits associated with avoided fertiliser manufacture and a reduction for energy generation from other sources.

- The **cost of other disposal** (class 2-5, monofils, farms, etc.) is **not** included in this study. The exact split of tonnage between each destination and the average costs of each is not well reported. It is also unknown how these splits and costs would change into the future. The lack of this disposal cost will result in each scenario showing a greater benefit than the potential true total cost.

- The **cost of an organics ban** is also **not** included. A ban in practical terms would be done by restricting landfill acceptance criteria. This would involve exceptions and defining percentage levels of organics in the landfill and/or in loads. It is not possible to apply a cost to this policy until it is more defined, including any complementary tools (e.g., requirement to sort). The cost could greatly vary depending on the approach, so it cannot be estimated at this stage. The lack of this policy cost will result in each scenario showing a greater benefit than the potential true total cost.

- **Additional landfill gas capture infrastructure**, as it relates to increasing Class 1 gas capture.

All costs are baselined to 2023 and presented in NZ$ millions.

For further information refer to Appendix A.6.0.

7.5.2 Cost Assumptions

To determine the potential impacts of changes with the different scenarios, we utilised a 'tipping point' modelling approach. Our methodology aimed to develop an enhanced understanding of the relative costs of disposal and diversion of waste materials faced by operators. Costs were taken from a wide range of sources, including previous reports, information held by Eunomia from a range of sources including waste contract procurement, and undertaking cost modelling of collections.

This involved developing costs faced by operators for different management options and then, based on the quantities of each type of material being disposed of to landfill, calculating the impacts that different rates of the levy would have on the economics of recovery versus disposal. The result is a situation where different materials from different activity sources, have different costs associated with their recovery. This means that each material/source combination has a different point at which the costs 'tip' from favouring disposal to favouring recovery. At a given price point the model therefore identifies which materials are cheaper to recover than dispose of, and these are labelled as 'recoverable'

The outputs of the modelling were then adjusted down by a factor ranging from 0.7 to 0.85 from the low to high performance scenarios to account for the likelihood that not all material that can technically be recovered will be recovered in practice and arrive at a set of 'recycling rates'. These outputs were then stress-tested and challenged within the team and compared to observed levels of recovery in high performing nations and a number or minor adjustments made to the recycling rates before use in the mass flow model.

It was also taken into account that some materials are more likely to 'leak' into other classes of disposal facility than others. For example, timber & rubble may move to Class 2-4 disposal rather than recovery, while kerbside food waste is unlikely to go to other than Class 1 when collected as part of kerbside rubbish.

For further detail on costs and diversion rates please refer to Appendix A.6.0.

8.0 Impact of Recommendations

The impacts of policy recommendations are split into three:

1. Impact on amount sent to the different destinations – i.e., policy impacting the BAU scenario and increasing landfill diversion for a low, medium or high intervention. The mass flow, environmental and financial impacts are described.

2. Impact on the gas capture happening at Class 1 landfills – i.e., policy impacting the current (lower and higher) gas captures to create a future high gas capture level. The mass flow is unaffected, though the environmental and financial impacts are described.

3. Impact on measurement of landfill gas capture and its reporting (qualitative analysis).

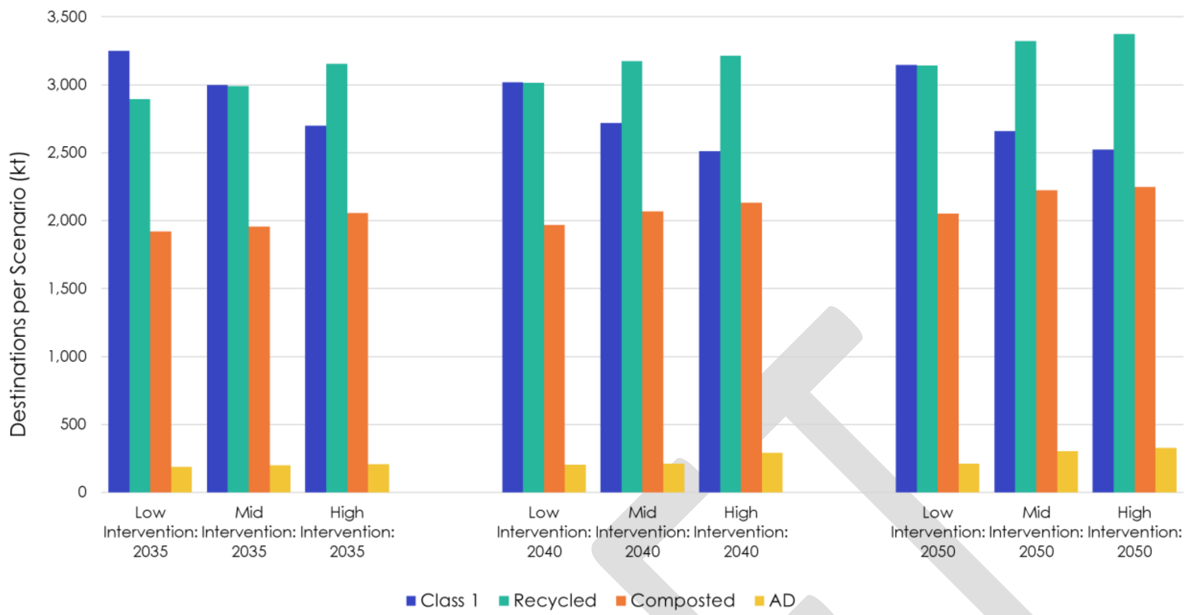
8.1 Option 1: Increased Diversion from Landfill

This option describes the combined effect of the increasing landfill costs (strongly influenced by rising ETS costs, alongside some levy cost increase), supported by organic waste disposal bans. The results describe increasing levels of government intervention and policy support, as described in Section 7.1.

8.1.1 Quantities of Waste Diverted

A key element driving the performance of the scenarios under Option 1 is the quantity and type of waste diverted. Totals of waste sent to each destination under each of the Option 1 diversion scenarios are shown graphically in Figure 8-1. The total waste generated in each year is constant across all scenarios. The graph shows that greater quantities of waste are sent to Class 1 facilities under the low intervention scenarios than under high intervention scenarios. Quantities of recycling increase over time, as does the amount of waste sent to AD. In later years, there is an increase in the total quantity of waste generated, and this leads to an increase in total waste being sent to Class 1 facilities under the low intervention in 2050 compared to the situation in 2040.

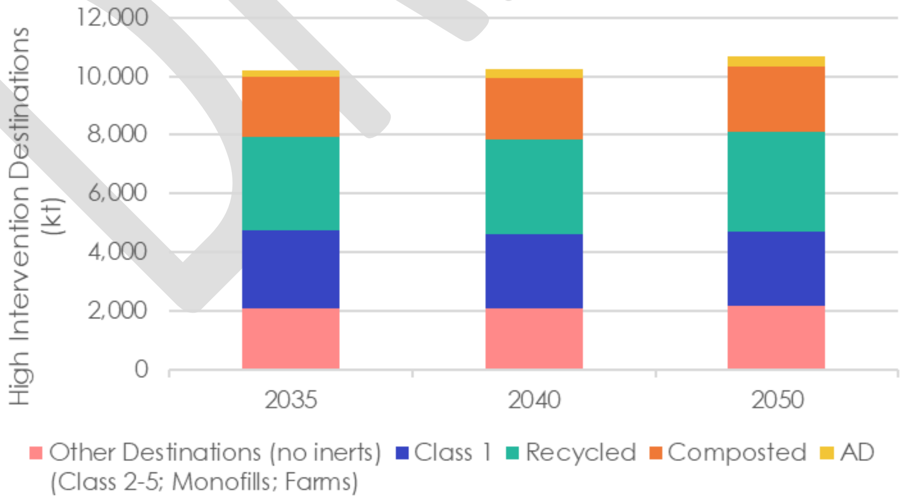
Figure 8-1: Sent to Class 1 Landfills, Recycling, Composting and AD (all diversion scenarios; all wastes; 2035/2040/2050; kt)



Sub-sections that follow discuss the situation in more detail for each of the levels of intervention under Option 1.

In the high intervention scenario, as is the case with all scenarios when assessing total tonnages handled in New Zealand, the amount sent to other land destinations represents the majority of waste (due to the scale of C&D wastes), shown in Figure 8-2.

Figure 8-2: Forecast Waste Destinations: High Intervention (kt)



Note: The tonnage of wastes classed as inert within 'other destinations' has been removed from the figure (representing around 30Mt in any given year).

Figure 8-3 focuses on changes to Class 1 landfills, recycling, composting and AD in the high intervention scenario. Levels of landfill diversion are high in this scenario, within increasing levels of diversion occurring over the years. The overall amount of waste generated also grows over time.

Although the change in forecast amount sent to each destination over time may not significant, the high intervention scenario projects over 1Mt less waste being sent to Class 1 compared to no intervention scenario (i.e., BAU) in 2050. The dynamic between the amounts sent to each destination informs the results of the environmental analysis.

Figure 8-3: Forecast Waste Destinations (focused): High Intervention (kt)

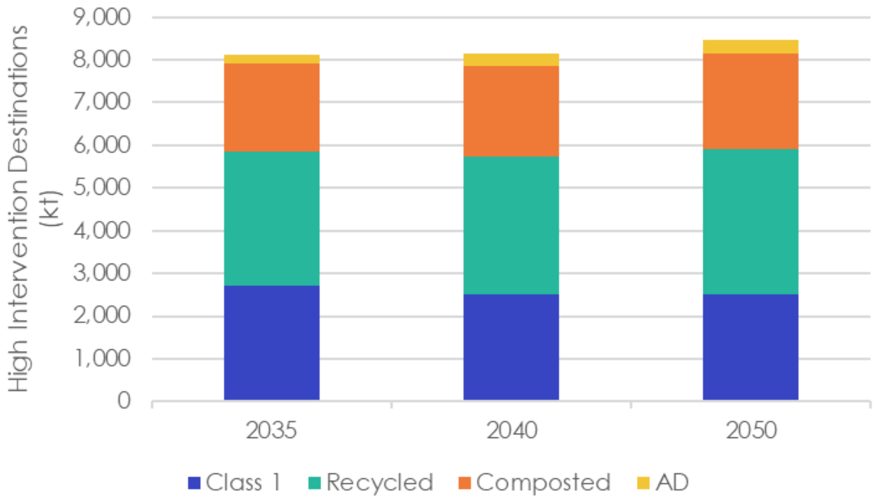
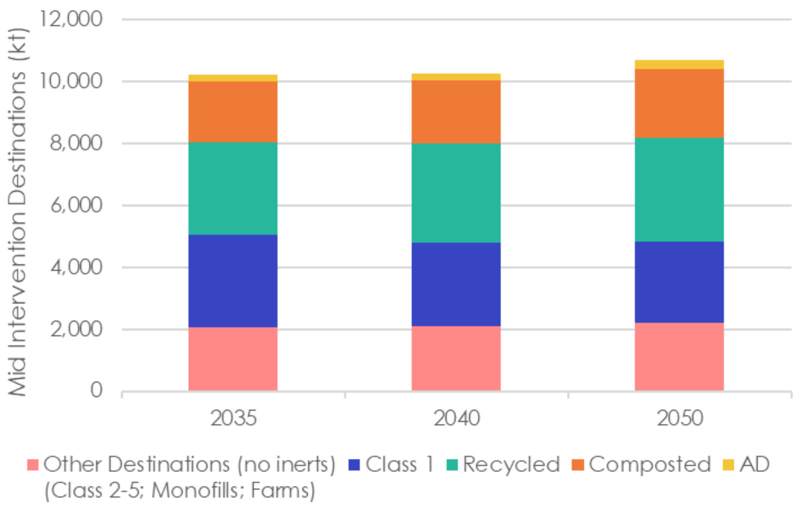


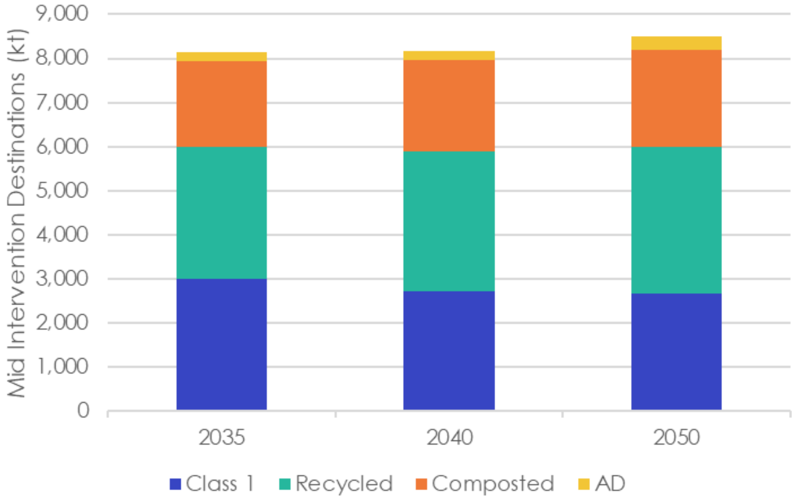
Figure 8-4 and Figure 8-5 show the medium intervention scenario – firstly showing the situation for all waste streams, followed by the situation with the dominant class 2-5 landfills removed.

Figure 8-4: Forecast Waste Destinations: Mid Intervention (kt)



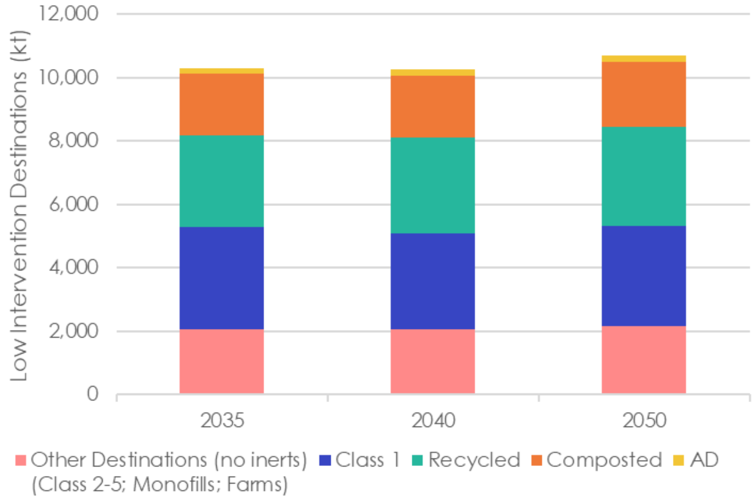
Note: The tonnage of wastes classed as inert within 'other destinations' has been removed from the figure (representing around 30Mt in any given year).

Figure 8-5: Forecast Waste Destinations (focused): Mid Intervention (kt)



In the low intervention scenario, the amount sent to other land destinations represents most waste (due to the scale of C&D wastes), as shown in Figure 8-6.

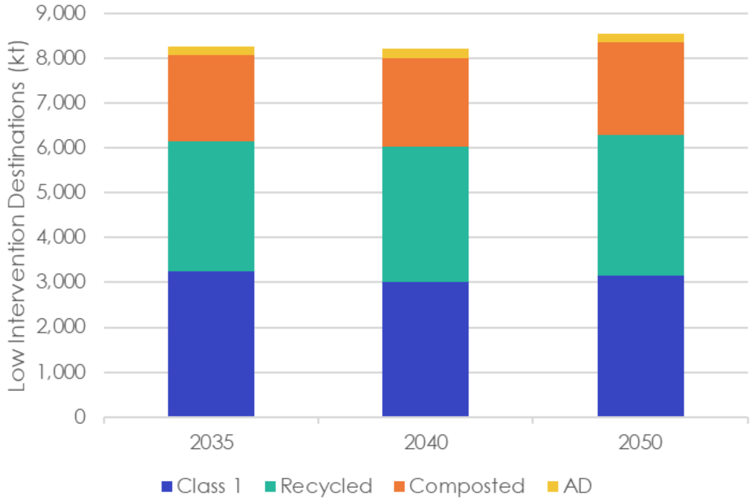
Figure 8-6: Forecast Waste Destinations: Low Intervention (kt)



Note: The tonnage of wastes classed as inert within 'other destinations' has been removed from the figure (representing around 30Mt in any given year).

Figure 8-7 focuses on changes to Class 1 landfills, recycling, composting and AD as destinations for the low intervention variant – removing the substantial influence of the other landfill classes and making it easier to see the changes in other waste management activities. Levels of landfill diversion are relatively low in this scenario, making the slight reduction in amount landfilled from 2035 to 2040 difficult to see. From 2040 to 2050, the absolute amount sent to Class 1 landfills increase, due to no change in the percentage diversion rates occurring whilst the overall amount of waste generated grows over time. In 2050, the low intervention scenario projects about 0.5Mt less waste being sent to Class 1 compared to no intervention (i.e., BAU) – so about half the level of diversion of the high intervention scenario. The dynamic between the amounts sent to each destination informs the results of the environmental analysis.

Figure 8-7: Forecast Waste Destinations (focused): Low Intervention (kt)



8.1.2 Environmental impacts

This study has focussed on two key environmental metrics: GWP100 and damage costs (i.e., the combination of air quality impact and GHG bio credits). These show the potential lifetime decrease in GHG emissions (kt CO_2e) and an assessment combining the GHG impacts with impacts on health relating to air pollution. Other environmental metrics associated with waste have not been assessed here. It is acknowledged there are other environmental impacts associated with waste management but there is relatively little robust data associated with quantifying these other impacts; as such, it is felt appropriate just to focus on these two elements which also correspond to areas of concern for stakeholders.

There are two variables impacting the assessed environmental outcomes:

1. Amounts of waste being sent to each destination:
   - The BAU tonnage scenario assumes that there is no additional policy intervention on tonnage and thus no additional diversion from Class 1 landfills to other destinations.
   - The low, medium, and high intervention scenarios show the level of policy intervention achieved in diverting tonnages of waste, compared to the BAU scenario.
2. The level of landfill gas capture occurring at Class 1 landfills:
   - Two estimates are given for current landfill gas captures (lower or higher); depending on the modelled outcome, these may continue into the future.
   - The future high gas capture scenario considers improved gas capture due to policy intervention.

These two variables, and the scenarios that sit under them, are independent of one another. In other words, diversion of waste can occur without gas capture improvement; gas capture improvements can occur without achieving any additional landfill diversion. The combination of these variables and their environmental impacts are assessed below.

8.1.2.1 Landfill diversion with no gas capture improvements

When considering the implementation of policies to increase diversion of waste from landfill, we present a series of low, medium (mid) and high diversion scenarios of option 1 – with the different levels being representative of a more substantial policy intervention, as described in Section 7.1. These, in turn, present a general pattern of increasing overall environmental performance across all the scenarios as the diversion from landfill progressively increases, with respect to carbon emissions savings and environmental damage cost impacts.

GWP100: No gas capture improvements

The impact of landfill diversion in terms of GWP100 are shown in Figure 8-8 and Figure 8-9. Impacts show the net impact associated with changes in the end-of-life scenarios modelled here. We first consider the impact where the level of gas capture at Class 1 landfills remains at current levels until 2050, whilst diversion from landfill changes. Figure 8-8 shows the impact with the lower level of assumed current landfill gas capture and Figure 8-9 shows the impact with the higher current capture.

Figure 8-8 and Figure 8-9 show the absolute emissions of the diversion scenarios alongside the BAU scenario. This means the BAU, low, mid, and high scenarios' GWP100 figures can be directly compared to one another. To re-iterate, BAU assumes no intervention and thus no additional diversion into recycling / composting / AD from Class 1 landfills. In the low, medium, and high scenarios, more diversion occurs over the years – without any change from the current (lower or higher) levels of landfill gas capture.

Figure 8-8 and Figure 8-9 show progressively more significant net negative GWP100 impacts for waste management activities. As was explained in Section 7.4, the net negative values arise as a result of the focus on the end-of-life impacts in the modelling; when such an approach is taken, overall impacts are dominated by benefits arising from recycling (which are net negative due to the impact of avoided emissions from reducing materials production from primary raw materials). Waste sector impacts in the national GHG inventory do not include recycling benefits and much of this impact will actually occur outside of New Zealand's geographical boundaries. As such, the benefits seen here include impacts occurring outside the country's territorial emissions inventory. The approach taken here, however, properly accounts for the end-of-life GHG benefits associated with the waste sector as it actually operates in New Zealand – showing clearly the end of life benefits associated with these activities.

The higher diversion scenarios aim to show indicative results obtained with stronger policy support: ETS costs increase, and this is further supported by other policies such as a requirement that producers sort waste. By contrast, where policy support for landfill diversion is relatively poor, as in the low intervention scenario, by 2050 net GHG benefits are less than half that seen in the high intervention scenario. Total benefits under high intervention for 2050 range between just over 800 to just under 1,000 kt CO_2e, depending on the level of capture infrastructure in place. Overall results are shown as more substantial net negative emissions on the graph as the increased benefits from recycling and composting/AD are sufficient to outweigh the combined impacts associated with landfill emissions. It is noted that in 2020, waste sector emissions in total were circa 3,500 kt CO_2e.[75] (Figures presented here include impacts that would be outside of New Zealand's territorial inventory.)

[75] See https://environment.govt.nz/facts-and-science/waste/waste-sector-emissions/

Figure 8-8: GWP100: Current (Lower) Landfill Gas Capture; All Diversion Scenarios

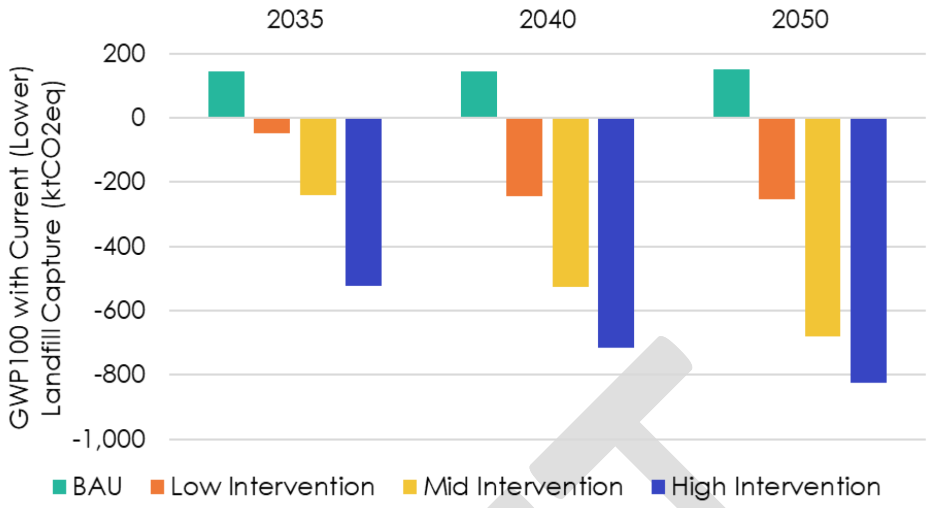
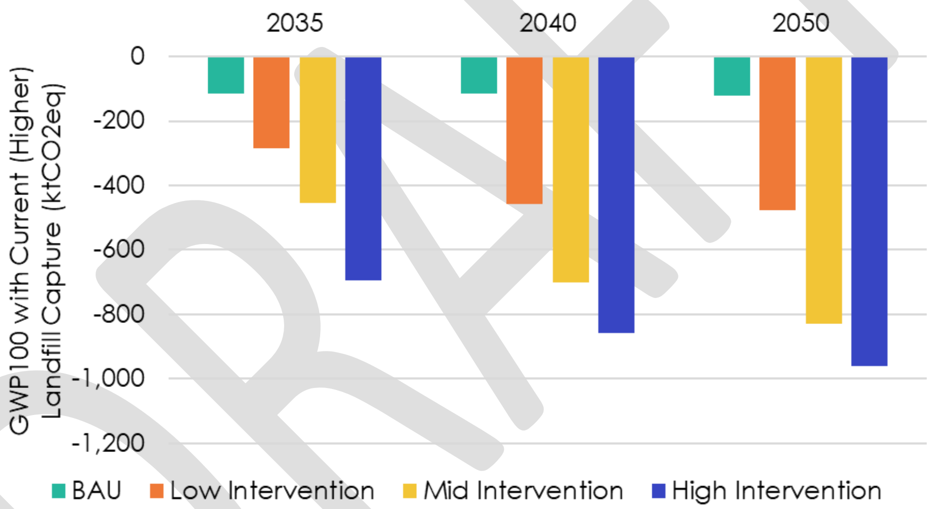


Figure 8-9: GWP100: Current (Higher) Landfill Gas Capture; All Diversion Scenarios



Damage Costs: No gas capture improvements

Figure 8-10 and Figure 8-11 show the absolute change in damage costs due to increasing diversion across the mass flow scenarios, whilst maintaining the current (lower) and current (higher) landfill gas capture levels, respectively. The two figures show a similar pattern to that of the total GWP100 results. In this case, there are slightly more substantial differences in variation between the damage costs at the different levels of intervention, since recycling also brings about significant environmental benefits in air pollution alongside the climate change impacts. By 2050 and under the high intervention scenario, results show a significant amount of environmental benefit. This is heavily influenced by the substantial benefits assumed to occur from avoided NOx emissions as a result of increased levels of recycling compared to the BAU tonnage scenario.

Results imply that the waste sector provides a net benefit to the country under the conditions modelled here. However, this is related to the system boundaries used in the assessment, which are focussing solely on the end-of-life stage, rather than the full lifecycle of materials which then become waste.

Figure 8-10: Damage Cost: Current (Lower) Landfill Gas Capture; BAU & Diversion Scenarios

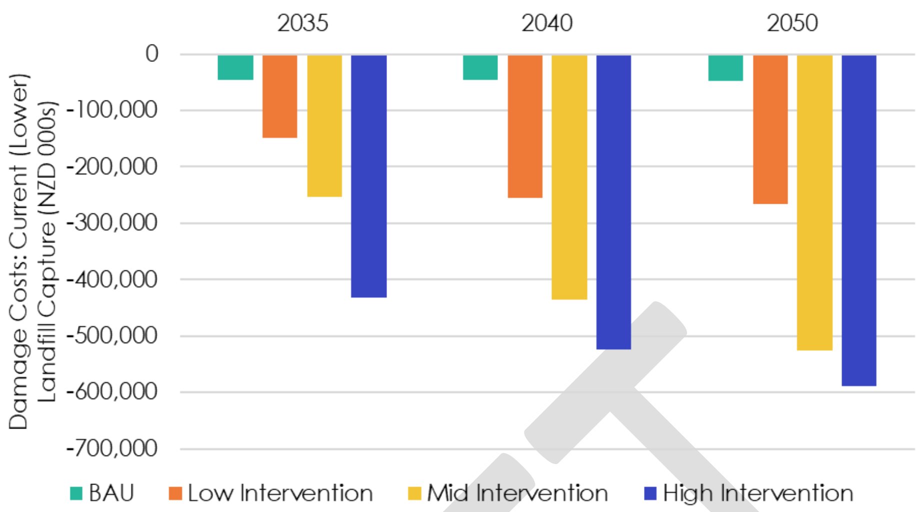
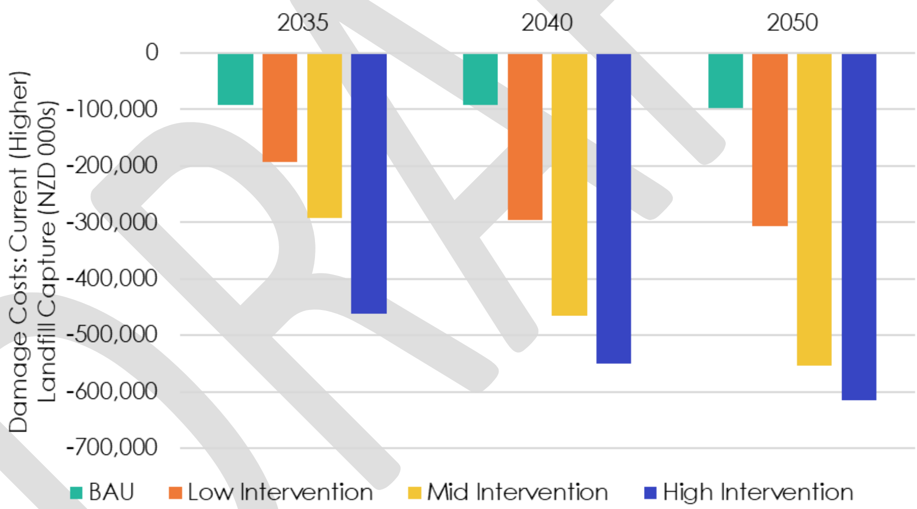


Figure 8-11: Damage Cost: Current (Higher) Landfill Gas Capture; BAU & Diversion Scenarios



8.1.2.2 Environmental Impacts of Increased Gas Capture alongside Class 1 Diversion

Alongside the low, medium, and high diversion scenarios, policy can be implemented to improve the gas capture occurring at Class 1 landfills. The previous sub-section assumed no improvement from current levels of capture. The following results are based on the future high gas capture scenario considers improved gas capture due to policy intervention.

GWP100: Increased Gas Capture

One mechanism to encourage diversion is the impact of an increasing ETS cost to landfill operators. This impact may also trigger an improvement of landfill gas capture at Class 1 landfills. Additionally, other policy mechanisms may be realised to promote measurement and reporting that result in a future higher level of capture being reported by Class 1 landfills, compared to current levels. In this situation, the New Zealand waste market may simultaneously see an increase in gas capture happening at Class 1 landfills alongside the landfill diversion into recycling/composting/AD – and the environmental benefit from such an impact is shown in this section.

Figure 8-12 shows the total impact in terms of the 100-year GWP metric - in kt GHG emissions - of option 1 diversion and the increase in capture at Class 1 landfills. Similar to Figure 8-8 and Figure 8-9, as landfill diversion increases through the low, medium, and high levels of policy implementation, there are greater benefits from progressively more recycling / biowaste treatment, and a progressively reduced tonnage going to Class 1 landfills. Alongside this, the additional cost of ETS is assumed to act as a spur to improve investment in capture infrastructure at the poorer performing sites, further decreasing environmental burdens associated with tonnage sent to landfill. The situation here is both improved waste diversion from landfill combined with good infrastructure for capturing landfill gas, and benefits thus come from both an increase in avoided landfill emissions as well as recycling/composting/AD benefits. These effects combine to result in a maximum impact of -1,095 kt CO_2e by 2050, under the high diversion scenario of this option. The impact of increasing gas capture at landfills is relatively modest compared to the impact of increased diversion:

- When compared to the BAU at high future gas capture in 2050 (almost -400 kt CO_2e shown in Figure 8-12), the impact of increased diversion is significant (representing a 180% decrease in GWP100 compared to the baseline).
- When compared to the same high diversion scenario under the (higher) baseline of landfill gas capture, the equivalent figure is -960 kt CO_2e (shown in Figure 8-9). This is a relatively modest improvement (14%) from increasing gas capture at landfills.

This shows that policies targeting both diversion of waste and targeting improving landfill gas capture can work in tandem to improve GWP100 results into the future. The effectiveness of implementation, monitoring and reporting on both fronts will determine whether high levels of impact can be achieved.

These figures can also be viewed in the context of total current waste sector emissions in 2020 of around 3,500 kt CO_2e (calculated by including both managed and unmanaged sites and wastewater). It should be noted that the figures are not directly comparable here, since the data presented here includes some emissions that would no longer form part of New Zealand's territorial inventory. Nevertheless, a maximum impact of -1,095 kt CO_2e in 2050 – although not directly comparable – is equivalent to almost a third (31%) of this sector total in 2020.

Figure 8-12: Total GWP100: High Future Gas Capture across Diversion Scenarios

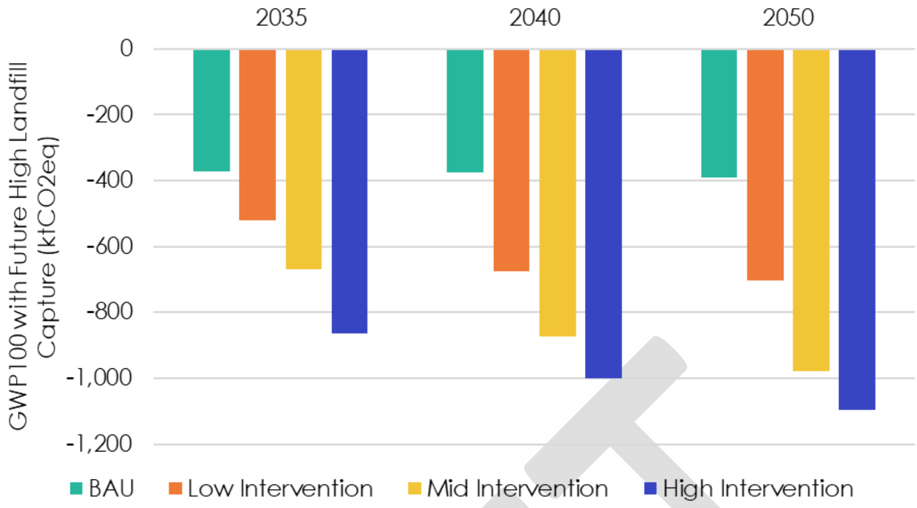


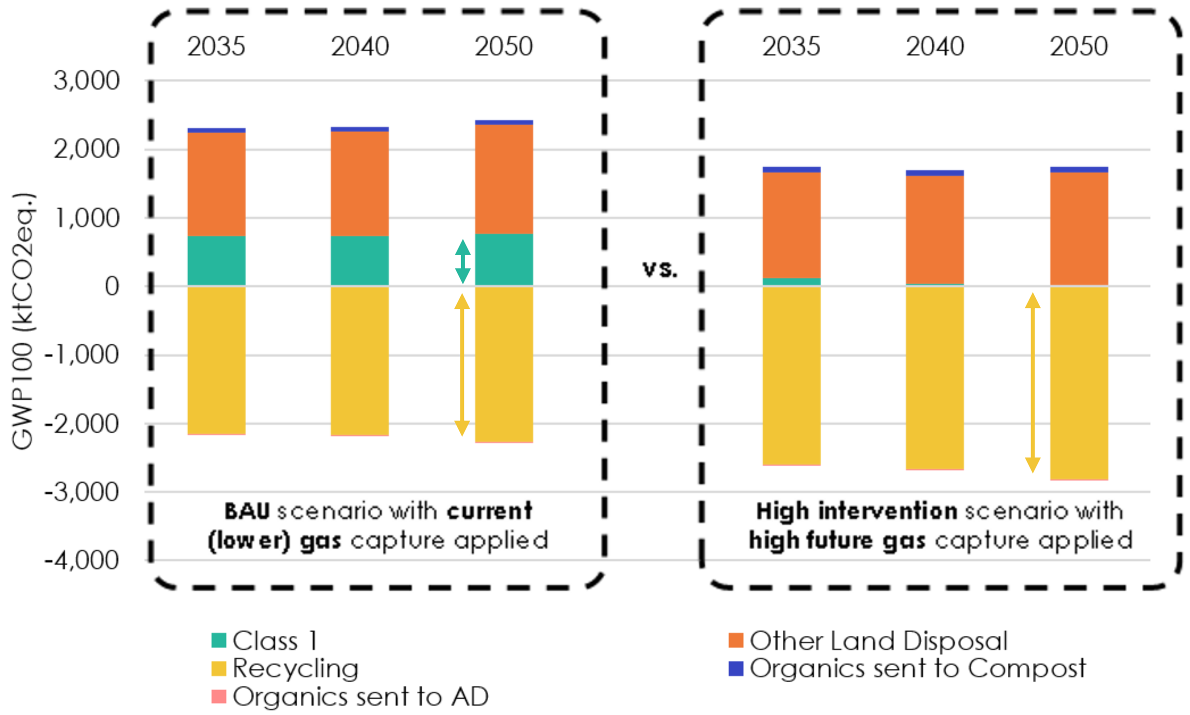
Figure 8-13 illustrates the breakdown of the contributing factors which make up the total net environmental impacts shown in previous graphs:

- On the left-hand side the **BAU scenario** is shown, which assumes no additional waste diversion from Class 1 landfills (i.e., it forecasts the same proportional split between waste management destinations, as current levels). It also applies the **current (lower) gas capture** levels to assess the environmental impact. Across 2035 to 2050, these environmental impacts represent no policy impact: no additional diversion and no improved capture.

- On the right-hand side the graph shows the high intervention scenario (i.e., high diversion from Class 1 landfills), coupled with the high future gas capture levels. In combination, these results show the largest forecast policy impacts.

Under the BAU tonnage scenario, changes in recycling benefits are only slight from 2035 to 2050. There is also a slight increase in landfill impacts occurring over time, because total waste quantities being sent to landfill are increased slightly. The impacts above the graph's x axis (predominantly landfill emissions), are slightly higher than those below it (mostly recycling). By comparison, under the high intervention scenario where landfill gas capture improvements are combined (right hand side), Class 1 landfill impacts appear negligible and an increase in recycling benefits is also seen simultaneously. This reduction in Class 1 emissions demonstrates the importance and impact of increasing Class 1 gas capture infrastructure compared to the current (lower) level of assumed gas capture. (Realising this level of impact would also rely on sufficient measurement and reporting of gas capture activities.) Whilst this change alone has a positive impact, additionally achieving high levels of waste diversion into recycling creates further benefits compared to New Zealand's current level of recycling. Both changes reflect the highest levels of improvement assumed to be realistically possible for New Zealand and require the policy to be implemented, monitored and enforced very effectively and holistically. (For example, diversion from Class 1 to other landfill classes must be minimal.)

Figure 8-13: Comparison of the BAU Scenario with current (lower) gas capture applied VS the High Intervention Scenario with the high future gas capture applied



GWP100 (ktCO2eq.)	BAU & Current (Lower) Gas Capture			High Intervention & Future High Gas Capture		
Destination \ Year	**2035**	**2040**	**2050**	**2035**	**2040**	**2050**
Class 1	**730**	**735**	**766**	**119**	**41**	**16**
Other Land Disposal	1,512	1,523	1,587	1,542	1,566	1,637
Recycling	**-2,158**	**-2,174**	**-2,265**	**-2,591**	**-2,668**	**-2,812**
Organics sent to Compost	72	73	76	78	81	86
Organics sent to AD	-11	-12	-12	-14	-20	-22

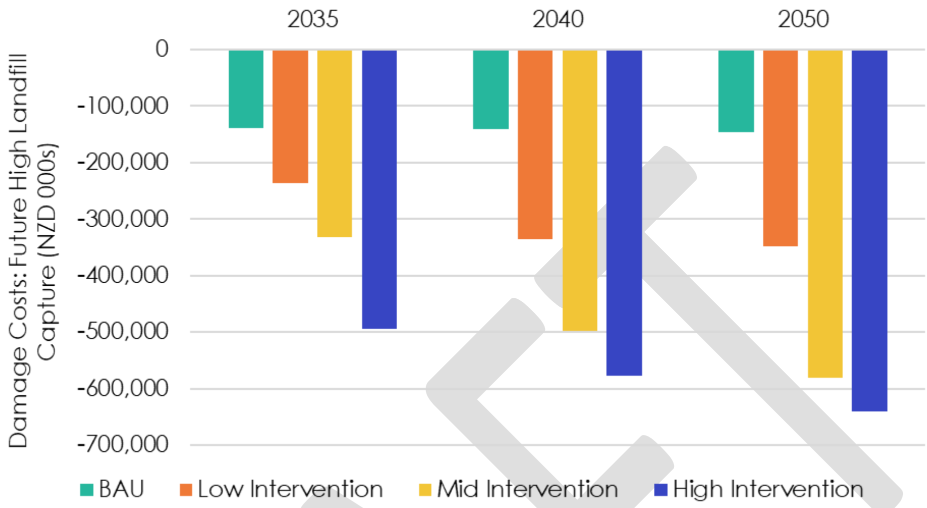
Damage Costs: Increased Gas Capture

For climate change impacts, the damage costs consider the likely future abatement costs of mitigating carbon emissions. For air quality impacts, the damage costs consider the impact on human health and the financial costs of those impacts. The cost assumptions in use are in alignment with NZ Treasury advice. As the capture in this scenario is improved, compared to Section 8.1.2.1, the resulting damage costs are lower (i.e., there is greater benefit).

Figure 8-14 shows the damage costs for each diversion scenario and the BAU, when assuming the future high gas capture level is happening at Class 1 landfills alongside improved diversion. The results show a similar pattern of impact to that of the GWP100 results. They are directly comparable to the results in Figure 8-10 and Figure 8-11 – the key difference being the assumed level of capture occurring at Class 1 landfills.

For instance, in 2050, the low intervention scenario ranges from about -$266M when the current (lower) level of capture is assumed (Figure 8-10), and decreases to almost -$350M when the capture at Class 1 landfills increases in the future (Figure 8-14). As before, it is important to note that these benefits are heavily influenced by avoided air pollution occurring from increased recycling, rather than just climate change benefits.

Figure 8-14: Damage Costs: High Future Gas Capture across BAU & Diversion Scenarios



8.1.3 Financial impacts of Option 1: Class 1 Diversion

Figure 8-15 shows the financial costs stemming from the additional separate collections and processing of recycling, composting and AD, whilst accounting for the benefit of savings from avoided landfill costs (including gate fees, ETS and levy fees). It also shows the additional recycling revenue that could be gained. The combined impacts of avoided landfill costs and increased recycling revenues result in increasing overall net benefits as the level of diversion increases from the low to the high intervention scenario. Whilst collection costs and recycling costs increase, revenues from recycling offset some of this increase. Figure 8-15 shows 2050 values in 2023 real terms, across the low, mid and high intervention scenarios. The greater the intervention, the higher the benefits from avoided landfill costs and recycling revenue. The potential cost of a ban has not been incorporated, as how it would be implemented and thus how it can be costed, is unknown.[76] This additional cost would reduce the level of net benefits shown here.

[76] The analysis drives diversion through cost of landfilling compared to costs of recycling, AD and composting.

Figure 8-15: Additional Monetary Costs of Diversion Scenarios, 2050 (NZ $m)

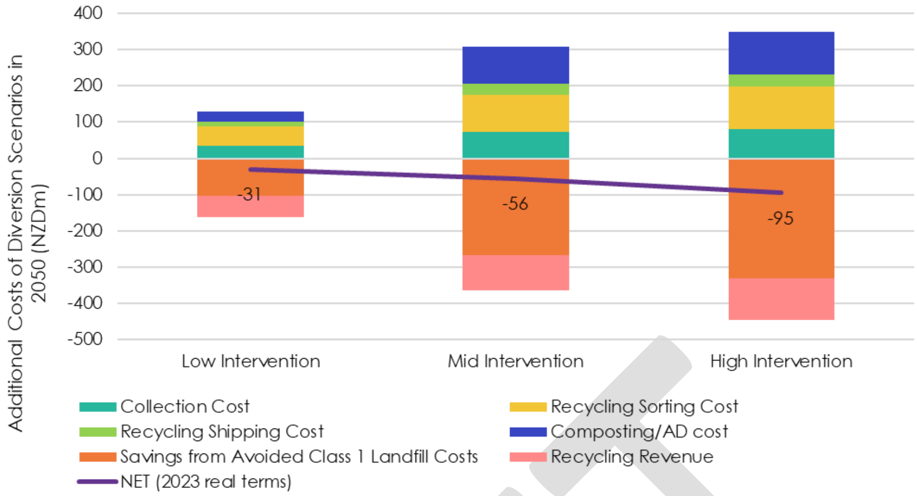


Figure 8-16 shows the total forecast costs for the BAU and diversion scenarios in 2050. In line with Figure 8-15, the net cost of the high intervention scenario (~$7.35bn) is $95m less than the BAU (~$7.44bn). The graph includes all of the New Zealand waste market within the scope of the cost modelling. The landfill costs (orange bar) are shown to decrease as interventions increase. This saving, coupled with the recycling revenue, outweigh the increase in the cost of collections.

Figure 8-16 shows collection costs as the single largest cost. In BAU, 'other' wastes (i.e., C&D and heavy industry) represent just over 60 percent of the collection cost. This reflects the significant portion of 'other' wastes within the total waste generated (75%). The costs of managing these waste streams post-collection (Class 2-5 landfills, monofils, etc.) have not been accounted for in this study, as they are not the focus of the study, nor this cost modelling. If the analysis were to exclude 'other' waste, collection would still be the largest cost in 2050 in each scenario – totalling $2.4-2.5bn. This is still over double the next largest value, the cost of sorting recycling at just under $1bn.

Figure 8-16: Total Costs of Diversion Scenarios in 2050 compared to BAU (NZ $m)

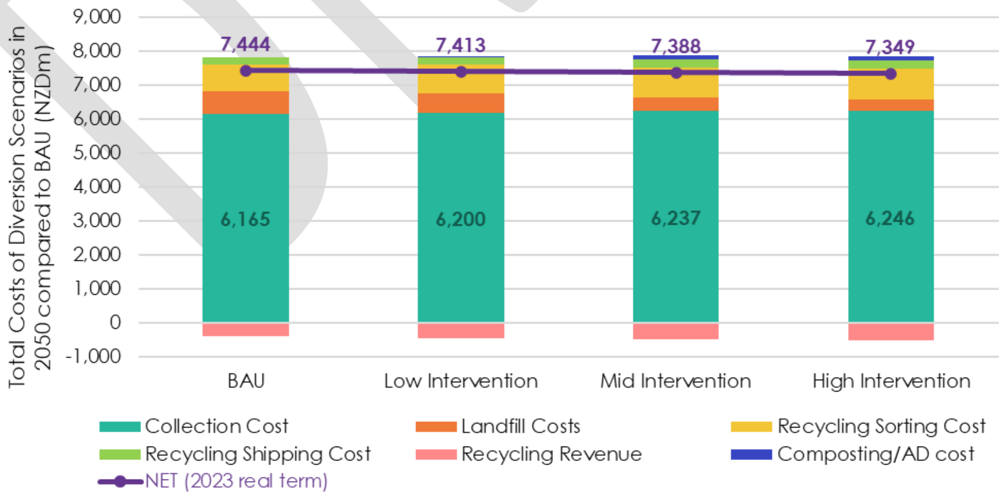
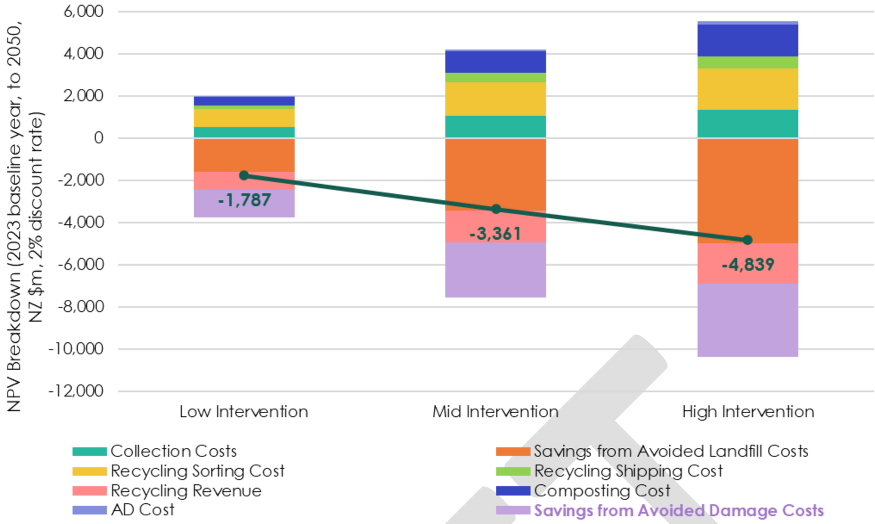


Figure 8-17 shows the net present value (NPV) analysis of the additional costs and benefits from undertaking the intervention scenarios, from 2023 to 2050 (using a 2% discount rate). The damage costs are on the same axis and show the environmental benefits that could be potentially gained from increased government intervention and diversion of waste from Class 1 landfills.

Figure 8-17: Cost Benefit Analysis of Three Diversion Scenarios (2023-2050; NZ $m)



Note: Costs and benefits shown are additional to the BAU (i.e., compared to no intervention scenario). For damage costs, future high gas capture levels are assumed for all scenarios. Additional landfill gas capture infrastructure costs are not shown in graph as they are so comparatively low. See Option 2 for more information on landfill gas capture infrastructure costs.

8.2 Option 2: Improve Landfill Gas Capture Only

Option 2 here does not consider any improvements in landfill diversion; only the BAU tonnage scenario is assessed here – i.e., the proportion of waste being sent to Class 1 landfills remains at current levels throughout the time period under investigation.

8.2.1 Environmental impacts

Figure 8-18 shows the results of applying improvements solely to the capture system, without the benefits of improved landfill diversion. This shows decreased benefits in comparison to Option 1, although some relatively significant changes are still seen. Under this option, net impacts from the waste management system in terms of GWP100 impacts are -391 kt CO_2e by 2050, compared to -1,095 kt CO_2e for the high intervention variant of Option 1 – with the difference being solely down to the changes in Class 1 impacts. A similar pattern is seen in respect of the changes in damage costs across the respective options, shown in Figure 8-19. Here, the reduction in landfill impacts is sufficient to result in net negative overall performance in respect of the waste management system from 2040 onwards. This represents a benefit in performance; a benefit which is not seen where the improvement in capture does not occur – as is seen by the steadily increasing green bars in the graph which represent current projected performance.

Figure 8-18: GWP100 Impacts from Improved Gas Capture Rates alone

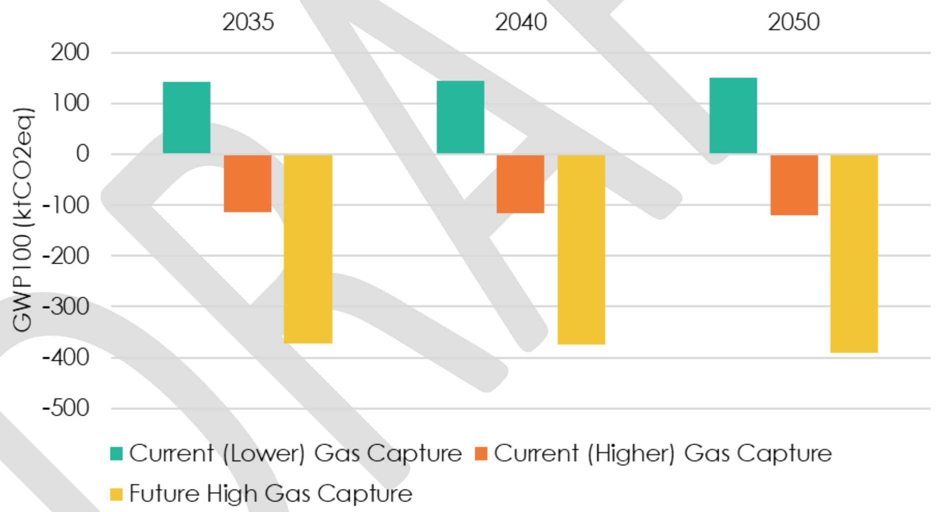
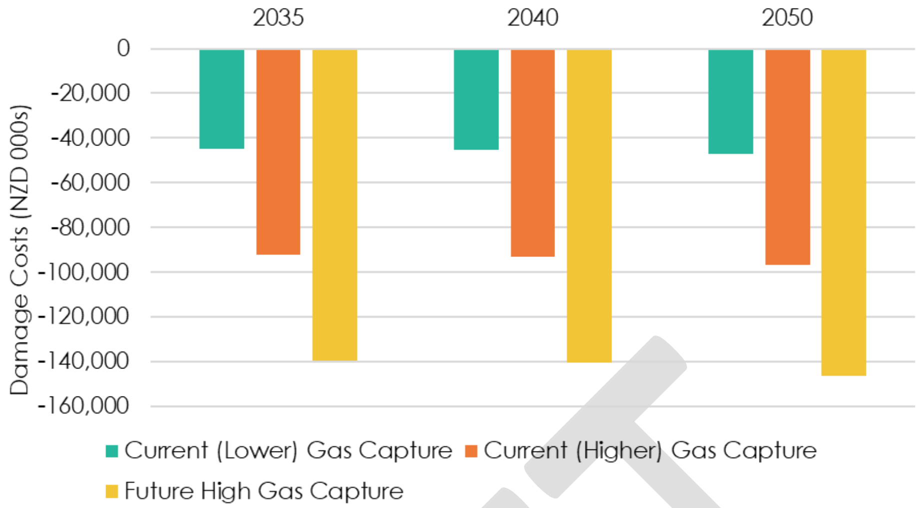


Figure 8-19: Damage Cost Impacts from Improved Gas Capture Rates alone



8.2.2 Financial impacts

The total costs of increasing landfill gas capture is much smaller compared to the costs observed in Option 1 – i.e., $1-2m shown in Table 8-1, compared to the billions of dollars in question in Figure 8-16 for Option 1. Table 8-1 shows the average forecast cost for additional LFGC in 2050. Greater improvement is needed to increase capture from the current (lower) gas capture level compared to the current (higher) level, so the top half of the table shows greater costs. There is considerable uncertainty in calculating these costs, as there is relatively little information on the volume of the landfill mass available at the majority of New Zealand's landfill sites; such information would be needed to improve the cost estimate for this option. However, the numbers provide an order of magnitude assessment of the approximate impact associated with improving the capture infrastructure.

Table 8-1: Forecast Costs of Additional Landfill Gas Capture Infrastructure ($m)

	Intervention Level	Estimated Forecast total Cost in 2050 (calculated using average $/t cost) - $m
Cost of Increasing to Future High from Current (lower) Gas Capture	Low:	2.3
	Mid:	1.9
	High:	1.8
Cost of Increasing to Future High from Current (higher) Gas Capture	Low:	1.4
	Mid:	1.2
	High:	1.1

8.3 Option 3: Improve Gas Capture Measurement

8.3.1 Environmental impacts

Improving LFG capture measurement and reporting will not directly result in changes to gas generation or capture rates. However, in order to manage LFG properly, accurate measurement is necessary. Improved measurement is likely to lead to greater awareness of losses and opportunities to improve gas capture, and subsequently to determine the impact of interventions. Specifically, because LFG emissions create liabilities for waste participants under the NZETS, accurate measurement and calculation of capture rates enables accurate incentivisation of actions to reduce emissions. In other words, the use of instruments such as the NZETS is only going to be as effective as the ability to accurately measure and calculate gas capture rates allows. Improved gas capture measurement could therefore lead to improved gas capture rates as a result of waste participants being accurately incentivised to reduce liabilities under the NZETS.

This benefit is likely to be unevenly distributed, however. Sites that currently have high levels of gas capture are likely to have diminishing returns from further investment, but sites with low levels of gas capture could be incentivised to invest in improved gas capture systems and practices. Survey data suggests that the largest sites already capture gas reasonably well, but there is no data on the actual performance (in terms of capture infrastructure design) of 20 sites in the country. There is uncertainty as a result in the performance of these sites, and this is reflected in the development of two baselines within the analysis. It is, however, expected that included amongst these 20 sites will be some relatively poor performers (and some Class 1 sites without gas capture) – these are likely to be impacted by policies to improve gas capture measurement.

The degree of the potential uplift in gas capture arising from the implementation of the improved measurement actions is outside the scope of current work to estimate. Further work is necessary to understand the levels of capture across the sites in particular which have failed to provide survey data; this, in turn, would provide greater understanding of the investment that would be required to improve capture rates. The implementation of this policy option would require landfill operators to submit information returns with a standardised gas generation model. This, in turn, would give MfE a much greater idea of the current standard of performance in site management across the country, and as such, improve the current understanding of the actual benefits of the current and future policy options it is intending to put in place.

8.3.2 Financial impacts

Financial impacts of this policy are similarly challenging to estimate in the absence of key performance data. It is expected that poorer performing sites would be encouraged – to at least a certain extent – to improve capture infrastructure; where this happens, investment would be needed at those sites, and the operators would therefore be financially impacted. Investment is more likely on sites that are expected to continue to operate for some time; where this is the case, investment levels when viewed across the lifetime of the site are anticipated to be relatively modest.

Estimates of the cost needed to upgrade the infrastructure developed under Option 2 suggest that the financial investment needed to improve the capture for each site is relatively small in comparison to the ETS cost needed to be paid if infrastructure is not improved.

9.0 Conclusions

The current landfill gas management regime was initially established in 2004 through the NES-AQ and further developed through the NZ ETS (with Class 1 landfills being required to participate from 2013). Aotearoa New Zealand's first and second *emissions reduction plans* include actions to address biogenic methane emissions from organic materials in landfills.[77] The *Second Emissions Reduction Plan (ERP2)* states that "*in 2022, the waste sector produced an estimated 3.5 Mt CO2-e (about 4.5 percent) of New Zealand's gross greenhouse gas emissions*." 93.3 percent of these emissions were in the form of methane and overall, 81 percent of waste sector emissions were attributed to solid waste disposal.[78]

Reducing emissions from landfill disposal is a key area to target in terms of overall emissions from the sector. This study aims to support this national ambition in two ways:

1. Outlining options for **improvement of the landfill gas capture regulatory framework**, and
2. Analysing options to **reduce emissions from Class 1 landfills**

9.1 Regulatory Framework Improvement Options

New Zealand's LFG regulatory regime consists of several components that interact but do not necessarily provide a cohesive approach in respect of LFG. The key components are:

- The National Environmental Standards for Air Quality under the RMA – which is applied by regional councils,
- The NZETS and the associated regulations, administered by the EPA,
- The Climate Change Response Act, administered by the MfE which sets emissions budgets and through the ERP identifies actions to meet carbon budgets, and
- The waste disposal levy, administered by the MfE. The levy does not directly address LFG but acts as a tool to disincentivise waste to disposal and, through the application of levy funds provides support for activities that could reduce emissions from disposal.

The current approach, while broadly functional, has led to several areas where there is potential for improvement. These include:

- Organic waste is in effect being treated differently depending on its destination, with Class 1 facilities being required to have leachate collection, gas capture, and facing higher waste disposal levy rates. This creates a perverse incentive to send material to Class 2-5 facilities, where the control of emissions is lower.
- The waste disposal levy is currently at a low to moderate rate compared to the best performing international examples. Application of an escalator to higher levels would provide clear signals to the industry an allow appropriate timeframes for investment.
- New Zealand is relatively unique in that the key instrument around minimising LFG emissions is an emissions trading scheme. This creates the requirement to estimate generation and capture rates. Other jurisdictions without this type of instrument (for example UK and Australia), measure

[77] New Zealand Government (2022) Te hau mārohi ki anamata: Towards a productive, sustainable and inclusive economy, Aotearoa New Zealand's first Emissions Reduction Plan
[78] New-Zealands-second-emissions-reduction-plan-202630.pdf

gas captured and provide incentive payments based on the total quantity of LFG captured and destroyed, which can be measured and calculated with reasonable accuracy.[79]

- There is no established national best practice standard or guidance for operation of LFG systems.
- There is no established national best practice standard or guidance for measurement of on-site emissions.
- Current reporting arrangements have resulted in some landfills claiming high instantaneous gas capture rates, which may not reflect actual gas capture rates (due to organic loading), and which do not reflect lifetime gas capture rates.
- There is a disconnect between the instantaneous LFG capture rates reported for the purposes of the NZETS and gas capture rates reported by the New Zealand government to the UNFCCC.
- While the NZETS has incentivised high gas capture rates amongst some landfills, the effect has been uneven, with larger facilities able to claim high rates, while smaller facilities generally do not.
- There is limited transparency as to how LFG generation calculations are made by operators when submitting claims for the ETS payments.

The LFG regulatory regime should present a consistent framework that takes a holistic approach and offers appropriate controls and incentives directed towards the desired outcomes of reducing emissions from landfills and improving gas capture. The recommended changes are intended to enable the industry to make investment and operational decisions that fairly and transparently reflect the risks and benefits of the various approaches to management of organics (i.e. landfills with and without gas capture, energy from waste, anaerobic digestion, composting etc.).

Importantly, these improvements can be made within the existing regulatory framework, and to deliver improved outcomes primarily requires some adjustments to current settings.

Potential key changes include:

- **Increasing the cost of landfilling through changes in waste disposal levy rate and ETS**. This, in turn, is anticipated to reduce the relative cost of recycling and composting and make it more competitive compared to landfill, thereby encouraging diversion. Although the value of NZUs is subject to market fluctuations, by making changes to how ETS obligations are calculated (noted below), the effective rate per tonne of material landfilled under the ETS could be increased. This would mean that a lower levy rate would be necessary to achieve comparable levels of diversion.
- **Organic disposal restrictions**. These can be achieved either via a ban on sending certain organic waste streams to landfill, or by a requirement to sort organic waste streams, such as food waste. In the New Zealand context, this policy option is considered within the analysis undertaken here for the Class 1 landfills, which are the sites where most organic material is sent. The analysis also considers the implications of banning organics from Class 2-4, and for Class 1 sites without LFG capture (i.e., that leakage of organics into other land disposal options is mitigated). It is noted that the banning of specific streams from landfill is, in practice, difficult to police by operators, since mixed loads will be arriving at the site continuously and the operator will be unable to inspect them in sufficient detail to ensure that no banned material enters the site. It is for this reason that effective implementation of a ban typically requires actions

[79] While simply incentivising gas capture could create an incentive to landfill more organics, it tends not to in these jurisdictions because organic waste diversion is incentivised through high landfill levy rates.

upstream from the landfill to occur, supported by sufficient regulatory control to ensure operators and waste generators are compliant with the ban / regulation.

- **A requirement for all Class 1 landfills to have landfill gas capture systems**. For very small sites, this includes the use of improved passive gas capture techniques (since these sites are likely to be too small for the engineered capture systems based on wells to be effective).

- **Improvements in landfill gas capture infrastructure** over the landfill lifetime for the remaining Class 1 sites that currently have gas capture systems in place. This includes meeting best practice well-spacing guidelines, improving the use of capture systems when the site is operational and the utilisation of best practice aftercare techniques.

- **Improve LFG measurement and reporting by allowing operators to claim, as close as possible, their actual lifetime gas capture rates** where the evidence can be presented, while allowing some lower level of lifetime gas capture to be claimed where partial evidence is available. This could involve removing the ceiling on LFG capture rates and having different emissions factor tiers linked to different standards of evidence. The higher the gas capture level that is claimed, the higher the standard of evidence required to support it (within defined tiers).

- **Improve the mass balance methodology used for compliance with the NZETS by requiring lifetime rather than instantaneous gas capture rates to be calculated.** The mass balance methodology was chosen as the basis for the current approach under the NZETS as all lifetime emissions are essentially accounted and paid for in the same period as the waste is deposited, avoiding issues with liabilities in respect of future emissions for this tonnage. With this as the rationale, it requires the use of a lifetime gas capture rate to be consistent. In other words, the emissions attributed to deposited waste needs to reflect the emissions profile from the time of deposition to when emissions effectively cease, rather than, as is the case at present, the emissions for the disposal facility in the year in which the waste is deposited. This adjustment would also have the added benefit of better aligning figures calculated for the purposes of compliance with the NZETS, with calculations made for the purposes of policy.

- **Update the mass balance approach through using a standard LFG generation model for all operators**. Under this approach MfE or EPA would operate an LFG model and would simply require operators to input/update the parameters. Once set up the model would only have to be updated with parameters that had changed. This solution would give Government greater insight and control of calculation, as well as confidence that the outcomes of the system were equitable and uniformly reliable. Government can also refine and update calculations over time. By taking on the responsibility for modelling of outcomes, Government would also reduce the time and cost burden for operators to comply with the regime.

9.2 Impact of Class 1 Landfill Emission Reduction Options

Building on the understanding gained about the current market and regulatory landscape in Aotearoa, policy options to reduce landfill emissions were defined and the economic, waste minimisation and carbon impacts quantified. The focus here was Class 1 landfills, as the main destination for residential, commercial, institutional, and industrial wastes. Stakeholder engagement with site operators, alongside close liaising with MfE, supported the short-listing of policy options to:

2. increase Class 1 landfill **diversion** (through increasing the cost of Class 1 landfills and restrictions on organics disposal);

3. improve landfill **gas capture infrastructure**; and

4. improve landfill **gas capture measurement**.

The first policy option relates to a potential set of policy tools that can **increase diversion from Class 1 landfill**. It includes a combination of levy and ETS increases (to make Class 1 disposal more expensive) and organic disposal restrictions to Class 1. These may trigger other tools and related outcomes such as a requirement to sort, separate collections (of organics), recycling targets (and related fines), promotion of home composting, etc. The exact combination of policies, their implementation and their enforcement is not yet clearly defined in legislation. Instead, a higher-level assessment of the implications of having greater or lower levels of policy intervention was assessed.

The BAU flow of waste to different destinations was established from which low, medium and high levels of policy intervention result in increasing levels of diversion from Class 1 landfills – with that diversion shifting waste to recycling, composting, and AD treatment options. A small portion is assumed lost to Class 2-5 landfills, monofills, etc.

Achieving high levels of diversion quickly, based on international examples, is challenging to achieve. However, given enough time and resources, almost 30 percent diversion of all wastes sent to Class 1 by 2050 is forecast in even the medium intervention scenario. Lower diversion – occurring due to fewer tools being used and/or those being less-well implemented - is estimated to half the overall level of diversion in 2050, from about 30 percent to 15 percent.

The GWP100 benefits under high intervention scenario in 2050 range between just over 800 to just under 1,000 kt CO_2e, depending on the level of capture infrastructure in place. A 0.8-1Mt CO_2e reduction in 2050 represents about 24-28 percent of the current reported emissions from the waste sector (an estimated 3.5 Mt CO2-e in 2022). The low intervention scenario is forecast to reduce GWP100 by around 400ktCO_2e compared to the BAU tonnage levels per destination (i.e., 10-12 percent of current emissions).[80]

The high intervention scenario shows about two times lower damage costs compared to the low scenario. Compared to no intervention at all (i.e., compared to BAU), the high intervention scenario leads to a result that has four to twelve times lower damage costs, depending on the level of baseline capture in use.

As the level of intervention increases, the costs of collection, recycling and composting/AD also increase. However, these additional costs are eclipsed by the forecast savings from avoided landfilling costs and additional revenue from recycling. The benefits are further realised when incorporating avoided damage costs. Simply put, although implementing higher levels of intervention costs more, the benefits are forecast to outweigh the costs.

A key sensitivity in this assessment is assuming almost all diverted waste is sent for treatment (recycling/composting/AD). If the waste is instead sent to other land disposal options that do not have gas capture (Class 2-5 landfills, etc.), then the environmental benefits do not stack up. Environmentally, diversion from Class 1 to other land disposal is a worse outcome than no diversion at all. Therefore, it is important to mitigate leakage to other land disposal options when implementing policies on Class 1 landfills.

The estimated **improvements to landfill gas capture infrastructure** show that by solely improving Class 1 landfill gas capture, from the current lowest estimated level to a higher future level, GWP100 could reduce by over 500 kt CO_2e, and the damage costs are forecast to reduce by as much as about $0.1bn in 2050.[81] The 'current lowest estimated level' is one of two landfill gas capture baselines, which are both considered due to the uncertainty in current gas capture data. This shows there is value in investing in improving gas capture infrastructure, as well as improving its measurement and reporting.

The assessment of **improvements to landfill gas capture measurement** was qualitative, due to the current uncertainties in the data being collected from landfill operators. This highlights the importance

[80] New-Zealands-second-emissions-reduction-plan-202630.pdf
[81] Cost shown is undiscounted, in 2023 real terms.

of having more accurate data with which to drive performance of landfill gas capture. The degree of the potential uplift in gas capture arising from the implementation of the improved measurement actions is outside the scope of current work to estimate. Estimates of the cost needed to upgrade the infrastructure developed under Option 2 suggest that the financial investment needed to improve the capture for each site is relatively small in comparison to the ETS cost needed to be paid if infrastructure is not improved. This study therefore recommends that there is value in investing in improving gas capture measurement and reporting.

9.3 Summary

In summary, this project has sought to understand in some detail how landfill gas is managed in Aotearoa New Zealand and identify practical opportunities for improvement, including reduction of emissions. The work found that, compared to international best practice, there are a range of areas where practices can be improved within the country. While the best performing Class 1 landfills in New Zealand compare reasonably well to overseas examples in terms of LFG management, there appear to be a wide range of practices here based on the data obtained thus far from operators. Thus, there is opportunity for more guidance and standards in relation to best practice.

New Zealand's use of the NZETS as a key tool for incentivising gas capture has had some success but brings with it challenges, particularly around how gas generation rates are calculated and reported. In most other countries this is not an issue, as LFG capture incentives tend to be based on actual quantities captured. There is scope to amend the current regulatory regime to better reflect actual lifetime gas capture rates and thus enable better alignment of practice with the intended outcomes of the existing NZETS incentive.

The potential impact of implementing the key recommendations for improvement were modelled. It was found that interventions could reduce LFG emissions by up to approximately 30 percent. Although implementing these changes would be more costly in waste management terms, these additional costs are eclipsed by the forecast savings from avoided landfilling and additional revenue from recycling. The benefits are further extended when incorporating avoided damage costs.

Appendices

A.1.0 Key agencies & their responsibilities

A.1.1 Ministry for the Environment

The Ministry for the Environment (MfE) is the primary government agency responsible for overseeing the policy, legislation and regulation in relation to landfill gas emissions. Some key responsibilities include:

- Primary responsibility for all legislation and regulation in relation to LFG
- Oversee the operation of the NZ ETS
- Preparation of emission reduction plans
- Advice to Government
- Prepare the GHG inventory and provide reporting to Intergovernmental Panel on Climate Change (IPCC)
- Gather waste data (including through the online waste levy system, OWLS)

A.1.2 Climate Change Commission

The Climate Change Commission was established by the Climate Change Response (Zero Carbon) Act 2019. It is an independent body that is charged with monitoring and providing advice on New Zealand's emissions budgets and the development of policies and measures to achieve those budgets. The Commission therefore has a role in advising on the scope and scale of actions and how the available mechanisms will be applied. In particular, section 5ZA of the Climate Change Response Act 2002 requires that the Commission must advise the Minister on the following matters relevant to setting an emissions budget:

a) the recommended quantity of emissions that will be permitted in each emissions budget period; and

b) the rules that will apply to measure progress towards meeting emissions budgets and the 2050 target; and

c) how the emissions budgets, and ultimately the 2050 target, may realistically be met, including by pricing and policy methods; and

d) the proportions of an emissions budget that will be met by domestic emissions reductions and domestic removals, and the amount by which emissions of each greenhouse gas should be reduced to meet the relevant emissions budget and the 2050 target; and

e) the appropriate limit on offshore mitigation that may be used to meet an emissions budget, and an explanation of the circumstances that justify the use of offshore mitigation (see section 5Z).

Collectively these factors are vital in determining the carbon price, and hence the degree of incentive for disposal facility operators to capture and undertake destruction of landfill gas. This process is managed through the NZ ETS, discussed in more detail in section A.1.3.

A.1.3 Environmental Protection Authority (EPA)

The key responsibilities of the EPA in relation to LFG are as follows:

- Receive data from waste participants on the quantity of waste disposed of annually at the disposal facility
- Verify the data
- Appoint and manage recognised verifiers (under the Climate Change (Unique Emissions Factors) Regulations 2009)
- Calculate the emissions obligations from the information supplied
- Audit NZ ETS participants for compliance with regulatory requirements
- Manage the surrender of NZUs in accordance with the disposal facilities 'obligations
- Prepares NZ ETS reports on emissions reported by waste participants.[82]

A.1.4 Recognised Verifiers

The EPA appoints qualified individuals as 'recognised verifiers'. The individuals must be experienced chartered accountants or chartered professional engineers.

The role of recognised verifiers is to verify the calculations and data used to determine UEFs.

The EPA must keep a list of individuals who have been recognised as verifiers and who are currently recognised.

The recognised verifiers review:

- Samples collected by the participant and tested for the purposes of the relevant regulation, and ensure they meet relevant standards and testing requirements.
- Measurements and confirm they have been carried out in accordance with the Regulations
- The calculations for the UEF and confirms that it has been undertaken correctly and in accordance with the prescribed methodology.

A.1.5 Regional and Unitary Councils

Regional and unitary councils are responsible for issuing and monitoring resource consents for air, land, and water discharges under the Resource Management Act (RMA) 1991. Monitoring of LFG fugitive emissions therefore comes within the regional and unitary councils' remit. Regional and Unitary Councils can take compliance action if resource consent conditions for air emissions from a landfill are breached.

A.1.6 Disposal Facilities

Disposal facilities that are waste participants have the following responsibilities in relation to LFG.

[82] Reporting under the NZ ETS is separate to reporting under NZ's Greenhouse Gas Inventory. New Zealand's Greenhouse Gas Inventory | Ministry for the Environment

- Record the quantities of waste disposed of at their facility, accounting for any waste that is initially disposed of then diverted in accordance with 4(1) of the Climate Change (Waste) Regulations 2010.
- Submit data to the EPA annually on the quantity of waste disposed of
- Surrender the correct quantity of NZUs in line with their obligations (i.e. 1 NZU for each tonne of carbon that it is calculated the disposal facility emitted in the period)
- If they wish to claim a UEF relating to waste composition:
  - Undertake waste composition analysis in accordance with the regulations
  - Ensure the waste composition analysis has been approved by a recognised verifier
  - Submit the data and calculations to the EPA
- If they wish to claim a UEF in relation to LFG collection and destruction system:
  - Undertake monitoring and testing in according with the regulations
  - Submit the required data to a recognised verifier
  - Calculate gross methane generation for the disposal facility for a year in accordance with either the IPCC waste model or another equivalent first-order decay model.

A.2.0 In-Depth Review of New Zealand Legislation, Regulations, Standards & Guidelines, and Context.

A.2.1 Legislation

The preceding section set out the broad operation of key elements of NZ's LFG management regime. This section reviews in more detail the relevant environmental legislation. The review is intended to identify existing gaps and issues in respect of the New Zealand legislation.

A.2.1.1 Climate Change Response Act 2002[83]

Public Act 2002 No 40

Date of assent 18 November 2002

Latest version: 1 January 2024

[83] https://www.legislation.govt.nz/act/public/2002/0040/latest/whole.html?search=ts_act_climate+change+response+act_resel&p=1#whole

Administered by: Ministry for the Environment.

The Climate Change Response Act 2002 (CCRA)provides a legal framework for New Zealand's response to climate change at a national level. Key provisions of the Act include measures to address greenhouse gas emissions, promote energy efficiency, and contribute to the country's international climate change commitments. This Act puts in place a legal framework to enable New Zealand to meet its international obligations under the United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Paris Agreement. The Act was amended in 2008 to encompass the New Zealand Emissions Trading Scheme (NZ ETS) which is New Zealand's principal response for reducing domestic emissions and its primary mechanism to meet international emissions reduction commitments. The Climate Change Response Act does not contain specific provisions related to landfill gas capture.

The purpose of the Climate Change Response Act 2002 Act is to:

- Provide a framework by which New Zealand can develop and implement clear and stable climate change policies;
- enable New Zealand to meet its international obligations under the Convention, the Protocol, and the Paris Agreement;
- provide for the implementation, operation, and administration of a greenhouse gas emissions trading scheme in New Zealand that supports and encourages global efforts to reduce the emission of greenhouse gases; and
- provide for the imposition, operation, and administration of a levy on specified synthetic greenhouse gases contained in motor vehicles as well as another levy on other goods to support and encourage global efforts to reduce the emission of those gases.

The Climate Change Response Act 2002 in New Zealand is administered by several government entities, and different aspects of the Act may fall under the authority of different agencies.

- **MfE** - plays a significant role in implementing and overseeing the Climate Change Response Act, including the preparation of emissions reduction plans.
- **Environmental Protection Authority (EPA)** – is responsible for the day-to-day administration of the ETS as well as compliance and enforcement
- **Climate Change Commission** – the Climate Change Commission was established under the Climate Change Response (Zero Carbon) Amendment Act 2019 to provide independent advice to the government on climate change issues, including emissions reduction targets and policies
- **Ministry of Business, Innovation and Employment (MBIE)** - is involved in energy-related policies and strategies, which can be closely linked to climate change response measures.

A.2.1.1.1 Provisions Specifically Related to Landfills

Under the CCRA a disposal facility is defined as follows:

disposal facility means any facility, including a landfill,—

(a) at which waste is disposed; and

(b) at which the waste disposed includes waste from a household that is not entirely from construction, renovation, or demolition of a house; and

(c) that operates, at least in part, as a business to dispose of waste; but

(d) does not include a facility, or any part of a facility, at which waste is combusted for the purpose of generating electricity or industrial heat

This is the same definition used in section 7 (1)(a) of the Waste Minimisation Act 2008 (WMA) but adds clause (d). The WMA also provides for any other facility to be prescribed as a waste disposal facility (Clause 7(1)(b).

The CCRA also uses the same definition of waste as is in the WMA:

waste means any thing that has been disposed of or discarded—

(a) including (but not limited to) any disposed of or discarded thing that is defined by its composition or source (for example, organic waste, electronic waste, or construction and demolition waste); but

(b) excluding any solid biofuel combusted for the purposes of generating electricity or industrial heat.

Commentary

Given that the WMA is under review consideration of the definitions of disposal facilities and/or waste may be pertinent. As an example, the 2002 version of the CCRA did not include a definition of disposal facility. The definition in the current version was added after the WMA was enacted.

It is also worth noting that at present the definition of a landfill would not cover most Class 2 facilities, so any attempt to extend gas capture to Class 2 facilities may require amendments to primary legislation.

Emissions are also defined in relation to landfills (because they are listed in Schedule 3) as "Carbon dioxide equivalent emissions of greenhouse gases from the activity."

Finally, **greenhouse gas** is also defined. In the Act this means—

(a) carbon dioxide (CO_2):

(b) methane (CH_4):

(c) nitrous oxide (N_2O):

(d) any hydrofluorocarbon:

(e) any perfluorocarbon:

(f) sulphur hexafluoride (SF_6)

Section 62 requires emissions and removals of emissions to be monitored (for activities listed in schedule 3 or 4 – which includes disposal facilities).

Section 63 establishes the liability for activities (including disposal facilities) to surrender units to cover emissions from their activity. 1 unit must be surrendered from each tonne of CO2e reported as being emitted. This is the mechanism that gives effect to the Emissions Trading Scheme.

Section 91 provides for approval of unique emissions factors (by regulations made under section 164)

Section 92 provides for the recognition of verifiers who are able to independently review the calculation of unique emissions factors by participating parties, including disposal facilities. The verifiers are tasked with ensuring that the calculations have been made correctly in accordance with the legislation and regulations but do not have a role in determining whether the methodology is technically appropriate.

Section 163 establishes the powers to make regulations in relation to methodologies and verifiers

Section 164 establishes the powers to make regulations in relation to unique emissions factors.

Schedule 3 Part 6 establishes disposal facilities as participants in the Climate Change Response Act 2002 (this in effect requires them to be a part of the Emissions Trading Scheme).

A.2.1.2 Climate Change Response (Zero Carbon) Amendment Act 2019

Date of assent 13 November 2019

Latest version: 13 November 2019

Administered by: Ministry for the Environment.

In 2019, the CCRA 2002 was further amended by the Climate Change Response (Zero Carbon) Amendment Act. These amendments provide a framework by which New Zealand can develop and implement clear and stable climate change policies that:

- Contribute to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5 degrees Celsius above pre-industrial levels; and
- allow New Zealand to prepare for, and adapt to, the effects of climate change.

The Climate Change Response (Zero Carbon) Amendment Act 2019 (Zero Carbon Act) is now incorporated in the primary legislation (i.e. the Climate Change Response Act 2002). This section highlights the key amendments made by the Zero Cabon Act in 2019.

The Zero Carbon Act established a framework for addressing climate change and transitioning to a low-emission economy. While the Zero Carbon Act set emissions reduction targets and outlined strategies for achieving them, it did not contain specific provisions addressing gas capture at landfills.

However, the Zero Carbon Act did include broader strategies and mechanisms to reduce greenhouse gas emissions across various sectors of the economy, which indirectly impacts landfill gas management efforts. Landfill gas, primarily composed of methane and carbon dioxide, is a significant contributor to greenhouse gas emissions. Therefore, measures aimed at reducing overall greenhouse gas emissions, as outlined in the Act, could indirectly affect landfill gas management practices. Under the Zero Carbon Act key terms include:

- **Biogenic methane** means all methane greenhouse gases produced from the agriculture and waste sectors (as reported in the New Zealand Greenhouse Gas Inventory).

- **Gross emissions** means New Zealand's total emissions from the agriculture, energy, industrial processes and product use, and waste sectors (as reported in the New Zealand Greenhouse Gas Inventory)

- **Net accounting emissions** means the total of gross emissions and emissions from land use, land-use change, and forestry.

The key components of the Zero Carbon Act include:

- **Emissions Budgets:** The Zero Carbon Act established a system of emissions budgets, which are five-yearly limits on the total amount of greenhouse gas emissions New Zealand can emit. These budgets are set to help the country achieve its long-term goal of net-zero emissions by 2050. Section 5X places a duty on the Minster for the Environment to set emission budgets and ensure that they are met. The Minister must ensure that the net accounting emissions do not exceed the emissions budget for the relevant emissions budget period. The legislation also sets the periods that the first six emissions budgets must be set for and when these need to be set by.

- **Climate Change Commission:** The Zero Carbon Act established the Climate Change Commission, an independent body responsible for providing advice on emissions budgets and the development of policies and measures to achieve those budgets
- **Sectoral Emission Reduction Plans:** The Zero Carbon Act provided for the development of sectoral emission reduction plans. These plans outline how specific sectors, such as agriculture, transport, and energy, and waste, will contribute to meeting emissions budgets (refer to section 89A.2.1.1above)
- **Carbon Neutrality and Carbon Sinks:** The Zero Carbon Act addressed the concept of carbon neutrality and recognizes the importance of carbon sinks, such as forests, in offsetting emissions.

A.2.1.3 RMA 1991 – Section 43 National Environmental Standards

Date of assent 22 July 1991

Latest version: 24 August 2023

Administered by: Ministry for the Environment, with powers provided to regional councils.

This section of the RMA makes provision for establishing regulations, known as national environmental standards. This is the enabling legislation for establishing a national environmental standard for air quality in relation to methane emissions from landfills (covered in **Error! Reference source not found.**below)

(1) The Governor-General may, by Order in Council, make regulations, to be known as national environmental standards, that prescribe any or all of the following technical standards, methods, or requirements:

(a) standards for the matters referred to in section 9, section 11, section 12, section 13, section 14, or section 15, including, but not limited to—

(i)contaminants:

(ii)water quality, level, or flow:

(iii)air quality:

(iv)soil quality in relation to the discharge of contaminants:

(b)standards for noise:

(c)standards, methods, or requirements for monitoring.

(2) The regulations may include:

(a)qualitative or quantitative standards:

(b)standards for any discharge or the ambient environment:

(c) methods for classifying a natural or physical resource:

(d) methods, processes, or technology to implement standards:

(da) non-technical methods or requirements:

(e) exemptions from standards:

(f) transitional provisions for standards, methods, or requirements.

A.2.2 Regulations

This section reviews in more detail the relevant environmental, regulations. The review is intended to identify existing gaps and issues in respect of the New Zealand LFG related regulation.

A.2.2.1 Climate Change (Waste) Regulations 2010 (SR 2010/338)

Date of assent 23 September 2010

Latest version: 1 January 2023

Administered by: Ministry for the Environment but powers given to the Environmental Protection Authority for delivery

The Climate Change (Waste) Regulations 2010 (SR 2010/338) were established under sections 163 and 164 of the Climate Change Response Act 2002. They set out a method for waste disposal facilities is to calculate emissions using a default emissions factor. The default emissions factors apply to all facilities that are defined as disposal facilities under the CCR Act.

These regulations first came into force on 1 January 2011, with the most recent version coming into force on 1 January 2023. Key parts of the regulations are noted below.

- The Regulations identify the information required to calculate emissions from operating disposal facilities
-
- The following apply regarding the regulations as set out in section 4(1) of the Act:
  - *"A waste participant must measure and record the gross tonnage and diverted tonnage of each class of waste disposed of at each disposal facility operated by the waste participant in the year in accordance* ***with regulations 11 to 14*** *of the Waste Minimisation (Calculation and Payment of Waste Disposal Levy) Regulations 2009".*[84]

  - **Method of calculating emissions from operating disposal facilities:**

[84] For reference regulations 11 to 14 of the *Waste Minimisation (Calculation and Payment of Waste Disposal Levy) Regulations 2009 cover the following:*
- Gross tonnage and diverted tonnage must be measured (Regulation 11)
- Gross tonnage measured by weight, volume conversion, or average tonnage (Regulation 12)
- Diverted tonnage measured by weight or volume conversion (Regulation 13)
- Conversion of volume to weight (Regulation 14)
- Request for approval of average tonnage system (Regulation 15)

"A waste participant must use the following formula to calculate emissions for each class of waste disposed of at each disposal facility operated by the waste participant in the year:

$E = (A - B) \times C$

where—

E is the emissions in tonnes for the class of waste

A is the gross tonnage of the class of waste

B is the diverted tonnage of the class of waste

C is, —

*(a) in relation to a class of waste for which no unique emissions factor is approved by the EPA under section 91 of the Act, the default emissions factor of **1.023**; and*

(b)in relation to a class of waste for which a unique emissions factor is approved by the EPA under section 91 of the Act, the unique emissions factor that the EPA has approved for that class of waste".

The DEF contained in the Climate Change (Waste) Regulations 2010, is **1.023** tonnes of CO2e for each tonne of waste disposed of. This figure was updated on 1 January 2023, by regulation 35 of the Climate Change (Emissions Trading Scheme and Synthetic Greenhouse Gas Levies) Amendment Regulations 2022 (SL 2022/267). The previous figure was 0.91 from a 2022 update; and prior to that the figure was 1.19, which had been introduced in 2016.

The update was based on new national composition data that had been calculated at this time. However, the DEF here is different from the DEF contained in the Climate Change (Unique Emissions Factors) Regulations 2009, section 23C(1)(g) (calculation of LFG capture and destruction rate), which is listed as **0.91** tonnes of CO2e for each tonne of waste disposed of. In this regulation the DEF was updated 1 February 2022, by regulation 4 of the Climate Change (Unique Emissions Factors) Amendment Regulations 2021 (LI 2021/284). However, this 2022 update was based on an error in calculation.[85] The error was corrected in the Climate Change (Waste) Regulations 2010 but not in the Climate Change (Unique Emissions Factors) Regulations 2009.[86]

The impact of the failure to update the DEF in the Climate Change (Unique Emissions Factors) Regulations 2009 is that, when calculating the efficiency of a LFG capture and destruction system, the calculation assumes that the default rate of generation of methane is low (0.91). This means that any gas capture system is going to appear more efficient when using the low default generation rate. Anecdotally this has seen most disposal facility operators choose to use the DEF for composition rather than apply for a waste composition UEF, as very few have a generation rate lower than 0.91. This is also evident by comparing gazetted UEFs from the previous two years.

[85] Both the defaults were calculated using the same waste composition (from the 2020 GHG inventory). The calculations in Climate Change (Waste) Regulations 2010 at 1 Jan 2023 used the emissions factors from Climate Change (Unique Emissions Factors) Regulations 2009 as of 1 Feb 2023 and arrived at a default of 1.023. The calculations in Climate Change (Unique Emissions Factors) Regulations 2009 at 1 Feb 2023 used the emissions factors from Climate Change (Unique Emissions Factors) Regulations 2009 as of 1 Jan 2018 and arrived at a default of 0.91.

[86] MfE advises that this error will be fixed by regulator amendment in 2024.

A.2.2.2 Climate Change (Unique Emissions Factors) Regulations 2009 (SR 2009/286)

Date of assent: 28 September 2009

Latest version: 1 February 2023

Administered by: Ministry for the Environment, but powers given to the Environmental Protection Authority.

The Climate Change (Unique Emissions Factors) Regulations 2009 (UEF Regulations) is a key piece of regulation in the relationship between the NZ ETS and landfill gas generation, capture and destruction. It sets out the key calculations and methodology by which 'waste participants' (in this context disposal facility operators) can determine a unique emissions factor for their facility (if they choose to).

It is worth noting that while incineration of waste with energy recovery is not considered a disposal facility under either the WMA or the CCR Act, it is captured through sections 18 -20 of the UEF Regulations, as it is considered a stationary energy activity. Review of this is outside of the current scope, however.

Section 6A sets out the criteria for the classes of waste for which a unique emissions factor may be used. This can be either all of the waste in a disposal facility, or waste from a particular source or sources that are disposed of at the disposal facility.

This provision allows for disposal facilities to adjust their overall liabilities by providing more accurate accounting for different types of waste entering the facility. For example, if a large quantity of inert waste is disposed of at the facility, this can be specifically accounted for and emissions liabilities for this tonnage would be calculated according to the specific UEF. Section 6A leaves it open as to how classes are defined, which means facilities can define their own classes.

Sections 23A through to 23D set out the methodology for disposal facilities to calculate and apply for a UEF. As this is a critical piece of regulation it is worth considering in some detail.

Section 23A makes provision for a waste participant to apply to the EPA for approval to use a unique emissions factor when calculating emissions in accordance with the Climate Change (Waste) regulations 2010.

Provision is made for two types of UEF:

- A waste composition UEF (UEFwc) for a class of waste (refer above), which can be used when calculating gas generation from the disposal facility. This must be done in accordance with section 23B in relation to waste composition or if the disposal facility has an LFG system, in relation to 23C or 23D.

- A gas capture and destruction UEF, which results from the calculation of a rate of capture and destruction at the disposal facility. This must be done in accordance with section 23C.

Section 23D is applied where the disposal facility operator wishes to apply for both a composition UEF and capture and destruction UEF.

Section 23B sets out how a facility must calculate a waste composition UEF if they choose to apply for one.

The core elements of this process are that they have to carry out at least 2 composition surveys of at least one week duration each, and the surveys must be at least 3 months apart and less than 12 months apart. The composition surveys must be done in accordance with Procedure 2 of the Solid Waste Analysis Protocol 2002 (SWAP) (refer A.2.3.1 for further detail on the SWAP).

The SWAP must record the fraction by weight of different components of waste with the biodegradable organic fractions broken down. The components used and the assumed tonnes CO2e per tonne of waste are as follows:[87]

Table 9-1: Components of Waste and Assumed Tonnes CO2e per Tonne of Waste

Composition Component	Assumed Tonnes CO2e per Tonne of Waste
garden waste:	1.68
nappy and sanitary waste:	2.016
all putrescible waste other than garden waste:	1.26
paper waste:	3.36
sewage sludge:	0.42
timber waste:	3.612
textile waste:	2.016
other waste (including plastics, ferrous metals, non-ferrous metals, glass, rubber, rubble, concrete, and potentially hazardous waste); and	0.0

The composition UEF for the facility is obtained by multiplying the proportion of each of the waste categories obtained from the SWAP surveys by the specified CO2e content and adding all of these together.

Section 23C sets out the requirements relating to application for unique emissions factor for an LFG collection and destruction system. In essence the key requirements are:

- Representative measurements of the volume of gas captured and destroyed have to be carried out over the period of one year
- Representative samples of the LFG collected have to be taken and tests carried out to determine the concentration of methane
- Using the above data, the quantity of methane conveyed to destruction equipment is then calculated

[87] Taken from the 2023 version of the regulations.

- The amount of methane that it is expected to be generated in the year is then calculated [as stipulated by section 23C (2)]. This is done in accordance with either the IPCC waste model or another equivalent first-order decay model. The modelling has to cover the life of the facility and include all areas that convey gas to the destruction equipment.
- Under 23C (2) the first order decay model should use actual annual waste composition and tonnage data where this is available. If limited data is available but it covers all the areas of the landfill, uses an appropriate methodology, and there has been no material change in the composition, then interpolated data can be used for any missing years. Failing this, landfills must use the default waste composition figures set out in Schedule 3 (noted below). Other key parameters in relation to the calculation of LFG generation stipulated include the following:
    - a split of 50:50 by weight between garden and other putrescible waste must be assumed when inputting historical or interpolated data; and
    - the estimated time for anaerobic generation to commence at the disposal facility or other area is 6 months; and
    - the following inputs must be used to the extent relevant when applying the model:

Parameter	Input
Methane correction factor	1
Fraction of degradable organic carbon (DOC) that degrades to methane	0.5
Fraction of LFG by volume that is methane	0.5
Oxidation factor	10 %
Density of methane at normal temperature and pressure	0.668 kg per cubic metre
Equivalent methane generation potential	As per the third or fourth column of Schedule 3
Decay rate constant	As per the fifth column of Schedule 3

- Next, the efficiency of the LFG collection and destruction system is calculated (section 23C (1)(f-g). This is done by multiplying the destruction efficiency of the LFG destruction equipment by the total tonnes of methane conveyed to the destruction equipment and dividing it by the estimated tonnes of methane generated at the site. Under the regulations the resulting figure cannot be greater than 0.9 (i.e. 90 percent gas capture and destruction).
- Finally, the UEF is calculated. This is done by subtracting the figure for the efficiency of the LFG collection and destruction system from one and then multiplying this by the default emissions factor value, (which is currently hard coded into the regulation as 0.91 tonnes of CO_2e per tonne

of waste). This means that the regulation needs to be updated every time a new DEF is calculated.

The reality is that most landfills do not have good historical composition data and so are using the default values set out in Schedule 3 of the regulations. If the composition is significantly different this could lead to substantial inaccuracies in the calculation of gas generation relative to what is actually generated.

Section 23D makes provision for waste participants to choose to use their own waste composition UEF (calculated under 23B) when calculating the landfill gas capture and destruction UEF (using the procedure in 23C). In other words, they can substitute the DEF figure of 0.91 noted above for a composition figure they have calculated (under 23B).

All the calculations need to be submitted to a registered verifier before the calculation is used to determine the tonnes of CO2e for which the disposal facility is liable under the Emissions Trading Scheme.

Sections 24 through to **34** set out the requirements for verifiers and process to become verified and surrender verifier status.

Schedule 1 sets out the emissions factors and thresholds. In relation to waste the key ones are:

Destruction factors (Schedule 2 in regs)

Destruction equipment	Destruction **factor**
Open flare	0.5
Enclosed flare	0.9
Internal combustion engines, gas turbines, and boilers	0.9

First-order decay model parameters (Schedule 3 in regs)

Waste stream component	Default waste composition data (SWAP)	IPCC DOC	Equivalent methane generation potential Lo (m^3 CH_4/tonne)	Decay rate constant k
Garden	5.7 %	0.20	100	0.100
Nappies and sanitary	2.5 %	0.24	120	0.100

Waste stream component	Default waste composition data (SWAP)	IPCC DOC	Equivalent methane generation potential Lo (m^3 CH_4/tonne)	Decay rate constant k
Putrescibles other than garden waste	9.0 %	0.15	75	0.185
Paper	5.9 %	0.40	200	0.060
Sewage sludge	1.9 %	0.05	25	0.185
Timber	12.6 %	0.43	215	0.030
Textile	5.0 %	0.24	120	0.060
Inert	57.3 %	0.00	0	0.000

There are a number of issues with the methodologies as set out in the regulations. A brief discussion of these is provided here.

Perhaps the most fundamental issue is that under section 23D, disposal facility operators can chose whether or not to use a default waste composition EF or use their own waste composition UEF when calculating a landfill gas capture and destruction UEF. This means that operators can choose to use whichever emissions factor is going to give them the most favourable gas capture rate, instead of which is most accurate. In our view a relatively simple solution would be to simply require all facility operators applying for an LFG capture and destruction UEF to use a waste composition UEF, and that the default EF should only apply where there is no LFG UEF being used.

Another issue is that the composition DEF, LFG destruction emission factors, and first-order decay model parameters are all 'hard coded' into the regulations. This requires regulations to be updated any time a new value may be determined. A more flexible and efficient method would be gazetting the latest figures annually and to reference the gazette notice in the regulations.[88]

A further issue with the current regulations (which was noted above) and which illustrates the issue with encoding values in regulation is that the DEF value is different in the Climate Change (Waste) Regulations 2010, and the Climate Change (Unique Emissions Factors) Regulations 2009 (which was a result of an error from updating the regulations at different times).

Another, perhaps controversial, issue is the allowance of a maximum of 90 percent gas capture and destruction efficiency. As indicated in our international review, this level of efficiency is higher than has been reliably verified in the highest performing international systems. From the latest gazette notice it can

[88] It is worth noting that for example the commonly accepted figure for global warming potential (GWP) of methane has regularly been revised over recent years. A different GWP value impacts the value of the EF that is calculated.

be calculated that 10 out of 19 disposal facilities report 90 percent gas capture and destruction efficiency.[89] It could be argued that the maximum allowable efficiency should be in line with the highest international rates. On the other hand, high rates of landfill gas capture are desirable, and operators should be incentivised to push the boundaries of the technology to maximise gas capture. If the cap of what can be claimed is set too low, then operators will not be incentivised to invest in the highest performing landfill gas systems or to innovate to improve capture. One option could be to set a lower nominal maximum but allow exceptions if a higher standard of proof can be provided to verify the capture rate.

A.2.2.2.1 Unique Emissions Factor Gazette Notices

Whenever a UEF is added or updated it is officially gazetted by the Environmental Protection Authority. The latest gazetted UEFs can be found here: Notice of Approval of Unique Emissions Factors - 2023-au3444 - New Zealand Gazette

Because the gazette in only updated when a new UEF is applied for it is necessary to go back several years to find UEFs for all the facilities with gas capture and destruction systems. To our knowledge the only requirement in regulation to update UEFs is if there is a 'material change' (Section 23C(2)(b)(i)(B)). There is however no definition of this or how this is to be monitored or determined (although it is understood that MfE may provide guidance to operators as to what constitutes a 'material change'). There is no requirement to update UEFs on a regular basis (except where there has been a 'material change' to composition which not defined), and no expiry date on UEFs. This means that facilities are only incentivised to update their UEFs if they show an improvement in gas capture relative to previous UEFs.

A.2.2.3 Climate Change (General Exemptions) Order 2009

Date of assent: 30 November 2009

Latest version: 1 January 2022

Administered by: Ministry for the Environment, but powers given to the Environmental Protection Authority.

This regulation provides some exemptions for small remote facilities, and facilities disposing of waste from a closed landfill.

Under section 12A of the Climate Change (General Exemptions) Order 2009, ETS obligations do not apply to landfills that have been in operation since before 1 January 2012 and either:

- dispose of less than 1,000 tonnes of waste per year and are located at least 150 km away from the nearest modern landfill by land; or
- dispose of less than 500 tonnes of waste per year and are located at least 75 km away from the nearest modern landfill by land; or
- are located at least 25 km away from the mainland for offshore islands.[90]

Section 13A provides a specific exemption for Fox Clacier landfill, while 13B provides an exemption for waste from a closed landfill that is transferred to a participating facility for disposal. This exemption recognises that operators that received waste from old landfills that are being remediated should not face NZ ETS obligations for waste that has already technically been disposed of.

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[89] Notice of Approval of Unique Emissions Factors - 2023-au3444 - New Zealand Gazette
[90] Waste | EPA

For further detail refer to sections 12A, 13A, and 13B of the Climate Change (General Exemptions) Order 2009.

The quantities of material that fall under these exemptions are low, and would not be expected to

A.2.2.4 Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (SR 2004/309)[91]

Date of assent: 6 September 2004

Latest version: 1 September 2020

Administered by: Ministry for the Environment, but powers given to Regional Councils under the RMA.

National environmental standards have been advocated by industry to give both a level playing field across regions and certainty in decision making under the RMA.

The Resource Management (National Environmental Standards for Air Quality) Regulations 2004 outlines regulations (26 and 27) pertaining to the control of greenhouse gas emissions at landfills. These regulations apply to landfills meeting specific criteria, including size and waste composition. Additionally, it states that if a more stringent rule, resource consent, or bylaw exists, it takes precedence over these regulations.

- **The specific criteria include:**

- **Landfill Criteria**: Landfills[92] covered by these regulations must have a total capacity of at least 1 million tonnes, contain at least 200,000 tonnes of waste, and are or likely to be accepting waste that consists of 5 percent or more (by weight) of putrescible or biodegradable matter.
- **Exemptions**: Landfills meeting the above criteria are exempt from regulations 26 and 27 until October 8, 2007, if they were operational on October 8, 2004, contained the required amount of waste, were accepting waste, and did not operate a gas collection system. Regulations 26 and 29 do not apply to a cleanfill[93]

Regulation 26 - Control of Gas

- **Discharge Prohibition**: No person is allowed to discharge gas into the air from a landfill.
- **Exception**: This prohibition doesn't apply if the landfill has a gas collection system meeting specific requirements, including methane emission limits of 5000ppm from the surface of the landfill and that the gas collected is flared or used as a fuel or to generate electricity.

Regulation 27 - Flaring of Gas

- If gas is collected and destroyed (must have):
- Flame arrestor
- Backflow prevention device
- Automatic isolation system
- Continuous automatic ignition system

[91] Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (SR 2004/309) (as at 01 September 2020) 3 Interpretation – New Zealand Legislation
[92] Note: under Section 3, landfill is defined as "a site where waste is disposed of by burying it, or placing it upon land or other waste", and waste is defined as "substances or objects that are disposed of or intended to be disposed of". These definitions are different to the definitions used under the WMA.
[93] A cleanfill is defined as: (a) a landfill that accepts only material that, when buried or placed, will not have an adverse effect on the environment; (b) does not include a landfill that contains 5% or more (by weight) putrescible matter

- Flue gas retention time of 0.5 seconds
- Minimum burning temperature of at least 750°C
- Permanent temperature indicator
- Sampling ports for emission testing
- Operation:
- Principal flares must be operational at all times, except during maintenance or malfunction.
- Backup flares are used only when principal flares are not operational.
- **Regulation 28 - Precedence of Stringent Rules**
- This regulation states that if there are rules, resource consents, or bylaws that are more stringent than regulations 26 and 27, those more stringent regulations take precedence.

In essence, the document establishes strict guidelines for controlling gas emissions from landfills, particularly through the use of gas collection and flaring systems, and it acknowledges that if there are stricter local regulations in place, they override these national standards.

A.2.3 Standards & Guidelines

A.2.3.1 Solid Waste Analysis Protocol (SWAP)

The SWAP is specifically mentioned in the Climate Change Unique Emissions Factors Regulations (2009) as referring to the Solid Waste Analysis Protocol 2002 published by the Ministry for the Environment in March 2002. At present there does not appear to be to be any provision for this to refer to more recent versions, therefore the SWAP 2002 is referenced here. As the SWAP is a pivotal tool in determining composition for the purposes of calculating UEFs, it is important that it is fit for purpose.

A.2.3.1.1 Description

In broad terms Procedure Two consists of:

- weighing all or most large vehicle loads entering the site and a proportion of smaller vehicle loads
- sampling a proportion of incoming loads in each vehicle category, (large or small) and sorting and weighing a sample of refuse from these into 12 primary categories
- statistical analysis and reporting

Procedure Two also provides for the use of visual classification to be used at 'larger facilities' to economically extend the dataset and potentially increase precision. It recommends that sort and weigh only be used but that if a visual classification is used it must be in conjunction with sort and weigh.

The SWAP outlines procedures for

- Survey design
    - Location
    - Load and source categories
    - Sampling plan, including tiered sampling, allocation of sampling effort and number of samples
    - Seasonality
    - Disposal site catchments
- Set up and training
- Survey execution including data recording, weighing vehicles, sorting and weighing, sub sampling, moisture content and visual classification
- Data analysis and reporting, including appropriate statistical analysis.

A.2.3.1.2 Commentary

Although the current version of the SWAP dates from 2002, there have been a couple of attempts to revise it, but neither of the versions has yet been officially published.

Issues with the 2002 version of the SWAP (Procedure Two) that have been noted include the following:

- The procedures are relatively time consuming and expensive to administer
- There are significant health and safety issues associated with the physical sorting of waste at landfill sites
- The subsampling method recommended in the SWAP is impractical and leads to bias in sample selection[94]
- The classifications used require updating to better align with contemporary needs
- The complexity of the procedures means there are few practitioners, which limits the capacity to undertake more SWAPS and gather more data
- As stated in the SWAP, the greater sample size achievable by visual surveys than sort and weigh audits (for an equivalent cost) can improve the precision of estimates
- The practical experience of some leading practitioners is that visual classifications are not only more practical and safer in relation to procedure two but, by virtue of enabling a much greater sample size, are able to generate more reliable composition data, in particular for primary classifications. Under the current SWAP visual only surveys may not be considered to be compliant with the 2002 guidelines (as required in the regulations).[95]

It is noted that, strictly speaking, according the 2002 SWAP, visual surveys should only be used to supplement sort and weight surveys, and that legally when determining a UEF Procedure Two of the SWAP should be followed. However, in practice the EPA has accepted visual surveys. There is therefore a disconnect between the written requirement and practice, which should ideally be addressed.

In undertaking the most recent review of the SWAP in 2021-2022, the Ministry for the Environment noted that the revised SWAP should "ensure that it facilitates the collection of consistent and reliable data on solid waste that can be used in waste emissions modelling and improves the collection of composition data".

The revised draft SWAP 2022 (unpublished) provided a specific section for undertaking a SWAP for the purposes of calculating a UEFwc.[96]

A.2.4 NZETS Operation

A.2.4.1 Emissions Budgets and Unit Supply

The Climate Change Response (Zero Carbon) Amendment Act 2019 introduced emissions budgets, the cap-and-trade system, and government auctioning.

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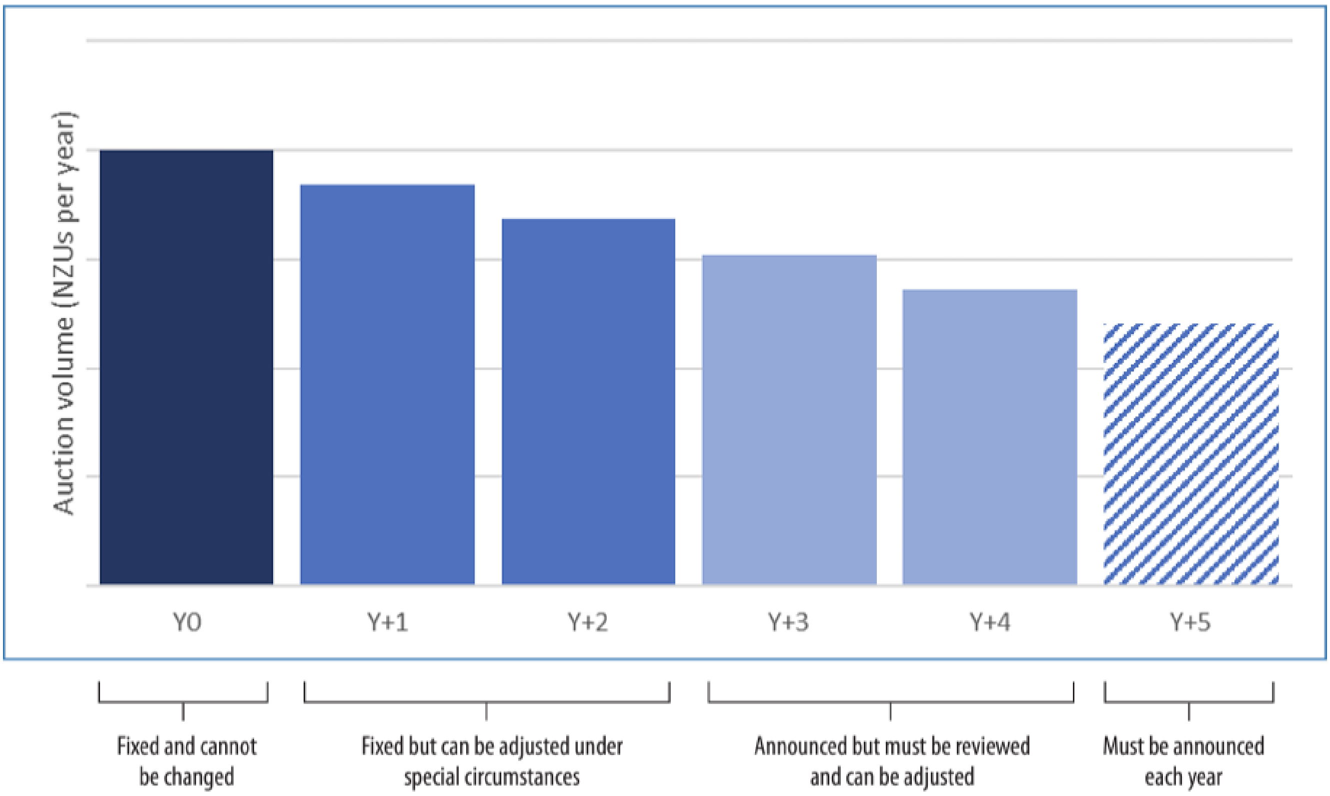
[94] The recommended method in Figure 5.6 of the SWAP 2002 involves spreading out a load to a depth of 0.5-075 metres deep and a worker walking across the load and collecting samples of 20 kg from randomly determined points. For a large truck, such as a transfer station bulk-haul vehicle, spreading the load out would take up 100s of sq metres, which is not practical. In addition a worker should never be required to walk over waste. This method may was considered suitable in 1992 when it was conceived and most waste was transported in trailers and small trucks. It's totally impractical for the current waste environment, where ~80% of waste arrives in landfills in 20 tonnes loads from transfer stations.
[95] The UEF regulations do not specify that visual surveys are not permitted and the ultimate decision is up to the recognised verifier.
[96] It is understood that the reason for delay in publication of the draft SWAP 2022 is concern over the statistical validity of the proposed procedures.

New Zealand's emissions budget is the total quantity of emissions that are allowed to be released during an emissions budget period. Each emissions budget covers a period of five years (except the first emissions budget which covers the period 2022-2025). The amounts allowed under each budget decrease over time aiming towards achieving New Zealand's legislated 2050 emissions reduction target of net zero (excluding biogenic methane, with a target of 24-27 percent reduction).[97]

The supply of units is determined by the government for a 5-year period and is intended to decline over time in a manner consistent with Aotearoa's emissions budgets and 2050 target. The government decides the settings for unit supply for five years in advance and they are extended by one year each year. Supply is fixed for the first year of a budget period but settings for any of the subsequent four years can be adjusted (subject to constraints). This is shown in the figure below.

Figure 9-1: Five Year Rolling Process for Setting Unit Supply



Source: Motu (2022) A Guide to the New Zealand Emissions Trading Scheme: 2022 Update

NZUs are issued via government auctioning, free allocation (currently limited to output-based free allocation in the industrial sector) and entitlements for forestry and industrial removals. The auction process is set out briefly in the following section.

A.2.4.2 NZU Auction Process

As noted above, emitters can obtain NZUs by purchasing them on the secondary market or by generating their own production of NZUs (for example, by planting forestry). A further way that NZUs can

[97] Emissions budgets and the emissions reduction plan | Ministry for the Environment

be obtained is by purchasing them at government auction. The government auction is a mechanism to regulate the supply of units in the market.

The government conducts four NZ ETS auctions per year. The price of NZUs is not fixed - rather, it is dependent on supply and demand (subject to certain regulatory limits and price controls, intended to maintain market stability and prevent excessive price fluctuations).

The government sets these limits and controls five years in advance but revisits them every year to ensure they align with New Zealand's emissions goals, the Paris Agreement, and the ultimate aim of achieving net-zero emissions by 2050.

Each auction has:

- A unit limit: This is the maximum number of NZUs available for purchase in that auction
- An auction price floor: This is the minimum price for which an NZU can be sold.

All participants in the auction pay the same price for NZUs, called the auction clearing price.[98] Units that are unsold in one quarter can be rolled over to the next auction within that calendar year. Any unsold units at the end of the calendar year are cancelled.

Recent Auction Impacts

Before 2023, there was strong demand for NZUs with the price reaching as high as $88.50 per NZU. However, in 2023, the carbon market was extremely unpredictable; with carbon prices fluctuating significantly, dropping to as low as $34 per NZU at one stage. It is worth noting that in the 2023 auctions the reserve or floor price was not met, and so the auctions failed to clear (i.e. no units were sold). The most recent auction for which there is data available at the time of writing was in December 2024 and resulted in a partial clearance (4,032,500 sold at the price floor of $64)[99].

A.2.4.3 Carbon Price

Apart from the quantity of landfill gas emitted, the other component of the calculation of a disposal facility's financial liability under the NZ ETS is the price of an NZU. The NZU price is ultimately critical in providing sufficient incentive for disposal facility operators to invest in gas capture technology that provides high levels of capture. It is worth noting that disposal facility operators may not be fully incentivised to decrease emissions (and hence the cost of their obligations) to the extent

hat they can pass NZ ETS costs on to customers. The effectiveness of this incentive therefore depends in part on the ability to pass on these costs.

The value of NZUs in the NZ ETS has fluctuated over time. NZUs initially traded around $15-20 per tonne when in launched in 2010 – 2011 before the price collapsed between 2012 -2015 to between $2 and $10 a tonne. They then had a period of relative stability between 2017 and 2020 of around $20 to $30 a tonne. The price briefly rose to $90 when the government revised the rules around what units were eligible and limited units to NZ forestry. The price was reasonably stable around $60 to $70 a tonne across most of 2023. However, with a recent partial clearance (i.e. the minimum price was reached but not all units were sold) of the most recent government auction the spot price has dropped to $54/tonne.[100]

The chart below shows the trading price between 2010 and 2020. As noted, for a number of years, it traded well below $20.

[98] Understanding NZETS auctioning: The basics and upcoming changes (buddlefindlay.com)
[99] nzets-interim-auction-monitor-report-december-2024.pdf
[100] Carbon Match accessed 24/03/24

Figure 9-2: NZU Trading Price 2010 - 2020

Source: [Getting to know The New Zealand Emissions Trading Scheme - NZ Carbon Farming]()

From 2020 through to 2022 it increased steadily to a high of over $85 due largely to changes made to the types of offsets that are eligible under the ETS. The chart below shows the increase in the NZU price from 2020 to 2022.

Figure 9-3: NZU Trading Price 2020 – 2022

Source: https://www.commtrade.co.nz/

As noted above New Zealand units (NZU)[101] currently change hands for between $50 and $60, with prices at $56.25 at the time of writing[102]. This is notably lower than the price of around $65 it was trading for during most of 2023.

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[101] NZUs are carbon credits that are officially accepted to offset liabilities under the NZ ETS

[102] According to carbon prices on www.carbonforestservices.co.nz and https://www.carbonmatch.co.nz/

Some of the large changes in the price of NZUs over time have reflected the different policy approaches that have operated at various points. Some of the key policy influences included:

- Initially, all emissions and removals were assessed at one unit per tonne.
- In 2009, the unit obligation for non-forestry sectors was reduced to one unit per two tonnes of emissions. This was intended to moderate the system's cost during a time of recession. The two for one obligation was extended indefinitely in 2012.
- After 2016 the two for one obligation for non-forestry sectors was phased out as follows: one unit per 1.5 tonnes (67 percent) in 2017, one unit per 1.2 tonnes (83 percent) in 2018 and one unit per tonne (100 percent) from 2019 onward. This phase out of the obligations applied to disposal facilities.
- Up until mid-2015 international units could be purchased as equivalent to NZUs. This meant that the domestic supply was not restricted, and this contributed to the low price around this time and allowed domestic emissions to continue increasing[103].
- Since mid-2015 only NZUs have been available for surrender, which restricted the supply and resulted in increases in the unit prices.
- The Climate Change Response (Zero Carbon) Amendment Act 2019 introduced carbon budgets, the cap-and-trade system, and government auctioning. This was implemented from the start of the first budget period in 2022 and was intended to act to reduce the supply of units over time while providing a mechanism for government to have some control over supply and therefore price.

While government policy has had a major influence on the operation of the carbon market, the carbon price in New Zealand is influenced by a complex interplay of government policy with market dynamics, international factors, economic conditions, technological innovation, and climate policy ambition.

A.2.5 New Zealand Waste Disposal Market Detail

A further and final factor that impacts on how LFG is managed in New Zealand relates to the operation of the waste disposal market.

The New Zealand solid waste disposal market has moved through a gradual transition from local government to private enterprise dominance. Through most of the twentieth century, local government owned all of the waste infrastructure, such as landfills and transfer stations, and provided rates-funded kerbside rubbish collection services to residential properties.

Local government responsibilities for waste management originated with the Health Act 1956, which *obliged* councils to provide sanitary works for the collection and disposal of waste for the purpose of public health protection.

While many of these services were contracted out to private enterprise, local authorities maintained ownership of the assets and were the dominant player in the residential waste collection and waste disposal markets. Private waste companies were primarily involved in commercial/industrial collections and contracting their services to councils.

[103] Motu (2022) A Guide to the New Zealand Emissions Trading Scheme: 2022 Update

The role of local councils changed when the Local Government Amendment Act 1979 inserted provisions relating to waste collection and disposal that had been absent in the original Local Government Act 1974. Under the Act, territorial authorities were *permitted*, but no longer obliged, to provide for the collection and disposal of waste, with the work being executed either by contract or by the territorial authority.

In this era, solid waste was disposed of at a large number of small council-owned landfills, which were poorly engineered by modern standards. A 1987 Department of Health survey identified 462 landfills, while MfE's 1995 *National Landfill Census* identified 327 landfills. [104]

The Resource Management Act 1991 (RMA) also had a significant impact on the expansion of the private waste disposal market. Tighter environmental regulations under the RMA resulted, over a period of a decade, in many of the smaller council-owned landfills throughout the country closing and being replaced by regional landfills, which are largely privately owned.

From the 327 landfills in the MfE's 1995 *National Landfill Census*, the MfE's *The 2002 Landfill Review and Audit* identified 115 landfills, and *The 2006/07 National Landfill Census*, 60. As of the time of writing MfE reports that there are 40 open Class 1 landfills.[105]

Two currently overseas-owned companies, WM (formerly Waste Management NZ Limited) and Enviro NZ, are the dominant players in the New Zealand waste disposal and collections sectors, particularly in the North Island. Currently WM and EnviroNZ either wholly or partly own the six largest Class 1 landfills in New Zealand, which accounted, in total, for an estimated 73 percent of all waste to Class 1 landfills.

A.2.5.1 Key Drivers for Private Owners

Private ownership of landfills in New Zealand has resulted in a range of different impacts. These include the following:

- A movement towards larger regional landfills
- Competitive regional markets for disposal
- The need for 'flow control'
- Significant improvement in the engineering and management of landfills

The drivers for each of these impacts is discussed briefly in the subsections below.

A.2.5.2 Movement Towards Larger Regional Landfills

As noted, engineering a modern sanitary landfill requires significant capital investment. Because of this large capital investment individual council ownership of/investment in small landfills became increasingly uneconomic. There have also been a lack of appropriate mechanisms and structures that would facilitate joint local authority ownership of landfills. In general, private enterprise has been better structured to access sufficient capital and expertise to build larger regional landfills.

Generally speaking, the costs of development and establishment do not increase in direct proportion to the size of the landfill. For example, site selection and investigation, geotechnical investigations, community consultation and consenting, leachate and gas collection systems all have high levels of fixed cost.

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[104] Ministry for the Environment (MfE), *1997 National Waste Data Report*. Ministry for the Environment, Wellington
[105] Waste facilities and disposal | Ministry for the Environment

Similarly, there are economies of scale in operation with staffing, machinery and compliance costs all likely to deliver lower per unit costs. In this context, large landfills are also able to invest more in gas collection and, combined with lower surface area to volume, are generally able to claim higher gas capture rates which offset their costs of NZ ETS compliance.

This means that, in effect (and all else being equal), the larger the landfill, the lower the cost per tonne of waste disposed of.

These factors provide a clear economic incentive to build the largest landfill practical. The presence of large regional landfills that are well-engineered and offer relatively cheap disposal has meant that they are able to out-compete smaller local landfills that are within their catchment.

It is worth noting as a counterpoint to the move towards larger regional facilities that there have been challenges in gaining consents for new large facilities or extending existing facilities (with the Waste Management owned Tirohia facility and their proposed Dome Valley facility being examples).

A.2.5.3 Competitive Regional Disposal Markets

Throughout most parts of New Zealand there is limited access to Class 1 landfills. The main exceptions to this are Wellington[106], Waikato, and Auckland. In these areas landfill customers have a choice of disposal and so the landfills will compete for customers. Within this environment, the price of disposal is a key factor to landfills being able to maintain market share.

A low cost per tonne will make the landfill competitive with alterative disposal and recovery options for that material (including enable it to attract waste from a wider catchment). This will help ensure that quantities landfilled can be optimised to ensure return on investment.

A low cost per tonne for landfill also provides a significant commercial advantage for companies that are vertically integrated. They are able to use the low internal cost of disposal to help ensure that their other services (collection, transfer station etc.) are competitive.

A.2.5.4 Flow Control

One of the effects of private sector investment in large infrastructure is that a reliable return on investment is strongly incentivised. The value of a large landfill is in the airspace it contains – in effect the volume than can be sold to fill up with waste. If the value of the airspace is not realised, then the return on investment will be low. For a large landfill to work financially it therefore requires a certain tonnage to be deposited. In effect the faster the landfill is filled up, the quicker the return on investment.

Large landfills therefore not only result in lower disposal costs, but the lower disposal costs themselves help ensure that waste continues to be deposited in the landfills at the fastest rate that is operationally practical.

In other words, by their very nature, large landfills are designed and incentivised to capture as much waste as possible, and this runs directly counter to efforts at waste minimisation.

Another aspect of flow control is that the large waste companies (WM and EnviroNZ primarily) also have substantial share of the private household and commercial collection markets. This enables them to make decisions about what happens to material once it is collected. By controlling collections these companies have a mechanism through which they can maintain the flow of waste into their facilities.

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[106] The Wellington landfills are all council-owned, and while there is some competition, it is more limited.

A.2.5.5 Summary of Disposal Market Factors

In summary the factors discussed above mean the landfill owners, in particular the large landfill owners, are highly incentivised to lower costs of landfilling as this help maintain market share, creates payback on capital investment, and provides a market advantage for vertically integrated companies. In this context, maximising the level of gas capture that can be claimed is a key component as this lowers cost and, even if the carbon price is high, this in effect serves to widen their level of competitive advantage over smaller, local facilities, as well as recovery options.

A.3.0 Stakeholder Engagement

A.3.1 Phase 1 Survey: Landfill Management Data

Working with MfE, Eunomia developed a stakeholder engagement survey which was distributed to landfill operators. Eunomia extracted the following information from the survey responses which was used to inform the gas capture calculations summarised in A.5.2.1.

The survey was administered by MfE and results provided to Eunomia.

The survey questions are shown below:

Q #	Question
1	What is the name of the landfill? - Landfill name
2	What is the physical address of the landfill? - Please write the physical address here
3	What year did the site open? - Year opened
4	What date was the consent issued? - consent
	Are there any materials specified as able to be collected at the landfill on the resource consent? - materials specified
	Are there any materials specified as not able to be collected at the landfill on the resource consent? - Please write your answer here
	When does the consent expire? - Consent expires
5	What is the remaining airspace at the landfill? - Please write your answer here
6	What is the estimated life of the landfill at current fill rates? - Estimated life of landfill
7	What is the expected closure date? - expected closure
8	What are the landfill characteristics? - Landfill characteristics

	What are the landfill characteristics? - Landfill characteristics (upload)
9	Please share the most recent waste composition information you have, by secondary SWAP classification and Activity Source if available. - Current waste composition
	Please share the most recent waste composition information you have, by secondary SWAP classification and Activity Source if available. - Please upload any supporting information for your answer above here
	How frequently has your landfill been audited for composition (by SWAP or similar method) since it opened? - Please write your answer here
10	Describe any key geographical features - Geographical features
11	What are the landfill management practices that impact on LFG generation and retention?
12	What are your passive LFG management systems?
	What are your passive LFG management systems? - How do they interact with active LFG systems? Please write your answer here
	% Area covered by active gas management system
13	Describe your installation plans for an active gas system
	Describe your installation plans for an active gas system - Upload supporting information here
14	Please describe your cell closure management practices that could impact fugitive emissions.
	What is the construction or composition of the capping used at the landfill? - Please write your answer here
	What is the cap depth? - Please write your answer here in centimetres

	Are closed/capped cells actively monitored for stability, erosion or cracking? - Please write your answer here
	Is there any history of cracking or erosion in or of capping materials? - Please write your answer here
	On what date(s) has capping been completed on cells in your landfill? - Cell one
	On what date(s) has capping been completed on cells in your landfill? - Cell two
	On what date(s) has capping been completed on cells in your landfill? - Cell three
	On what date(s) has capping been completed on cells in your landfill? - Cell four
	On what date(s) has capping been completed on cells in your landfill? - Please enter any other information on capping dates here
	On what date was installation of your landfill gas capture system completed? - Enter date here
15	If you use engines to convert collected gas to electricity, what is the destruction efficiency of your landfill gas engines (%)?
	If you flare the landfill gas what is the destruction efficiency of your flares (%)? - Please write your answer here as a percentage
16	What is the average duration of annual engine downtime at the site (in %)?
17	When engine(s) are down for maintenance, is the gas flared, vented, or not recovered?

18	Describe your monitoring systems for fugitive emissions - Please write your answer here
19	What is the model in use on site to predict landfill gas generation? - Please write your answer here
20	What are the models key parameters?
21	What is the annual gas collected and destroyed in tonnes CH4 or m3/h at a specific CH4 concentration?
22	If your site generates and exports electricity, can you please provide annual data on electricity exported to the grid?
23	Has there been any unusual activity in the landfill in the past 10 years due to unforeseen circumstances?
24	What processes do you have in place to accommodate earthquake risks and ensure the LFG collection systems are not compromised in the event of an earthquake?
25	What costs have arisen to develop the most recent stage of gas capture infrastructure?
26	What costs have arisen to develop gas capture over the site's lifetime?
27	What costs have arisen for the site's operation in relation to landfill gas capture operation?
28	Do you have any other information or feedback on landfill gas capture systems and their use in Aotearoa that you would like to provide? - Any other feedback on the proposal

A.3.2 Phase 2 Stakeholder Interviews

A.3.2.1 Introduction

Phase 2 of the project focused on developing potential policy and regulatory options to address issues that have been identified with the current approach. To help ensure that the recommended policy options will be appropriate and effective for implementation in New Zealand, a stakeholder engagement process was undertaken. This process helped identify potential barriers to implementation and possible adjustments. Stakeholders were asked for their views on best practice examples, what should be included within the longlist of policy options, and consideration of barriers to successful implementation of these policy options that would need to be overcome. It is noted that any proposals for regulatory change will go through a full policy development process by MfE, including formal consultation and further targeted engagement with the sector.

A separate formal stakeholder engagement report has been provided to MfE and should be referred to for full details of the process.[107]

The purpose of the phase 2 engagement was:

- To consult with key stakeholders, including disposal facility operators and industry bodies, on potential policy options for reducing emissions from landfilling
- To solicit feedback on potential regulatory approaches, with a focus on identifying barriers and opportunities within New Zealand's existing regulatory framework
- To seek input on possible solutions including the potential consequences of different approaches to addressing the issues
- To identify key parties for involvement in any ongoing development and implementation of the project recommendations

A list of stakeholders to engage with was developed and agreed in consultation with the Ministry for the Environment. Stakeholders were contacted initially by e-mail or phone call and were provided with an explanation of the project and the information that was sought. A copy of a questionnaire was provided, and stakeholders were given the option of completing the questionnaire and sending it back and/or arranging a video call with one of the project consultants to go over the questionnaire or discuss any queries. In addition, Eunomia was invited to address meeting of the WasteMINZ Disposal to Land Sector Group Steering Committee, which took place on 29 November 2024.

Responses to questionnaires and feedback from the interviews were then collated and analysed.

A.3.2.2 Summary of Findings

The survey found a diversity of opinion, with landfill operators particularly focused on the role that well managed Class 1 facilities can play and seeking recognition for this as a legitimate option for management of organics, while others in the industry, in particular councils, saw management of organics in line with the waste hierarchy, with reduction and capturing value through diversion as key. There was common ground however in that the industry by and large would like to see an organic waste and LFG management regime that takes a more holistic approach and fairly and transparently reflects the risks and benefits of the various approaches to management of organics (i.e. landfill with and without gas capture, energy from waste, anaerobic digestion, composting etc.).

While the current regime is seen to be broadly functional and is viewed as having led to improvements in gas capture rates, there was also recognition that the current system has room for improvement and has led to some unintended and less desirable outcomes such as: incentivising disposal of waste (including organic wastes) in less well engineered landfills, the use of DEFs for calculation of NZETS obligations which do not accurately reflect actual composition, variations in the standards of LFG practice between sites, and inconsistency between calculations used for ETS purposes and for the GHG inventory.

Overall, our analysis identified the following key themes:

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[107] Eunomia (2025) Stakeholder Engagement Report - Phase 2 For the review of landfill gas capture regulatory system and options assessment for effective emissions abatement. Prepared for the Ministry for the Environment, March 2025

General Organic Waste Management

- Respondents, in particular councils, indicated broad support for the principles of the waste hierarchy.
- A policy and regulatory regime should take account of the complexities of cost and benefits of different approaches to organic waste management (including GHG impacts, soil health, circular use of materials etc.) rather than characterising certain technologies or methods as 'good' or 'bad'.
- Organic management options should be evaluated on a case-by-case basis, taking account of local/regional conditions, and that disposal to well-engineered Class 1 landfill is a legitimate the option to be considered.

Application of the Waste Levy and ETS and other regulation

- There should be consistent requirements for all types of disposal facilities accepting organics and/or organic waste should not be permitted for disposal in Class 2-5 type facilities.
- Moving from a levy regime based on landfill type to a flat rate or to a levy rate based on material type would help avoid issues with material being incentivised to be disposed of at less well engineered Class 2-5 facilities.
- Any change to regulation or policy need to be justifiable and not simply impose greater administrative burden or costs for minimal improvement. A relatively common view among private operators was that, while flawed, the current regime has led to marked improvements in gas capture rates.
- Stricter regulation and or higher costs on Class 1 disposal without corresponding measures on other forms of disposal (or even recovery) could have perverse consequences by incentivising material to go to less well managed sites or processes.
- Blanket 'bans' for material to Class 1 are not realistic as there will be some streams of material that have no practical alternative (such as biosecurity waste, disaster waste, or contaminated material). Any ban would have to have exceptions and practical ways of monitoring and enforcement that were not onerous and did not put unrealistic requirements on landfill operators (such as inspecting every load).
- Alternative measures that incentivise higher LFG capture rates should be considered (such as the Australian ACCU scheme.

Measuring and Reporting

- Greater standardisation around how LFG is measured and reported, including training and upskilling and implementation of standards nationally - for practitioners and regulators.
- There was some support among landfill operators for removal of the 90% gas capture cap to incentivise maximising LFG capture.
- Improve the DEF and associated processes to enable a low-cost compliance option that more accurately reflects local situations.
- Consideration should be given to improving alignment between the NZETS measurements and reporting and IPCC guidance.
- Introduce a mechanism to allow LFG to be accounted for over the life of the landfill to smooth annual fluctuations in quantities and capture rates.

Other Comments

- Changes could have unintended consequences and should be introduced with plenty of lead in time to allow industry time to adapt and/or for there to be a course correction if there are issues.
- Consideration should be given to how biosolids that go to monofils are managed and reported on within the NZETS and GHG reporting regimes, as this material is not currently accounted for.
- Class 1 landfills are designed to accept a certain amount of organic wastes, and reducing the quantities significantly could impact the ability to capture and destroy carbon emissions over time.

A.4.0 Mass Flow Modelling Approach

The overview of approach is described in Section 7.2**Error! Reference source not found.**. Below are details of the data inputs and assumptions that support feed into the analysis.

A.4.1 Baseline Tonnages of Waste, per Destination

The amounts sent to treatment and disposal destinations are outlined below, including Class 1 and other class landfills, recycling, composting (including AD), and other disposal. A table per source is provided: residential, mixed ICI and other wastes (C&D and heavy industry) sources. The source of the tonnages are derived from previous work funded by the Ministry for Environment[108].

Table A- 1: Kerbside Waste Destinations (kt)

Material	Class 1	Class 2-4	Recycling	Composting	Other Disposal (e.g., monofills, farms)
Paper R	83	1	195	0	0
Paper NR	22	0	0	0	0
Plastic R	22	1	25	0	0
Plastic NR	105	6	0	0	0
Kitchen waste	308	0	0	35	0
Greenwaste	172	13	0	239	0
Non-compostable	25	0	0	0	0
Other Organics	28	0	0	0	0
Ferrous metal	34	1	80	0	0
Non-ferrous metal	12	1	10	0	0
Glass	40	0	147	0	0
Textiles	78	3	18	0	0
Nappies and sanitary	95	0	0	0	0
Timber R	2	0	0	0	0
Timber NR	53	0	0	0	0
Inert	94	6	0	0	26

[108] [108] Eunomia (2024) New Zealand National Recycling Rate Issues and Options. Report for Ministry for the Environment

Potentially Hazardous	17	0	0	0	0
Total	**1,191**	**32**	**475**	**275**	**26**

Table A- 2: Mixed ICI Waste Destinations (kt)

Material	Class 1	Class 2-4	Recycling	Composting	Other Disposal (e.g., monofills, farms)
Paper R	96	6	354	0	26
Paper NR	18	0	0	0	0
Plastic R	9	2	53	0	250
Plastic NR	158	12	0	0	17
Kitchen waste	72	0	0	272	0
Greenwaste	40	6	0	111	0
Non-compostable	14	6	0	0	0
Other Organics	13	0	0	1,406	1,033
Ferrous metal	29	3	578	0	61
Non-ferrous metal	7	3	57	0	0
Glass	22	1	29	0	1
Textiles	103	10	10	0	1
Nappies and sanitary	39	0	0	0	3
Timber R	19	2	0	0	0
Timber NR	42	7	0	0	1
Inert	151	353	514	0	2,089
Potentially Hazardous	16	1	0	0	73
Total	**850**	**414**	**1,595**	**1,790**	**3,557**

Table A- 3: 'Other' (C&D and Heavy Industry) Waste Destinations (kt)

Material	Class 1	Class 2-4	Recycling	Composting	Other Disposal (e.g., monofills, farms)
Paper R	36	10	0	0	0
Paper NR	6	1	0	0	0
Plastic R	3	5	0	0	0
Plastic NR	56	29	0	0	0
Kitchen waste	13	0	0	0	0
Greenwaste	9	5	0	0	0
Non-compostable	2	5	0	0	0
Other Organics	33	0	0	0	307
Ferrous metal	26	3	68	0	0
Non-ferrous metal	3	5	7	0	0
Glass	11	4	41	0	0
Textiles	50	23	0	0	0
Nappies and sanitary	7	0	0	0	0
Timber R	56	25	97	0	0
Timber NR	156	75	0	0	0
Inert	417	3,112	525	0	24,393
Potentially Hazardous	584	0	0	0	0
Total	**1,470**	**3,301**	**737**	0	**24,701**

A.4.2 Forecasting Diversion Scenarios

More information can be found in appendix A.6.0, and in the main body within section 7.0.

A.4.2.1 Diversion Rates

The below rates are used to assess the level of diversion across the different policy intervention scenarios.

Table A- 4: Diversion Rates Used in Scenarios (based on level of intervention achieved across different years)

Scale of Intervention.	Lowest	Low-Mid	Mid	Mid-High	Highest
Paper Recyclable	14%	27%	68%	73%	77%
Paper non-recyclable					
Plastic Recyclable	23%	47%	73%	79%	84%
Plastic non-recyclable					
Kitchen waste	8%	15%	17%	50%	60%
Greenwaste	10%	20%	69%	78%	83%
Non-compostable					
Other Organics					
Ferrous metal	7%	13%	40%	50%	54%
Non-ferrous metal	16%	33%	64%	68%	72%
Glass	13%	26%	40%	42%	45%
Textiles	13%	25%	36%	41%	43%
Nappies and sanitary					
Timber Recyclable	21%	43%	52%	55%	60%
Timber non-recyclable					

Note: Lack of diversion rate indicates that the waste stream is not targeted for diversion. For example, a non-recyclable stream is assumed to not be targeted for diversion from Class 1 to recycling.

A.5.0 Environmental Modelling Approach

This section covers both the quantification of carbon impacts and impacts from key emissions to air which have the greatest impact on human health – which for waste treatment facilities are principally NOx, particulates, and ammonia.

A.5.1 General approach to carbon modelling

A.5.1.1 Approach to Biogenic Carbon

Biogenic carbon emissions are those that originate from organic material like food and garden waste, as opposed to the emissions coming from fossil carbon in oil-derived materials. It is often considered that biogenic carbon emissions need not be incorporated into total emissions, because they are 'short cycle', i.e. "only relatively recently absorbed by growing matter". [109] Note that methane emissions from organic material *are* included because they are considered to be anthropogenic in nature, whereas biogenic CO_2 emissions are in effect viewed as similar to or part of the natural carbon cycle.

This perspective follows the approach taken in developing the national inventories for climate change emissions, which countries submit on an annual basis to the United Nations Framework Convention on Climate Change (UNFCCC). Biogenic CO_2 emissions occurring from, for example, the combustion of wood and other organic items, as well as that arising the organic decay in ecosystems, are excluded from these annual inventories. The carbon incorporated within these items is assumed to have been sequestered from the atmosphere into the plant within the previous years' growth. Inclusion of both impacts is therefore considered to result in a double-counting of impacts. A similar approach has been taken in life-cycle assessments, which consider the global warming potential of systems over a 100-year period.

However, application of the above approach is problematic when accounting for landfill impacts, as a significant proportion of the biogenic carbon is not released as biogenic CO_2 (or as methane) but instead remains sequestered in the landfill; in this way, landfills act as an imperfect 'carbon capture and storage' facility. In contrast, all of the biogenic CO_2 emissions are released from incineration at the point of combustion. As such, the two systems are not being compared on a like-for-like basis where this approach is applied to considering emissions from residual waste treatment systems.

Therefore, this omission of short cycle biogenic carbon emissions is acceptable *as long as a carbon credit is applied for the biogenic carbon which is stored in a landfill*. If no adjustment is made, the exclusion of the biogenic CO_2 emissions will overestimate landfill impacts relative to other forms of treatment in which all the biogenic carbon is released as CO_2 into the atmosphere.

The use of such an approach is recommended by authors from the Technical University of Denmark (who developed the EASEWASTE model), and in Defra's modelling guidance. [110, 111] Despite often being omitted from similar analyses in the literature, a carbon sequestration credit is included in this analysis. A similar approach was used in the peer-reviewed EU Reference Model on Municipal Waste as well as

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[109] DEFRA (2014) *Energy from Waste: A Guide to the Debate, Revised Edition*, February 2014

[110] Christensen, T., Gentil, E., Boldrin, A., Larsen, A., Weidema, B. and Hauschild, M. (2009) C balance, Carbon Dioxide Emissions and Global Warming Potentials in LCA-modelling of Waste Management Systems, Waste Management & Research, 27, pp707-717

[111] Department for Environment Food and Rural Affairs (2014) *Energy recovery for residual waste: A carbon based modelling approach*, accessed 31 March 2020, http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19019

Eunomia's work for the Greater London Authority in developing an Environmental Performance Standard for municipal waste treatment. [112,113]

A.5.1.2 Carbon Dioxide Equivalents of GHGs

A CO_2 equivalent (CO_2e) is a unit of measurement that is used to standardise the climate effects of various greenhouse gases. When reported, all GHGs are reported in CO_2e, the values for which are given in Table A-5. The modelling is undertaken on the basis of impacts taking place over 100 years – this is in line with a 100-year Global Warming Potential, which is a standard approach for life cycle assessments.

Table A-5: Carbon Dioxide Equivalents of GHGs

GHG	Carbon Dioxide Equivalents, (CO_2e)
CO_2	1.00
CH_4	34.00
N_2O	265.00

A.5.1.3 Carbon Intensity of Energy Generation

The carbon intensity of electricity generation and consumption is modelled based on a grid mix that has a high percentage of renewables by 2030 – related to the country getting close to, but not achieving, an earlier target set by the Labour party of achieving 100% of supply from renewable sources by 2030. It is further assumed that a significant contribution from renewable generation comes from the use of hydro electricity (the latter is relevant when considering the emissions to air from electricity generation). The use of electricity is assumed to result in carbon emissions of 0.05 kg CO_2 / kWh electricity.

A.5.1.4 Damage Costs for carbon impacts

Many countries consider the cost to society of GHG emissions on the basis of an aggregated cost of mitigating climate change action. This is the case for New Zealand, but also for other countries such as the UK. The current values recommended for valuing GHG emissions in policy appraisals in New Zealand are set out in Table A-6. This shows that the Treasury uses an increasing value for the GHG abatement cost over time.[114] The modelling considers impacts of policy options between the present day and 2050. However, since landfill impacts continue for many years beyond the point of initial deposition, carbon impacts extend beyond 2050 – and so the higher cost is relevant for these subsequently occurring emissions.

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[112] Eunomia Research & Consulting Ltd., Copenhagen Resource Institute, and Satsuma (2019) *The European reference model on municipal waste*, 2019, https://www.eionet.europa.eu/etcs/etc-wmge/products/final-version-of-waste-model-handbook_april-2019.pdf

[113] Eunomia Research & Consulting (2017) *Greenhouse Gas Emissions Performance Standard for London's Local Authority Collected Waste – 2015/16 Update*, Report for Greater London Authority, January 2017, https://www.london.gov.uk/sites/default/files/gla_eps_report_2015-16_final.pdf

[114]

Table A-6: Cost of Mitigating GHG emissions in NZ

Cost of GHG mitigation	Cost per tonne of CO_2
2020-2030	$155
2030-2050	$256
2050 onwards	$463

It is important to note that the NZ abatement costs are relatively low in comparison to others used in other countries. The current UK cost of abatement, for example, is $574 per tonne of CO_2 (when converted from pounds to NZ$), and this cost also rises over time – such that by 2050 costs are estimated at £854 per tonne of CO2 (based on 2020 prices).[115] Whilst there could be some variation in the costs of abatement between the different countries, the modelling methodology used in the UK confirms that the model considers global carbon abatement costs and global carbon values – suggesting that there could be scope for further increases in the abatement costs currently in use in New Zealand.

A.5.2 Landfill GHG modelling

A.5.2.1 GHG Inventory Model for Landfill emissions

The methane emissions calculated here were based on New Zealand's existing GHG Inventory model used to submit annual emission data to the UNFCCC. Using inputs from the MfE team, updates to model were made using the following general approaches:

- Reviewing the existing calculations and comparing the values with international best practices for calculations of this type in the literature
- Assessing its current weaknesses such as the lack of data from operators.

The key updates to the GHG Inventory model included:

- Incorporating landfill operator data obtained from the survey where available, as described in Appendix A.3.0, notably
    - site-specific waste composition from SWAP audits and the operator survey
    - using site specific capture rates where data where possible, calculated

[115] See https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation

    - using site-specific coverage characteristics, that is, the proportion of operational, temporary, and permanently capped areas.
    - using site specific opening and expected closure dates
    - changes in site coverage at the end of a site's operational expected lifecycle, with decreases in operational and temporary capped areas, and increases in permanently capped areas.
- Using UK based capture rate assumptions associated with each cover type as detailed in Table A-7.
- Using IPCC organic decay rates following feedback from IPCC
- Linearly extrapolating site specific waste input until 2150 – previously only forecast until 2050.

The amended GHG Inventory model did not amend the following existing:

- Methane Correction Factor (MCF) per year
- Decomposable Degradable Organic Carbon (DDOC) and Degradable Organic Carbon (Doc) per waste material type
- Methane Oxidation Factor in the top layer (the IPCC aligned 10 percent)
- Fraction of methane in landfill gas
- Site specific waste input predictions pre 2050

Landfill Specific Assumptions

Table A-7 shows the assumptions used in modelling landfill emissions. These are, for the most part, aligned with the DEFRA's UK landfill model used in its submission to the UNFCCC on landfill methane emissions, which Eunomia helped update.

Table A-7: Landfill Assumptions

	Landfill Assumption	Assumption
	Oxidation of methane through the landfill cap	10%
Capture Rate (excl. losses)	active areas of the site	50%
	temporary capped areas of the site	85%
	permanently capped areas of the site	100%
Losses	from failed wells	10%
	site specific losses before a Low CV is installed	10%
	site specific losses after a Low CV flare is installed	20%

Flare usage	Number of years post operations cease that low CV flares are installed	20 years
	Duration of Low-CV flare usage before active gas collection stops	15 years
Default Coverage in the absence survey data (based on Kate Valley survey response)	active tipping areas	5 %
	temporary capped	68 %
	Permanent capped post-operations	26 %
Change in cover type over time once operations cease	active tipping areas	-100 %
	temporary capped	20 %
	permanent capped	20 %

A key difference in the Eunomia model compared to many other LCA models used in the UK is that the Eunomia model includes consideration of the storage of biogenic carbon not emitted as CO_2. A biogenic carbon storage credit is therefore applied to adjust the landfill factors. The approach is described in Appendix A.5.1.1.

A.5.2.2 GWP100 Calculations for Landfill

The NZ GHG Inventory model is designed to produce outputs required for the year-on-year GHG inventory modelling cycle and sets out the emissions in each year from 1950 to 2150, relating to the historic tonnages landfilled up to that year, as well as current tonnages. The New Zealand GHG Inventory model is converted into a policy model to assess landfill options, using key data from the year on year calculations contained in the GHG Inventory model. The policy model considers future impacts, and allows for the calculation of a GWP100 impacts for landfill, whereby the impact of one tonne of waste is considered over the next 100 years after deposition in landfill – with all those impacts attributed to the initial year of deposition. In such a way, the impact of future policy changes can be estimated.

The policy model uses the same decay rates as the GHG Inventory model, the same calculation methodology for the time series (i.e., the same first order decay equations as used in the GHG Inventory model) and also uses the same core assumptions on DDOC. Development of the policy model involves the calculation of an aggregated lifetime capture rate from all the landfills in New Zealand, which is derived from the GHG Inventory model, where the rate is calculated across all sites using a weighted average capture rate (the rate being weighted by tonnage).

The policy model also includes a credit for un-emitted biogenic CO2 for future landfilling, in line with the methodology set out in Section A.5.1.1.

A.5.3 Carbon Modelling of other waste systems

A.5.3.1 Avoided Emissions Through Recycling

Emissions avoided through recycling conventional plastics have been calculated by subtracting the impact of primary production from the recycling process emissions. Primary production values assume that the material is made from 100 percent virgin inputs. Table A-8 gives the sources for the values for avoided emissions from recycling of conventional plastics used in the modelling.

Table A-8: Sources of Data: Avoided Emissions from Recycling

Material		Primary production	Secondary production
Glass	**Glass Re-melt**	Ecoinvent	Turner et al for sorting; Ecoinvent for re-processing
Metals	**Closed Loop Al.**	International Aluminium Institute (IAI)	Turner et al for energy and sorting emissions; IAI for carbon
	Closed Loop Fe.	Ecoinvent	Ecoinvent
Plastics - closed loop	**PET bottles**	Plastics Europe Ecoprofiles	Chen et al (China)
	PET trays	Plastics Europe Ecoprofiles	Average of values from Chen et al and Franklin Associates (US)
	HDPE	Plastics Europe Ecoprofiles	Average of values from Chen et al and Franklin Associates (US)
	PP	Plastics Europe Ecoprofiles	Average of values from Chen et al and Franklin Associates (US)
	PVC	Plastics Europe Ecoprofiles	Chen et al
	PS (HIPS)	Plastics Europe Ecoprofiles	Average of values from Chen et al and Campolina et al (Brazil)
	LLDPE	Plastics Europe Ecoprofiles	No data found
Cartons		Mass balance data from Turner et al; impacts for specific materials (paper, plastic, aluminium) as per this table	

Material	Primary production	Secondary production
Paper	Ecoinvent (virgin newsprint, Europe)	Ecoinvent (recycled newsprint, Europe)
Card	CEPI / FEFCO	CEPI / FEFCO
Wood (MDF production)	Turner et al	Turner et al
WEEE	Mass balance data from Turner et al used for energy-related impacts; impacts for specific materials as per this table.	Net carbon recycling benefits from Eunomia (Product Policy study); mass balance data from Turner et al used for energy-related impacts, with impacts for specific materials as per this table.
Textiles	Ecoinvent	Eunomia assumption developed from modelling

Sources: ecoinvent database 3.6, available from https://v36.ecoquery.ecoinvent.org/Account/LogOn?ReturnUrl=%2fHome%2fIndex; International Aluminium Institute (2015) Life-cycle Inventory Summary by Region and Unit Process; Turner D, Williams I and Kemp S (2015) Greenhouse gas emission factors for recycling of source-segregated waste materials, Resources, Conservation and Recycling, 105, pp186-197; Plastics Europe ecoprofiles available from https://www.plasticseurope.org/en/resources/eco-profiles ; Chen Y, Cui Z, Cui X, Liu W, Wang X, Li X and Li S (2019) Life cycle assessment of end-of-life treatments of waste plastics in China, Resources, Conservation and Recycling, 146, pp348-357; Campolina J, Sigrist C, Faulstich de Paiva J, Nunes A and Aparecida da Silva Moris V (2017) A study on the environmental aspects of WEEE plastic recycling in a Brazilian company, Int J Lifecycle Assess, March 2017; Franklin Associates (2011) Cradle-to-gate Life cycle Inventory of Nine Plastic Resins and four Polyurethane Precursors, Report for the Plastics Division of the American Chemistry Council; CEPI / FEFCO (2015) European Database for Corrugated Board Life Cycle Studies; WRAP data on bulky waste available from https://www.wrap.org.uk/content/bulky-waste-overview

Table 9-2 sets out the assumptions used in the analysis in respect of the net avoided emissions resulting from recycling processes – which are drawn from the sources set out in Table A-8. The net avoided emissions are calculated by subtracting the avoided primary production figures from the impacts associated with secondary production.

Table 9-2: Net Avoided Emissions from Recycling

tonnes CO_2e / tonne pollutant	Primary production	Secondary production	Net avoided emissions from recycling
Aluminium	9.4	0.812	-8.6
Steel	1.9	0.078	-1.8
Glass	0.6	0.359	-0.2
Paper	1.3	0.999	-0.3
Card	0.2	0.400	0.2
Carton	1.8	1.116	-0.7
HDPE	1.9	0.203	-1.7
LDPE	2.0	0.220	-1.8
PE	1.9	0.203	-1.7
PET	2.5	0.298	-2.2
PP	1.7	0.217	-1.5
PS	2.5	0.266	-2.3
PVC	2.1	0.236	-1.9
Wood	0.17		-0.2
Textiles			-2.9

A.5.3.2 Composting

Assumptions for composting treatment plant are shown in Table A-9 below. Data are largely derived from work Eunomia has undertaken historically with operators of UK composting facilities, with the exception of the carbon sequestration assumption (Eunomia assumption, calculated from the carbon balance of the composting process), and the nutrient benefit from compost, which is taken from the Ecoinvent database.

Table A-9: Assumptions for Composting Treatment Plant

Parameter	Assumption
Emission methane g / tonne input	900
Emission N_2O g / tonne input	59
Electricity use, kWh / tonne	30

Diesel use, litre / tonne	0.3
Carbon sequestration credit, compostable plastic, kg CO_2 / tonne input	55
Nutrient benefit from compost, food waste, kg CO_2e / tonne input	40

A.5.3.3 Anaerobic Digestion

Assumptions for anaerobic digestion facilities are shown in Table A-10 below. Data are largely derived from work Eunomia has undertaken historically with operators of UK AD facilities. No carbon sequestration credit is assumed for AD processes.

Table A-10: Assumptions for Anaerobic Digestion Facilities

Parameter	Assumption
Heat used in the process, % of heat generated	33%
Electricity used in the process, % of electricity generated	10%
Methane generation, compostable plastics, m^3 CH_4 / tonne volatile solids	390
Methane generation, food waste, m^3 CH_4 / tonne volatile solids	351
Methane slip, g CH_4/ kWh energy	1.5
Fugitive methane emissions, % C to CH_4	1.5

A.5.4 Air Quality Modelling

For landfills, the air pollution impacts that can be quantified via the use of damage costs - which are aimed at evaluating the human health impacts – are mainly associated with emissions from the combustion of landfill gas and the use of gas engines to generate electricity. Impacts associated with AD facilities and composting plant are based on European plant.

The situation is somewhat more complicated for emissions from recycling as the data require the combination of emissions from both primary and secondary production, and in the case of the former, many facilities are based in countries other than New Zealand. This is the case for plastics and metals recycling. Where this is the case, the health impacts are not accounted for within the analysis.

A.5.4.1 Damage Costs for air pollution

The New Zealand government has developed a dataset which considers the impacts upon human health associated with the emission of key air pollutants. The data are based on the estimated costs to society of these emissions occurring, including the financial costs associated with ill health such as hospital admissions related to respiratory illness.[116]

Table 9-3 presents the current damage cost dataset, with the data presented in terms of the financial impact per tonne of pollutant emitted. The data in the table includes three sets of values reflecting the uncertainties associated with quantifying this type of impact.

Table 9-3 Damage cost data – health impacts of air pollution

Pollutant	Damage costs for health impacts, NZ$ per tonne of pollutant (2025 prices)
VOCs	$1,191
PM2.5	$666,179
NO_x	$408,377

Source: New Zealand CBAx model, available from https://www.treasury.govt.nz/publications/guide/cbax-spreadsheet-model

It is noted that the damage cost used here for NOx pollution is relatively high compared to similar assumptions developed in other countries where point source pollution (from industrial facilities) is being considered. The figures are more similar to those which are applied for the assessment of pollution arising from vehicles: health impacts here are typically higher as more of the pollutant is emitted closer to the ground, giving greater propensity for the pollution to impact on surrounding populations than is the case when pollution is emitted via a chimney. However, this may be appropriate for landfill sites which typically do not use an emissions stack.

A.5.4.2 Air Quality Emissions Assumptions

Data on the air pollution emissions from waste treatment facilities is presented in Table 9-4, and shows data for landfill and biowaste treatment.

Table 9-4: Emissions to Air from Waste Treatment Facilities

	Emissions grams per tonne of material sent to treatment facility		
	Landfill	**Composting**	**Anaerobic digestion**
NH_3	721	20	13
VOCs	5	12	40
PM2.5	2	0	20

[116] See Appraisal Toolkit Spreadsheet 2020, available at https://www.gov.uk/government/publications/assess-the-impact-of-air-quality

SO_x	13	1	20
NO_x	145	0	250

Table 9-5 presents the net emissions to air from dry recycling activities that typically take place in New Zealand (other materials are assumed not to impact on New Zealand air quality, although impacts will occur in various countries overseas). Net emissions are shown, considering the avoided air pollution benefits associated with reduced primary production occurring from the recycling activity – alongside the contribution to local emissions occurring as a result of the re-processing activities.

Table 9-5: Net Emissions to Air from Dry Recycling taking place in New Zealand

	Emissions kg per tonne of material recycled		
	Paper	**Glass**	**Wood**
VOCs	0	-0	0
PM2.5	0	-1	-1
SO_x	-5	-5	0
NO_x	-3	-3	-1

A.6.0 Phase 2 Diversion Rates and Cost Modelling Methodology

A.6.1 Scope

The Tipping Point model considered material going to Class 1 disposal. This material was subdivided into Activity classifications based on the following Activity Sources:[117]

- Construction and Demolition (C&D)
- Industrial Commercial and Institutional (ICI)
- Landscaping
- Residential
- Kerbside
- Special

A.6.2 Research on Costs and Tonnages

The key methods used to develop our understanding of costs were:

- **Information on disposal costs.** Information on disposal costs was derived primarily from work previously undertaken by Eunomia for the Ministry and updated to account for NZETS and cost escalations. [118] This was the core data for determining disposal costs and tipping points. Information on total tonnages, charges and the tonnages disposed of at each rate of charge, Activity Source and Composition by Activity Source was sought from each of the disposal facilities. Information provided was analysed to enable it to be used in the model. Where the full range of information was not available assumptions were made.
- **Information held by Eunomia**. Eunomia holds a substantial amount of information from previous work we have done including work on National Recycling Rates[119], the Infrastructure and Waste Services Stocktake[120], waste levy research, council waste assessments, council waste contract procurement, and work with industry. This varied dataset was used to develop estimates of typical industry costs for the purposes of the landfill diversion model
- **Cost Modelling**. Information provided by operators tended to lack granularity, particularly around collection costs for different material types. We undertook simple cost modelling of collection costs for different commercial waste streams as well as referencing previous cost modelling work undertaken by Eunomia for household collections for a range of local authorities around the country. The outcomes of the cost modelling were compared to information from the operators to ensure they were broadly realistic.

A.6.3 Landfill Diversion Model

A proprietary model was adapted to calculate the tonnage impacts of different levy rates on different materials and the points at which they might 'move' out of Class 1 landfill. The model is based on using composition data and Activity Source. For each material under each Activity Source, a cost of collection and disposal (including levy) was applied as well as a cost of separate collection and cost of

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117 We note that these activity source classifications have now been superseded, however for the purposes of the model, the available waste audit data was presented in these classification and this was deemed most useful in respect of the modelling.
118 Eunomia (2019) Survey of Class 1 Landfill Disposal Fees to Support Landfill Levy Research. Report for Ministry for the Environment.
119 Eunomia (2024) New Zealand National Recycling Rate Issues and Options. Report for Ministry for the Environment
120 Eunomia (2021) National Resource Recovery – Infrastructure and Services Stocktake and Gap Analysis. Report for Ministry for the Environment

alternative processing/recovery. When the cost of collection and disposal plus levy exceeded the cost of separate collection and alternative processing/recovery then the material would be identified by the model as 'moveable'. In this way as different materials from different activity sources become 'moveable' at different rates, a picture is able to be constructed of the impact of changes to the rate of the levy.

A.6.4 Data and Modelling Limitations

There are a number of limitations to the study that should be kept in mind when reviewing the outcomes. These include the following:

- **Disposal Costs.** It should be noted that disposal costs vary markedly depending on a range of factors including location/facility, level of competition, advertised rates versus bulk rates, marginal costs and internal costs, inclusion of transfer costs, ETS costs, Levy etc. For the purposes of this modelling exercise, we derived an assumed average national cost of disposal (based on update prior research[121]), which excluded GST, transfer, Levy, and NZETS costs. The reality however is that the costs of recovery and disposal, and consequently the tipping points, will vary for each locality. This means that while the results identified specific points at which material 'tips', in practice this will be a continuum with price levels around which material moves.
- **'Recoverable' vs Diverted.** It should be emphasised that the modelling shows the point at which material becomes (on average) cheaper to recover than to landfill. This is not necessarily the same as the point at which the material will actually move from landfill to recovery (or alternative disposal). There are a range of factors which will mean that, in reality, diversion is likely to occur over a wider range of levy values for each material. These include:
    - The opportunity cost of changing to new systems or collection arrangements
    - Each operator has different cost structures, which means material becomes economic at different levy values
    - Within each classification different product and material types from different sources have different costs of diversion
    - For some materials the issue may be more to do with a lack of facilities than with price - i.e. a material might be theoretically 'moveable' but practically not. Establishing a facility may divert materials that are 'moveable' at a range of price points (for example establishing an in-vessel composting facility might lead to more processing of both food and garden waste which are each moveable at different price points)
    - The presence of loss or 'leakage' in the system. This includes where for example, materials are not properly separated and/or it is impractical to separate, material is contaminated and/or unsuitable for recovery, material is separated but there are losses in the recovery process.

Because the points at which material will move are complex and to a large extent uncertain at present, we have not attempted to show this in the modelling.

- **Incompleteness of Information.** Information was sought from a range of sources however information was not able to be obtained from all key sources, and not all information is up to date. There was very little information available on the differences between various grades of material, which will, in reality, be important for determining what is recovered
- **Composition Data.** Available composition data breaks materials down into a standard number of classifications, which limits the granularity possible in any analysis. For example, plastics are classified as 'recyclable' or 'non-recyclable'. Recyclable plastics is defined as including plastic containers 1-7, but there is no further breakdown by polymer type. Some of these containers may not in fact be recyclable, or there may be no viable market for those

[121] Eunomia (2019) Survey of Class 1 Landfill Disposal Fees to Support Landfill Levy Research. Report for Ministry for the Environment.

'recyclable' plastics. On the other hand, plastic films and offcuts from commercial sources may be readily recyclable but would be classified as 'non-recyclable'. For the purposes of the modelling, we assumed only the material classified as 'recyclable' or 'compostable' would be diverted in response to changes in the levy. This naturally limits the amount of material that can be diverted by a change in levy. Furthermore, different grades of material have different tipping points, depending on source, level of contamination etc. So different grades/sources will move at different points, but there is almost no data on this.

- **Market Prices and Costs.** The modelling uses commodity values and prices for recovered materials roughly in line with current market conditions. Given the volatility of markets, this is likely to change over time which will affect when materials reach the tipping points. This volatility can also impact the viability of recovery. There needs to be a margin for operators, so that when commodity prices are low, their operations remain viable.
- **No Waste Minimisation Effect.** For the purposes of the modelling we assumed that raising the levy would not result in a reduction in the total amount of waste produced.
- **Diversion to Other Forms of Disposal.** The model primarily identifies the price points at which it is economic for material to 'move' from landfill. It is not specific about where that material moves to. One option is that material could move to other forms of disposal (e.g. material could move from a Class 1 facility to a class 2-5 facility, which may have a lower rate of levy applied). We did not model the impact of differing rates of levy on different classes of landfill and the degree to which this might lead to material simply switching disposal facilities.

A.6.5 Key Assumptions and Base Data

A.6.5.1 Composition

The following composition data was based on analyses by Waste Not Consulting in 2024 and supplied as part of a project for Ministry for the Environment.

Estimated National Waste Composition by Activity

	C&D	ICI	Landscaping	Residential	Kerbside	Special
Paper Recyclable	2.7 %	11.8 %	0.8 %	9.4 %	6.7 %	0.0 %
Paper Non-recyclable	0.5 %	2.2 %	0.1 %	0.6 %	2.2 %	0.0 %
Paper Subtotal	**3.2 %**	**14.0 %**	**0.9 %**	**10.0 %**	**9.0 %**	**0.0 %**
Plastics Recyclable	0.2 %	1.1 %	0.1 %	0.5 %	2.2 %	0.0 %
Plastics Non-recyclable	4.0 %	19.4 %	2.0 %	9.6 %	8.9 %	0.0 %
Plastics Subtotal	**4.2 %**	**20.5 %**	**2.0 %**	**10.1 %**	**11.1 %**	**0.0 %**
Putrescibles Kitchen/food	0.1 %	8.9 %	0.6 %	5.8 %	31.2 %	0.0 %
Putrescibles Comp. G'waste	0.7 %	2.7 %	46.2 %	6.3 %	14.9 %	0.0 %
Putrescibles Non-comp G'waste	0.1 %	0.8 %	19.1 %	1.0 %	1.7 %	0.0 %
Putrescibles Multi/other	0.0 %	1.5 %	0.2 %	0.3 %	2.9 %	5.0 %
Putrescibles Subtotal	**1.0 %**	**13.9 %**	**66.1 %**	**13.5 %**	**50.6 %**	**5.0 %**

	C&D	ICI	Landscaping	Residential	Kerbside	Special
Ferrous metals Primarily ferrous	1.9 %	1.3 %	0.2 %	1.9 %	0.8 %	0.0 %
Ferrous metals Multi/other	1.0 %	2.3 %	0.4 %	5.8 %	1.2 %	0.0 %
Ferrous metals Subtotal	**2.9 %**	**3.6 %**	**0.5 %**	**7.8 %**	**2.0 %**	**0.0 %**
Non-ferrous metals Subtotal	0.3 %	0.9 %	0.0 %	0.6 %	1.1 %	0.0 %
Glass Recyclable	0.2 %	1.2 %	0.1 %	0.9 %	2.9 %	0.0 %
Glass Glass multi/other	0.9 %	1.5 %	0.1 %	1.4 %	0.9 %	0.0 %
Glass Subtotal	**1.0 %**	**2.7 %**	**0.1 %**	**2.2 %**	**3.8 %**	**0.0 %**
Textiles Clothing/textile	0.2 %	2.8 %	0.1 %	3.4 %	2.2 %	0.0 %
Textiles Multi/other	4.2 %	9.9 %	0.7 %	16.0 %	1.7 %	0.0 %
Textiles Subtotal	**4.4 %**	**12.7 %**	**0.8 %**	**19.4 %**	**4.0 %**	**0.0 %**
Nappies Subtotal	**0.0 %**	**4.8 %**	**0.2 %**	**1.6 %**	**9.7 %**	**0.0 %**
Rubble Cleanfill	6.3 %	0.9 %	22.3 %	0.8 %	0.0 %	0.0 %
Rubble Plasterboard	9.2 %	0.2 %	0.0 %	0.4 %	0.0 %	0.0 %
Rubble Multi/other	12.7 %	5.3 %	1.0 %	2.1 %	4.2 %	0.0 %
Rubble Subtotal	**28.3 %**	**6.4 %**	**23.3 %**	**3.4 %**	**4.2 %**	**0.0 %**
Timber Reusable	6.0 %	0.7 %	0.5 %	1.3 %	0.0 %	0.0 %
Timber Untreated & unpainted	8.1 %	4.4 %	0.4 %	2.5 %	0.0 %	0.0 %
Timber Multimaterial/other	39.8 %	11.1 %	4.6 %	26.2 %	2.7 %	0.0 %
Timber Subtotal	**53.8 %**	**16.3 %**	**5.5 %**	**30.1 %**	**2.7 %**	**0.0 %**
Rubber Subtotal	**0.8 %**	**2.1 %**	**0.5 %**	**0.9 %**	**0.4 %**	**0.0 %**
Pot hazard Subtotal	**0.1 %**	**2.0 %**	**0.0 %**	**0.4 %**	**1.7 %**	**95.0 %**
TOTAL	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**
Proportion of Activity	20 %	27 %	2 %	6 %	27 %	17 %

A.6.5.2 Levy Rates

It was assumed that the structure of the levy would consist of a rate for Class 1 landfills and a separate lower rate for other facility types. The model was only concerned with transfer out of Class 1 and does not differentiate between destinations for that material – whether to recovery or to disposal at another type of facility.

For the purposes of modelling, it was also assumed that clean material, which is currently accepted at Class 1 facilities for engineering works and does not attract a levy, would not be levied.

Levy rates were modelled at $10 increments up to $180. Beyond this point, no further diversion was modelled to take place (although this could change if information is received that would change any of the key assumptions). The model could use any increment - $10 increments were used for the purposes of practicality – it was felt that any finer increments would likely give a false sense of accuracy while larger increments might conceal useful data.

The values shown below are the key values used in determining the tipping points for different materials from different Activity Sources. Values are derived from a range of sources including operator interviews, published data including advertised gate fees, and cost modelling.

Collection Costs Per tonne

Collection Type	Approximate Values	Source
Kerbside Rubbish	$125	Based on Hermes Modelling
Kerbside Recycling	$192	Based on Hermes Modelling
Kerbside Food	$224	Based on Hermes Modelling
Kerbside Green	$115	Based on Hermes Modelling
Residential (Skips)	$208	Based on Collection Modelling
Residential (Inorganic/Bulky)	$188	Based on Collection Modelling
ICI	$63	Based on Collection Modelling
C&D	$28	Personal Communication: Stacy Goldsworthy, Green Vision Recycling
Landscaping	$206	Based on Collection Modelling

Processing & Disposal Costs

Processing Costs Per tonne	Approximate Values	Notes
MRF Glass Out	$ 225.00	Based on tendered pricing and quotes from MRFs (note wide range)
MRF Glass In	$ 255.00	Based on tendered pricing and quotes from MRFs (note wide range)
Organics - Green	$ 100	Based on tendered pricing and quotes
Organics - Putrescible	$ 135	Based on tendered pricing and quotes
Stockfood	$ 41	Based on tendered pricing and quotes
C&D Sorting	$ 23	Personal Communication: Stacy Goldsworthy, Green Vision Recycling
Mixed waste sorting	$ 110	Estimate
Landfill Disposal	$ 80*	Based on Eunomia 2019 Survey of Class 1 Landfill Disposal Fees to Support Landfill Levy Research,

	Report to Ministry for the Environment and adjusted for inflation

* Excluding levy charges and GST but including ETS charges. The rate accounts for the fact that large landfills, which make up most of the tonnage, have the lowest disposal rates and effectively reduce their ETS liabilities by approximately 90%.

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