Chapter 4d:

Reducing emissions – opportunities and challenges across sectors

Waste

The majority of waste emissions are from biogenic methane, with smaller amounts of carbon dioxide and nitrous oxide also being generated from composting, incineration and wastewater treatment. There are practices and technologies available to reduce the amount of waste and associated emissions. While only emissions at the final destination point of waste are considered in the Greenhouse Gas Inventory, there are also potential emissions reduction opportunities in other sectors that may result in tackling waste.

This chapter explores the sources of emissions from the waste sector and opportunities to reduce them – including avoiding waste, waste recovery, lower-emission landfills and low global warming potential (GWP) refrigerants. Refrigerants are covered in this chapter as resource recovery mechanisms such as product stewardship apply to both waste and refrigerants.

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4d.1 Introduction

New Zealanders create many forms of waste in their day to day lives. There are emissions associated with the creation, handling, processing and storage of this waste, particularly biogenic methane emissions from organic waste. There are a range of practices and technologies that can reduce the amounts of waste and associated emissions.

Our primary focus is on emissions from the management of organic waste. For the purpose of this discussion, we view all waste with a decayable organic content (DOC) value as 'organic' – including waste with very low DOC such as construction and demolition waste. Greenhouse gases are emitted throughout the lifecycle of organic and inorganic resources until they turn to waste. These emissions can happen at a range of stages in a product/material lifecycle, for example when: produced on farm, extracted from nature, manufactured, sold, used or transported, and ultimately, when disposed of to a landfill.

Opportunities to reduce non-disposal emissions may be accounted for in the other sectors; for example, reducing emissions from the collection and movement of waste are accounted for in the transport sector. However, in the context of our discussion 'waste emissions' are only from the emissions at disposal – usually from organic waste decaying at landfill.

Nonetheless, we know that moving from a linear economy (on a 'take-make-use-throw' setting) to a more circular economy (where resources are repeatedly used), would result in less emissions from waste disposal, and from extraction, production, consumption and transport processes.[1]

Most waste disposal emissions are biogenic methane (92% of all waste emissions, expressed in CO_2e), with the remainder being small amounts of carbon dioxide (2.5%) and nitrous oxide (5.5%), which are generated from composting, incineration, and wastewater treatment. Overall, biogenic methane from waste makes up around 10% of total biogenic methane emissions with agriculture making up the other 90% in Aotearoa.[2] Our analysis is largely focused on how to reduce biogenic methane emissions from organic solid waste disposal because these make up most (81%) of the biogenic methane emissions from waste.

[1] (Ramboll et al., 2020)
[2] Modified from the national Greenhouse Gas Inventory (Ministry for the Environment, 2020b).

Table 4d.1: Waste disposal points and emissions from decay

Waste sites	Waste volumes (thousand tonnes) 2018	Emissions (Mt CH_4) 2018
Municipal with LFG capture	3,557	0.0279
Municipal without LFG capture	153	0.0278
Non-municipal	5,517	0.042
Farm fills[3]	551	0.0236

Municipal sites with landfill gas capture (LFG) (see Box 4d.1) accounted for most of the volume from households. These are class 1 landfills servicing urban centres which receive a mixture of household and commercial waste. Municipal sites without landfill gas capture are a mixture of legacy sites which are now closed and a handful of active municipal landfills. These sites are not required to capture landfill gas as the tonnage of organic waste and/or total capacity of waste they receive falls below the legislative requirement. Municipal landfills receive high volumes of food, paper and wood waste.

Box 4d.1: Landfill gas capture

Landfill gas capture systems typically comprise of vertical and/or horizontal extraction wells connected to a pipe network designed to extract biogenic methane gas from landfills. The instantaneous collection efficiency of a LFG capture system is the percentage of landfill gas collected when compared against the predicted generation rate. It is not only a function of the effectiveness of the collection system, but also considers factors such as the original landfilling methods, depth of waste, leachate saturation levels and cap permeability. Different landfills have different gas capture efficiencies, with newer landfills tending to have higher rates of gas capture due to more efficient design. There is also a 'lifetime' capture efficiency or a 'temporally weighted collection efficiency' which considers gas collection over a lifetime.[4] Approximately 87% of biogenic methane gas captured is used for energy generation with the other 13% being flared (landfill gas burnt which converts it to a small amount of CO_2 emissions.[5])

Non-municipal sites are class 2-5 landfills which receive commercial and industrial waste. The most common waste types across the aggregate category of municipal landfills were construction and demolition, garden and wood waste. However, we do know that there are differences in the different landfill classes with some such as class 2 Landfills accepting more waste with organic content and class 5 Landfills (Cleanfills) theoretically accepting no organic waste. With farms in Aotearoa having no access to a doorstop waste collection system, farmers are responsible for managing their own waste. We estimate that around half is burnt and half is stored with the buried amounts producing biogenic methane emissions and the burnt waste producing smaller volumes (in CO_2e terms) of carbon dioxide, nitrous oxide and methane emissions. Garden, paper and wood waste are the most common categories from farm sites. Neither farm sites nor non-municipal

[3] Farms send about half of their waste to be burnt, which produces roughly 0.152 Mt CO_2e of emissions meaning that the total volume of waste produced at farms is around 1,102 kt.
[4] (Barlaz et al., 2012)
[5] (Ministry for the Environment, 2020b)

landfills are required to capture landfill gas as the volumes of organic waste they receive does not meet the threshold required under current regulations.

Box 4d.2: Wastewater treatment emissions

Wastewater treatment contributes around 10% of waste emissions from their operational emissions with the sludge they produce that get sent to landfill being accounted for in landfill emissions. However, we have not focused on this as the opportunity to reduce emissions is small. From analysis of evidence and discussions with stakeholders, we have identified some opportunities to reduce emissions from wastewater treatment. These include increasing water conservation,[6] better sludge management, and capturing fugitive emissions.[7] However, due to the poor data on wastewater treatment plants and the complexities of measuring baseline emissions and any reductions, it is difficult to quantify the emissions reduction potential of various options. We agree with the Productivity Commission's conclusion about the need to establish "*an agreed measurement approach and to assess… costs of its use in any relevant scheme."*[8] With better data, we anticipate being able to do more analysis on this area.

Refrigerants are substances essential to the functioning of air conditioning, refrigeration, and freezing technologies. They absorb heat quickly, so are critical to heating and cooling cycles in these systems and appliances. The energy efficiency of many refrigerant-containing products like heat pumps means their use in increasing, as they provide both cost savings and environmental benefits.

Refrigerants (mostly hydrofluorocarbons – HFCs) are typically emitted during the lifetime of their product (e.g. air conditioners, fridges), or once that product is disposed of (if not disposed of correctly). While their volumes in Aotearoa are not large, they are often potent, long-lived greenhouse gases (see Box 4d.3), with global warming potential hundreds of times that of carbon dioxide. Preventing these emissions could have a measurable impact on our country's overall emissions profile.

While refrigerants are not part of New Zealand's Waste Greenhouse Gas Inventory (refrigerant emissions are captured under Industrial Processes and Product Uses), they are in this section as the options to reduce refrigerant emissions are similar to those necessary to reduce waste emissions.

Box 4d.3: What about refrigerants?

Refrigerants are chemicals used commonly across the economy in refrigeration and air conditioning equipment. Applications include refrigeration systems in homes, supermarkets, cool stores and industrial factories, and air conditioning in cars and office buildings.

Hydrofluorocarbons (HFCs) are the most commonly used refrigerants, and replaced chlorofluorocarbons (CFCs) after the ozone depleting properties of CFCs were identified. Roughly 500 tonnes are consumed annually in Aotearoa to charge new and service existing equipment. Additionally, about 400 tonnes are imported in vehicles and other finished products – for example in car air conditioning units. There is a large 'bank' of approximately 7,000 tonnes of refrigerants in existing equipment in Aotearoa.[9]

Many refrigerants are extremely potent greenhouse gases

[6] (Environment Agency, 2009)
[7] (Global Methane Initiative, 2013)
[8] (New Zealand Productivity Commission, 2018, p. 472)
[9] (Ministry for the Environment, 2018)

Although we use relatively low volumes of refrigerants, they have very high global warming potential (GWP). The most common refrigerant in Aotearoa, HFC-134a, has a GWP of 1,400 – this means one kilogram of HFC-134a has the same global warming impact of 1.4 t CO_2. Another common refrigerant, HFC-404A, has a GWP of 3,900.

We have been increasing our use of refrigeration and air conditioning equipment. The substances used in this equipment are potent greenhouse gases which can escape over time.

Increased economic activity, a growing population, and increased demand for and movement of perishable goods has increased our use of refrigerants over time.

Prior to 1996, chlorofluorocarbons were the chemicals typically utilised as refrigerants. However, these were recognised to be destructive to the ozone layer and their use was prohibited under the Montreal Protocol and Ozone Layer Protection Act (1996). CFCs have been largely eliminated from use globally and were chiefly displaced by HFCs, which do not destroy ozone. Emissions from the leakage of HFC refrigerants from refrigeration and air conditioning equipment grew from zero in 1990 to about 1.7 Mt CO_2e in 2018, because of the displacement of CFCs by HFCs. As a result, HFC refrigerants are a significant source of emissions growth.

In 2019, New Zealand ratified the Kigali Amendment to the Montreal Protocol, an international agreement to phase down global usage of HFCs. However, modelling carried out for the Ministry for the Environment shows that there is a gap between the emissions reductions that will be achieved under our Kigali Amendment phase down of bulk HFCs, and our obligation to reach net zero emissions by 2050.

We are keen to understand the potential opportunities offered by increasing resource efficiency and moving to a circular economy in Aotearoa. We know that recovering and reusing inorganic material such as aluminium and glass will typically produce less emissions than those involved in producing new materials. Many of these emissions reductions are in non-waste sectors, such as building, manufacturing and transport. We also know that transitioning to a circular economy can generate substantial economic benefits.[10] However, more research and data is needed to quantify the extent to which a circular approach may reduce emissions.

The analysis here is tempered by an acknowledgement of the general unreliability and absence of waste data in Aotearoa. Where possible we have filled gaps in official data (which rely on projection, assumptions and expert opinion) with additional research and analysis.

Box 4d.4: Te Ao Māori and Waste

Based on input from interviews with Technical Reference Group members and insights from iwi/Māori it is evident that a holistic approach to waste creation and management is essential if we are to achieve intergenerational solutions for reducing emissions from the waste sector.

Throughout our evidence gathering and advice, we have drawn on the framework *He Ara Waiora – A Pathway towards Wellbeing* (version 2)[11] to inform our understanding of a Te Ao Māori perspective on wellbeing, sourced in mātauranga Māori. He Ara Waiora underpins our analysis regarding impacts for iwi/Māori and provides appropriate framing to assess impacts of emissions reductions and increased removals for iwi and Māori.

[10] (Auckland Tourism, Events and Economic Development & Sustainable Business Network Circular Economy Accelerator, 2018)
[11] (McMeeking et al., 2019)

He Ara Waiora provides a high-level interpretation of how Māori view the world holistically, which is consistent with the perspectives we heard through engagement with Māori with respect to waste creation and management.

As an example, we heard that Māori traditionally lived within a circular loop waste system, which returned all toenga (remains/leftovers) back to Papatūānuku, without detriment to the whenua, awa (waterways), or moana (ocean). Appropriate mechanisms to manage this system are preserved in tikanga e.g., human organic matter was not mixed with toenga kai and other compostable materials.[12] Drawing on He Ara Waiora, with a wairua and taiao centric approach to wellbeing, encourages us to consider mātauranga Māori and tikanga in a transition to a circular economy systems as one option to lower emissions in the waste sector.

4d.2 Options for reducing emissions

As a country, Aotearoa is comparatively wasteful with municipal waste generation being among the highest per capita in the OECD.[13] We generated approximately 14.3 million tonnes of waste in 2018, of which 10.3 million tonnes was sent to landfill. Around half of this waste has an organic portion which can decay at landfill.[14] The remainder of the waste is recovered (see definition below). Our recycling (excluding incineration) rate of 28% is relatively low, compared to Australia's 62%[15] or the European Union's recycling rate of 47%.[16]

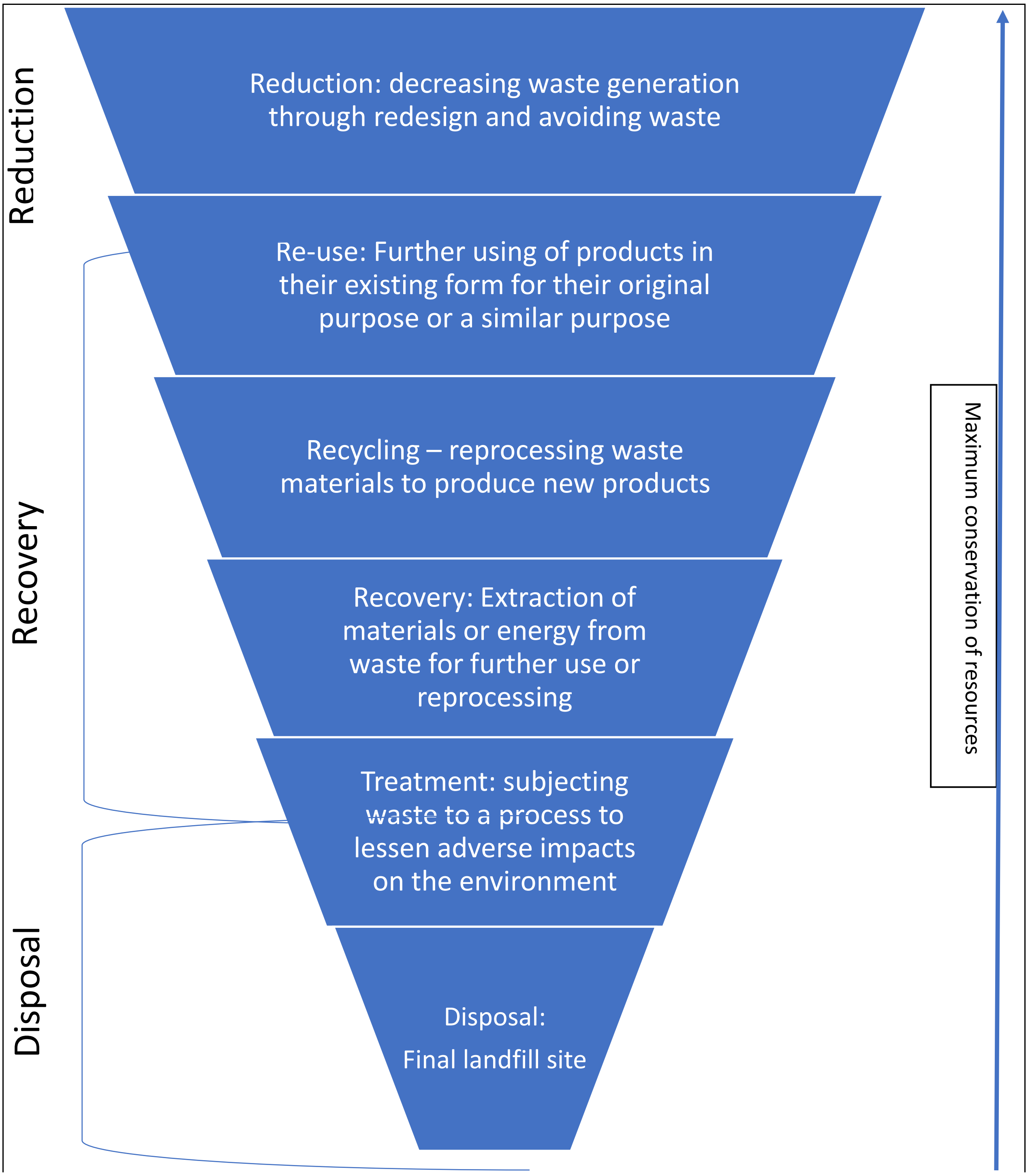
Figure 4d.1: Waste sector and potential interventions

Even though we cannot fully quantify the emissions associated with the manufacturing, importation and transport of much of the waste we generate, we have assessed the opportunities and challenges for reducing waste emissions across the following categories. These opportunities are a mixture of

[12] (Auckland Council, 2017)
[13] (OECD, 2018)
[14] Assumption from Eunomia figure of 28% recovery rate holds steady.
[15] (Department of the Environment and Energy (AU) & Blue Environment Pty Ltd., 2018)
[16] (European Environment Agency, 2019)

practices and technologies and are aligned with the waste hierarchy[17] as well as international practise[18]:

1) **Avoiding waste:** avoiding the generation of waste at source
2) **Waste recovery:** recovering waste through reuse, recycling and recovery
3) **Landfill gas capture:** improving the efficiency of landfill gas collection systems and increasing the proportion of waste going to landfills that capture that gas



[17] (*Waste Minimisation Act*, 2008)
[18] (Bogner et al., 2007) and (Fischedick et al., 2014, pp. 785–792)

Figure 4d.2: The Waste Hierarchy[19]

The waste hierarchy is an internationally recognised evaluation tool which shows the preferred pathways to maximize resource recovery through the different stages of waste management.[20]

Comparing our waste statistics to other countries shows there are opportunities to reuse much of the waste generated and reduce emissions across the economy including those directly generated from waste itself.

Waste to energy has been a frequently debated topic in the waste sector. It covers a range of actions including burning captured biogenic methane to generate electricity, anaerobic digestion, and incineration. Small scale waste to energy plants and anaerobic digestors appear to be more viable than large scale waste to energy incineration, which has uncertain economic and environmental viability. Large-scale waste incineration would also generate additional carbon emissions as inert waste made from fossil fuels such as plastics are incinerated.

This section has indicative costs based on Commission analysis of work done by different stakeholders. The actual costs are included in the modelling of the current policy reference cases and scenarios and will be included in the documentation of the modelling. However, there is an overall lack of quality data in the waste sector in Aotearoa. An increase in quality data collection would significantly help to identify and realise emissions reduction opportunities.

Table 4d.2: Opportunities for reducing emissions

Option	**Opportunities and challenges**
Avoiding Waste	Preventing waste from being created in the first place provides a big potential opportunity to reduce emissions. There are two key ways to make less waste: 1) Production processes can be improved to generate less waste. For example, houses can be built in a way that minimises the number of timber offcuts that are produced and/or goods can be designed to create less waste, for example through reducing the packaging. 2) Changes in consumption patterns can reduce production of waste and waste emissions. There are a range of options which can lead to changes in consumption patterns, for example, helping consumers buy more durable products. Potentially, almost all waste sources and their emissions could be avoided or eliminated. However, this goal is unlikely to be achieved in the near-term given our country’s systems and infrastructure that support widespread behaviour change are underdeveloped. It is difficult to quantify the exact size and cost of the opportunity of avoidance as it is reliant on significant behaviour change and widespread changes to product design and production systems. Because many of our goods are manufactured overseas, Aotearoa has little direct control over how much waste these goods can potentially generate.

[19] (Eunomia et al., 2017)

[20] (Department for Environment, Food and Rural Affairs (UK), 2011)

Option	Opportunities and challenges
	Nevertheless, international examples suggest the potential here is great. For example, over the decade from 2006 to 2016, Ireland reduced its waste generation by nearly 50% primarily due to European Union's directives such as those to prevent food waste and promote resource efficiency.[21] It is also important to note there is a lag between action and emissions reductions because it takes time for organic waste already landfilled to decay. Even if no new waste was generated from 2020, waste emissions would fall 50% by 2035 and 75% by 2050.[22] Work has not been done to assess the full range of opportunities and costs for waste reduction in Aotearoa. However, in many circumstances, reducing waste also increases efficiencies and would be low or no cost. For example, banning junk mail could reduce the paper waste stream by up to 30%, and also reduce costs for businesses.[23] Businesses and industries need to be supported and upskilled to help them understand the cost of their inputs and waste, and how to reduce it. Reducing waste going to landfills provides wider benefits. Landfills have disruptive effects on environmental quality and poorly managed landfills can contaminate surrounding land and waterways. Many current and old landfills are close to rivers and the coast and will be increasingly at risk as climate change raises sea levels and increases the frequency of storms and floods.[24] The flooding of the Fox River on the West Coast in 2019 destroyed an old landfill, spreading an estimated 135 tonnes of rubbish over more than 60 kilometres of river and coastline.[25] In terms of cultural impacts, some old landfills are located on land taken from Māori but returned through Settlement or other means. Māori-collectives responsible for managing the land are actively seeking to understand how to restore their whenua.
Waste Recovery	Recovering organic material away from landfills to other uses can reduce direct waste emissions and could also reduce emissions in other sectors and increase overall efficiency of resource use.[26] Organic waste can generally be reused, composted/recycled, or converted to energy. **Reuse and recycling** of materials such as paper and wood could be increased, from the re-use of wood waste in new builds to the reprocessing of paper waste to cardboard.

[21] (Eurostat, 2020)
[22] (Ministry for the Environment, Unpublisheda)
[23] (Ministry for the Environment, Unpublishedb)
[24] (New Zealand Government, 2019a)
[25] (Westland District Council, 2019)
[26] (Ramboll et al., 2020)

Option	Opportunities and challenges
	Composting food and garden waste converts organic waste into fertiliser in a process that gives off greenhouse gas emissions such as nitrous oxide, biogenic methane and carbon dioxide. Home composting of food scraps has been a familiar ritual for generations of New Zealanders and there is increasing commercial-scale composting of waste from commercial and industrial sites. For example, the Living Earth facility in Christchurch composts 50-100,000 tonnes of food and garden waste each year,[27] directly reducing biogenic methane emissions.[28] The resulting compost can be used in the agricultural sector, potentially displacing synthetic fertilisers and sequestering soil carbon[29]. However, there are no robust figures on the potential of this to reduce emissions across the agricultural sector in Aotearoa. The Productivity Commission cited **waste to energy** as *'one key avenue'* for a low emissions economy.[30] The Ministry for the Environment has also published a guide for waste to energy which emphasises that projects must move up the waste hierarchy.[31] The approach includes a range of options: • Wood waste can be burnt for heating or as fuel in industrial boilers, as is planned for Christchurch Hospital[32] and already implemented in a high temperature incinerator for treated wood at Golden Bay Cement.[33] • Organic (and inert) waste can also be incinerated in large-scale plants to generate electricity. However, the process is expensive to develop and requires a large and high calorific waste stream to run. On current volumes, only Auckland is large enough to support what would be considered a large waste to energy plant by international standards.[34] Additionally, burning inorganic materials such as plastics could further increase emissions over landfill disposal and incentivise that waste is sent to incinerators, which would decrease reuse and recycling, and result in more fossil fuel emissions.[35] • Biogenic methane from anaerobic digesters can also be used to generate biogas, a key renewable energy source. In this context, these refer to dedicated plant which help induce the biological process whereby microorganisms break down biodegradable material in an oxygen-free environment to generate bioenergy sources.[36] A large-

[27] (Living Earth, 2020)
[28] The exact amount of emission reductions is challenging to estimate, as it depends on whether the food waste would have otherwise gone to landfill with high biogenic methane capture rates or unmanaged landfill with no gas capture.
[29] (NSW Government: Environment, Climate Change and Water & The Organic Force, 2011)
[30] (Ministry for the Environment, 2020a)
[31] (Ministry for the Environment, 2020c)
[32] (New Zealand Government, 2019b)
[33] (BERL, 2019, pp. 38–39)
[34] (BERL, 2019, p. 31)
[35] (Hoffart, 2019)
[36] (Science Direct, 2020)

Option	Opportunities and challenges
	scale plant is currently being built in Reporoa to process a range of feedstock's including Auckland's food waste.[37] Small-scale anaerobic digestors are also in used across Aotearoa, such as wastewater treatment plants.[38] • Biogenic methane captured from landfills can also be captured to generate electricity. However, this is generally considered to sit within the 'disposal' tier of the waste hierarchy as opposed to the 'recovery' tier. Redvale, the country's largest municipal landfill, generates enough energy to power 14,000 homes.[39] While diverting organic waste from landfills can reduce biogenic methane emissions, the total emissions involved in diverting waste from landfill needs to be considered. For example, recovering and transporting large waste volumes for processing using diesel trucks may generate more emissions than it saves.[40] Decarbonisation of this part of the transport fleet would resolve this issue. If all organic waste was recovered from landfills, waste emissions could reduce by nearly 50% by 2035 and up to 75% by 2050 in Aotearoa. This depends on the mix of recovery options as composting, waste to energy, and anaerobic digestion will have their own emissions factors.[41] However, the resource recovery sector would need to be scaled up, new bioenergy facilities constructed and behavioural changes embedded in society. End uses for the diverted waste (such as composting or as recycled product) would also need to be developed. Our analysis suggests between 5% and 60% (depending on waste type) of the organic waste stream could be recovered by 2030 and 60-95% of the organic waste stream could be recovered by 2050.[42] Ministry for the Environment analysis shows that the marginal cost of abatement might range from a cost saving of $34 to a cost of $618 per tonne of CO_2e.[43] Increasing resource recovery rates through landfill diversion would also generate employment opportunities. The Ministry for the Environment has estimated that up to five times as many jobs could be created in recycling as disposal.[44]
Modern, low emissions landfills	Any organic waste which is not emissions or resource efficient to recover could be sent to landfills which have efficient biogenic methane capture systems. While many municipal landfills already have high-efficiency gas capture

[37] (Auckland Council, 2020)
[38] (Boušková & Thiele, 2018)
[39] (Office of the Prime Minister's Chief Science Advisor, 2019)
[40] (Waste Management NZ Ltd, 2018)
[41] The delay in emissions reductions is because it takes time for existing organic matter in landfills to decompose.
[42] Analysis of options, discussions with stakeholders.
[43] Costs based on MfE MACC work. For that exercise, mitigation costs were calculated as dollars per tonne of abatement in CO_2e.
[44] (Ministry for the Environment, 2019)

Option	Opportunities and challenges
	systems, some landfills do not have capture systems at all. These include municipal landfills which receive low volumes of waste and legacy landfills, as well as non-municipal and farm fills. Currently, over 75% of solid waste sector emissions are from disposal sites have no requirement to capture landfill gas.[45] The efficiency of the capture systems is important. Increasing the average efficiency of existing gas capture systems could reduce overall emissions. Ensuring all landfills which accept organic waste have efficient systems installed would also reduce emissions. Installing landfill gas capture systems at all farm fills is likely to be prohibitively expensive and impractical with many thousands of farm sites across the country. However, farms and rural communities could have access to drop-off points for waste, which will help reduce emissions Closed or legacy landfills continue to produce biogenic methane, as the organic waste in them breaks down.[46] Fitting gas capture systems to these sites could further reduce emissions from the baseline, although this may be challenging, expensive and have a limited effect as these systems will have lower capture efficiency. Even without capture systems, biogenic methane emissions will reduce over time as the organic waste decays, eventually reaching zero as all the waste decays. However, this process may take decades depending on a number of factors including the waste composition of the legacy landfill. The potential for emissions reduction for modern, low emission landfills is less when waste reduction and waste recovery is higher as there is simply less waste which means less waste emissions from landfills to reduce. Analysis by our team informed by data from Ministry for the Environment has estimated the cost of abatement for different landfill gas options might range from around \$20 - \$450 per tonne of CO_2e.[47] The large variance in abatement cost is due to the different potential assumptions around operational lifespan, gas capture efficiency, electricity prices and running costs. Landfill gas capture systems can also reduce local air pollution and provide other co-benefits such as renewable energy generation.
Low global warming potential (GWP) refrigerants	Hydrofluorocarbons are subject to the Emissions Trading Scheme, via the synthetic greenhouse gas levy. As NZ ETS prices rise, so will the price of importing goods containing refrigerants. 2020 is the first year of phasedown of hydrofluorocarbons (HFCs) in Aotearoa under the Kigali Amendment to the Montreal Protocol. The phasedown of

[45] (New Zealand Productivity Commission, 2018)

[46] It has been estimated that closed landfills will continue to emit 73 kt biogenic methane in 2035 and 31 kt biogenic methane in 2050. (Ministry for the Environment, Unpublisheda)

[47] Costs based on MFE Guidelines on Landfill Gas Accounting (Ministry for the Environment, 2004, pp. 13–20) and confirmed with stakeholders

Option	Opportunities and challenges
	HFCs imported in bulk (i.e. for insertion into equipment in Aotearoa) would reduce our use of HFCs imported in bulk by 81% in 2036 from the average consumption over 2011-2015. HFCs 'pre-charged' into products overseas (like heat pumps) are not included in our Kigali Amendment phasedown, as they were anticipated to reduce in line with other countries' phasedowns, and are subject to the synthetic greenhouse gas levy. The Ministry for the Environment is examining possible further interventions at different stages of the refrigerant lifecycle[48], including: ***Incentivising or requiring usage of alternatives.*** Alternative refrigerants with low global warming potential such as ammonia and hydrofluoroolefins (HFOs) and HFC blends can be used in place of HFCs. HFO-HFC blends offer intermediate emissions reductions and can be used in existing equipment, however other blends are not compatible and require new equipment. ***Prohibition on import of high-global warming potential HFCs***. Internationally, import prohibitions reflect the availability of more environmentally friendly technology options, and are designed to prevent import of high-GWP refrigerants when less-warming alternatives are available. A rapid phase out of powerful refrigerants could mean there is insufficient refrigerant to service the existing fleet of equipment which may result in 'stranded assets.' There may also be an increased safety burden and cost of housing a flammable and toxic substance on site. This is particularly relevant for organisations with medium sized systems who have enough charge for fire to be a serious risk but because of their scale do not have the systems and processes to manage it. ***Regulated Product Stewardship.*** Refrigerants were declared a priority product under the Waste Minimisation Act in 2020. This means the introduction of a refrigerant stewardship scheme could significantly increase our ability to destroy HFCs that would otherwise be emitted to the atmosphere at the end of a product's life, by addressing leakage and poor end of life disposal practises also reduces emissions. Currently, a voluntary program is in place in Aotearoa, but the overall recovery rate is low. Regulated product stewardship will assess a range of policy options to reduce refrigerant emissions by addressing improper disposal and installation practices, and bringing equipment leakage to attention. ***Integrating refrigerant management across building and infrastructure policy.*** Encouraging use of carbon footprint and benchmarking tools such as carboNZERO and CEMARs, and GREENSTAR. Government procurement activities could require selection of low emissions refrigerants.

[48] (Verum Group, 2020)

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