Appendix Q

Greenhouse Gas impact assessment

Woodlawn Advanced Energy Recovery Centre

Greenhouse gas assessment

Prepared for Veolia Environmental Services (Australia) Pty Ltd

July 2022

Woodlawn Advanced Energy Recovery Centre

Greenhouse gas assessment

Veolia Environmental Services (Australia) Pty Ltd

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Version	Date	Prepared by	Approved by	Comments
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Executive Summary

Veolia Environmental Services (Australia) Pty Ltd (Veolia) owns and operates the Woodlawn Eco Precinct (the Eco Precinct), located on Collector Road, approximately 6 kilometres (km) west of Tarago, 50 km south of Goulburn and 70 km north of Canberra. The Eco Precinct is located in the Goulburn Mulwaree local government area (LGA).

Veolia is proposing to develop and operate the Woodlawn Advanced Energy Recovery Centre (ARC), an energy recovery facility (ERF), at the existing Eco Precinct. The ARC will be designed to recover energy from residual waste that would otherwise be disposed of to landfill ('Bioreactor') at the Eco Precinct.

EMM Consulting Pty Ltd (EMM) was commissioned to undertake this greenhouse gas (GHG) assessment for the project. The GHG assessment provided operational estimates of 'Scope 1', 'Scope 2' and 'Scope 3' GHG emissions for three different scenarios:

- Baseline Scenario. This scenario represented the current operation of the Eco Precinct.
- Scenario 1. This scenario represented the future operation of the Eco Precinct, but with no ARC. The throughput of waste received at the Eco Precinct and sent to the Bioreactor applied to this scenario was the existing approved limit of landfilling (ie 1.13 Mtpa).
- Scenario 2. This scenario represented the future operation of the Eco Precinct with the ARC. Again, the approved limit of waste to the Eco Precinct was used, but in this case a proportion of the waste was diverted to the ARC and not placed in the Bioreactor.

The two future scenarios represented maximum future annual GHG emissions from the Eco Precinct, with and without the ARC in operation.

The export of electricity from the Eco Precinct to the grid was considered, as this effectively represented a GHG offset (negative emission) for the project. The assessment also provided a comparison of quantified GHG emissions with NSW and national emission inventories.

Construction-phase GHG emissions were not considered in the assessment, given the short-term nature of construction, the relatively low emission rate, and the conservative nature of the operational assessment.

Compared with a current baseline (Scope 1, 2 and 3 emissions) of 117,228 t CO_2-e/year, total operational GHG emissions were 238,072 t CO_2-e/year in Scenario 1 (future, no ARC), and 323,850 t CO2-e/year in Scenario 2 (future, with ARC). The difference between Scenario 1 and the Baseline Scenario was driven almost entirely by an increase in fugitive methane emissions. The difference between Scenario 2 and Scenario 1 was dependent on the trade-off between an increase in emissions due to the thermal treatment of residual waste, and a reduction in fugitive methane emissions.

When the substitution of electricity was taken into account in Scenario 2, the net operational GHG emissions were 71,828 t CO_2-e/year. This represented an overall reduction of 51% compared with Scenario 1, noting that Scenario 1 was based on peak generation of landfill gas. The net emissions for Scenario 2 of 71,828 t CO_2-e/year represented 0.01% of national GHG emissions, and 0.05% of GHG emissions in NSW. When viewed on the scale of total emissions from all sources in NSW and Australia, the emissions from the Eco Precinct are not considered significant.

The GHG emissions intensity of electricity generated by the project (0.64 kg CO_2-e/kWh) is lower than the GHG emissions intensity if electricity from the NSW grid (0.85 kg CO_2-e/kWh).

It is therefore concluded that, through the reduction of fugitive methane emissions and the substitution of grid electricity, the project has the potential to eliminate a substantial quantity of CO_2-e emissions, relative to a 'business-as-usual' future scenario.

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1 Introduction

Veolia Environmental Services (Australia) Pty Ltd (Veolia) owns and operates the Woodlawn Eco Precinct (the Eco Precinct), located on Collector Road, approximately 6 kilometres (km) west of Tarago, 50 km south of Goulburn and 70 km north of Canberra. The Eco Precinct is located in the Goulburn Mulwaree local government area (LGA).

Veolia proposes to develop and operate the Woodlawn Advanced Energy Recovery Centre (ARC) (the project), an energy recovery facility (ERF), at the Eco Precinct. This involves the development of an additional waste management technology at the Eco Precinct, processing a portion of the waste stream which is already approved to be received as part of integrated waste management operations, and recovering energy from the process.

EMM Consulting Pty Ltd (EMM) has been commissioned by Veolia to undertake a greenhouse gas (GHG) assessment for the project.

This GHG assessment has been prepared to form part of the environmental impact statement (EIS) for the application for the project. It provides estimates of 'Scope 1', 'Scope 2' and 'Scope 3' emissions for anticipated peak year emissions at the Eco Precinct, with and without the installation of the project, relative to current operational emissions. The study also provides a comparison of quantified GHG emissions with NSW and national emission inventories.

This GHG assessment addresses the Secretary's Environmental Assessment Requirements (SEARs), issued on 2 July 2021. Table 1.1 lists the matters relevant to this assessment and where they are addressed in this report.

Table 1.1 Relevant matters raised in SEARs

Requirement	Section addressed
Greenhouse Gas and Energy Efficiency – an assessment of the proposal's greenhouse gas emissions (reflecting the Government's goal of net zero emissions by 2050), including an assessment of cumulative impacts with existing site operations	This report

2 The project

2.1 Eco Precinct background

The Eco Precinct comprises the following integrated waste management operations, energy recovery technologies and energy generation, and other sustainable land uses, including the following:

- Woodlawn Bioreactor (the Bioreactor) – a landfill in which leachate is recirculated to help bacteria break down the waste, enhancing the early generation of gas, enabling more efficient, capture and extraction of landfill gas, including leachate and landfill gas management systems.
- Woodlawn BioEnergy Power Station – utilises landfill gas from the Bioreactor to generate electricity.
- Woodlawn Mechanical Biological Treatment (MBT) Facility – process municipal solid waste (MSW) to extract the organic content from a portion of the MSW for use in tailings dam remediation.
- Agriculture – includes a working farm (sheep and cattle) that applies sustainable management practices.
- Aquaculture and horticulture – use of captured waste heat from the BioEnergy Power Station for use in sustainable fish farming and hydroponic horticulture at the Eco Precinct.
- Renewable energy generation – the Woodlawn Wind Farm (operated by Iberdrola) which has an installed capacity to generate up to 48.3 MW and a solar farm (operated by Veolia) with installed capacity to produce up to 2.3 MW.

The Eco Precinct is served by the Crisps Creek Intermodal Facility (IMF) near the village of Tarago. The Crisps Creek IMF is located approximately 8.5 km to the east of the Eco Precinct (by road). Operations are augmented by two waste transfer terminals located in Sydney; the Clyde Transfer Terminal, which commenced operation in 2004 with the Bioreactor and Crisps Creek IMF, and the Banksmeadow Transfer Terminal, which commenced operating in 2016.

Waste is transported from the Sydney transfer terminals in purpose-built shipping containers by rail on the Goulburn-Bombala Railway line to the Crisps Creek IMF from the Eco Precinct. At the Crisps Creek IMF the containers are loaded on to trucks for delivery to the Eco Precinct. Waste from the local area is also approved to be transported to the Eco Precinct by road.

Figure 2.1 summarises the current approved waste volumes for the Eco Precinct.

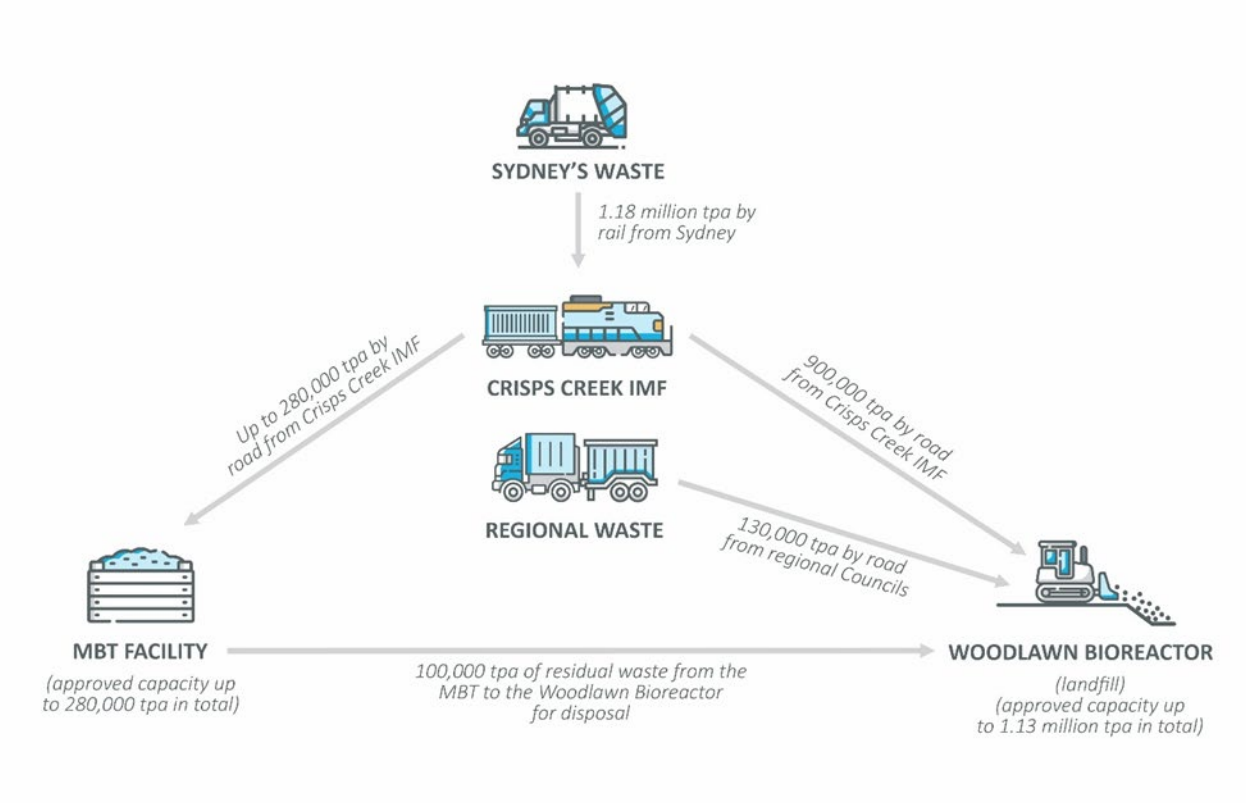

Figure 2.1 Approved waste volumes at the Eco Precinct

2.2 Project overview

The project will involve construction and operation of the following key ARC components:

- construction of the ARC, comprising an ERF for the thermal treatment of residual municipal solid waste (MSW) and commercial and industrial (C&I) waste (referred to as waste feedstock) that would otherwise be disposed to landfill;
- thermal treatment in the ARC of up to 380,000 tonnes per annum (tpa) of residual waste feedstock;
- installed capacity of up to 30 megawatts (MW) of electricity (generation of up to 240,000 megawatt hours (MWh) of electricity per annum);
- on-site management of residual by-products generated by the ARC, including construction of an encapsulation cell; and
- construction of ancillary infrastructure to facilitate construction and operation of the project, including a new access road.

3 Legislative setting

This section provides an overview of the international and national policies, agreements and frameworks that regulate and manage GHG emissions.

3.1 International context

3.1.1 Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science in relation to climate change. The IPCC prepares comprehensive Assessment Reports about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place. This first assessment report of the IPCC served as the basis for negotiating the United Nations Framework Convention on Climate Change (UNFCCC). The IPCC released its Fifth Assessment Report (AR5) in 2013/2014 and is currently in its sixth assessment cycle, producing the Sixth Assessment Report (AR6) due in 2022. The IPCC also produces a variety of guidance documents and recommended methodologies for GHG emissions inventories, including, for example, the 2006 IPCC Guidelines for National GHG Inventories (IPCC 2016) and 2019 Refinements (IPCC 2019).

3.1.2 United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC entered into force in March 2004 and provides the basis for concerted international action to mitigate climate change and to adapt to its impacts. With 197 Parties, the Convention has nearly a universal membership. The Conference of the Parties to the Convention (COP) are used to advance the implementation of the Convention.

The objective of the Convention is to stabilise GHG emissions 'at a level that would prevent dangerous anthropogenic interference with the climate system'. It states that 'such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner'[1].

- The UNFCCC:
- puts the onus on developed countries to lead the way in reducing GHG emissions;
- directs funds to climate change activities in developing countries;
- receives regular reports from developed countries on climate change policies and measures; and
- recognises adaptation to climate change.

3.1.3 Kyoto Protocol

The Kyoto Protocol was adopted in 1997 and was entered into force in 2005. There are currently 192 Parties to the Kyoto Protocol.

Building on the UNFCCC, the Kyoto Protocol commits industrialised countries and economies in transition to reduce GHG emissions in accordance with agreed individual targets. These targets add up to an average 5 % emission reduction compared to 1990 levels over the first commitment period (2008 – 2012).

[1] https://unfccc.int/process-and-meetings/the-convention/what-is-the-united-nations-framework-convention-on-climate-change

The Doha Amendment to the Kyoto Protocol was adopted for a second commitment period (2013 – 2020) and entered into force in December 2020. Under the second commitment, Parties will reduce GHG emissions by at least 18 % below 1990 levels. Under the second commitment period, Australia negotiated two emission reduction targets: an unconditional target of 5 to 15 % below 2000 emission levels by 2020, plus a conditional target of 25 % below 2000 emission levels by 2020 (DISER 2021c).

3.1.4 Paris Agreement

At the 2015 United Nations Climate Change Conference (COP21) held in Paris in December 2015, Parties to the UNFCCC reached the Paris Agreement, a global climate change agreement aimed at reducing GHG emissions in order to limit global temperature rise this century to between 1.5-2°C above pre-industrial levels.

Under the Paris Agreement, all Parties are required to put forward GHG emission reduction targets through Nationally Determined Contributions (NDCs). All Parties are required to report on national emissions, with a review of targets set to occur every five years from 2020.

Australia ratified the Paris Agreement in November 2016. Australia's target under the Paris Agreement is to reduce GHG emissions by 26-28 % below 2005 levels by 2030. In 2020 Australia affirmed its 2030 target and outlined emission reduction strategies and measures undertaken since 2015 (DISER 2021c).

3.2 Australian context

3.2.1 The National Greenhouse and Energy Reporting Scheme

The National Greenhouse and Energy Reporting (NGER) scheme, established by the *National Greenhouse and Energy Reporting Act 2007* (NGER Act), is a single national framework for reporting information about greenhouse gas emissions, energy production and energy consumption.

Facilities or corporations must report under the NGER scheme if they emit GHG emissions or produce/consume energy at or above the following trigger thresholds:

- greater than 25 kilotonnes (kt) GHG emissions (as CO_2-e) or produce/consume greater than 100 terajoules (TJ) of energy (facility level); or
- greater than 125 kt of GHG emissions (as CO_2-e) or produce/consume greater than 500 TJ of energy (corporate level).

Veolia currently reports annual GHG emissions from the Bioreactor and the MBT under the NGER scheme.

The NGER Act is underpinned by the National Greenhouse and Energy Reporting Regulations 2008 and the National Greenhouse and Energy Reporting (Measurement) Determination 2008. The Measurement Determination provides methods, criteria and measurement standards for calculating GHG emissions and energy data and covers Scope 1 and Scope 2 emissions (emission scopes are discussed further in Section 4.1) and energy production and consumption.

The Measurement Determination has been updated for 2020–21 onward to include:

- the global warming potentials (GWPs) prescribed by the IPCC in its Fifth Assessment Report (AR5); and
- updating Scope 2 emission factors; for each state.

3.2.2 New South Wales – Climate Change Policy Framework

The NSW Climate Change Policy Framework (NSW OEH 2016a) outlines the NSW Government objective of net-zero emissions by 2050 and to increase climate change resilience in NSW. The intent of the framework is to maximise the economic, social and environmental wellbeing of NSW in the context of climate change and current and emerging policy settings and actions to address climate change. The framework sets out seven policy directions for the NSW government to respond to climate change. The Premier and the Minister for the Environment's Draft Climate Change Fund Strategic Plan (NSW OEH 2016b), sets out priority investment areas and potential actions for up to $500 million of new funding from the Climate Change Fund for five years from 2017 to 2022. It organises potential actions into three priority investment areas:

- accelerating advanced energy – aims to provide greater investment certainty for private sector, accelerating new technology to reduce future costs and helping communities make informed decisions on a net-zero emissions future;
- national leadership in energy efficiency - focuses on building energy productivity and lowering energy prices; and
- preparing for a changing climate – aims to reduce costs to public and private assets that arise from climate change, reduce impacts on health and wellbeing, particularity in vulnerable communities and manage impacts of climate change on natural resources, ecosystems and communities.

Further to the NSW Climate Change Policy Framework, the NSW DPIE released the Net Zero Plan Stage 1: 2020-2030, dated 14 March 2020, which provides greater detail on initial strategies for the state to meet net zero emissions by 2050 by delivering a 35% cut in emissions by 2030 compared to 2005 levels. The plan outlines initiatives to balance economic growth, job creation and emission reduction.

4 Scope of the assessment

4.1 Accounting of greenhouse gas emissions

For accounting and reporting purposes, GHG emissions are defined as 'direct' and 'indirect'. Direct emissions (also referred to as Scope 1 emissions) occur within the boundary of an organisation and are a result of the organisation's activities. Indirect emissions are generated as a consequence of an organisation's activities, but are physically produced by the activities of another organisation (DISER 2021a).

Indirect emissions are further defined as Scope 2 and Scope 3 emissions. Scope 2 emissions occur from the generation of the electricity purchased and consumed by an organisation. Scope 3 emissions occur from all other upstream and downstream activities, such as the downstream extraction and production of raw materials or the upstream use of products and services.

Scope 3 is an optional reporting category (Bhatia et al 2010) and should not be used to make comparisons between organisations, for example in benchmarking GHG intensity of products or services. Typically, only major sources of Scope 3 emissions are accounted and reported by organisations.

Examples of Scope 1, 2 and 3 emissions are provided in Figure 4.1.

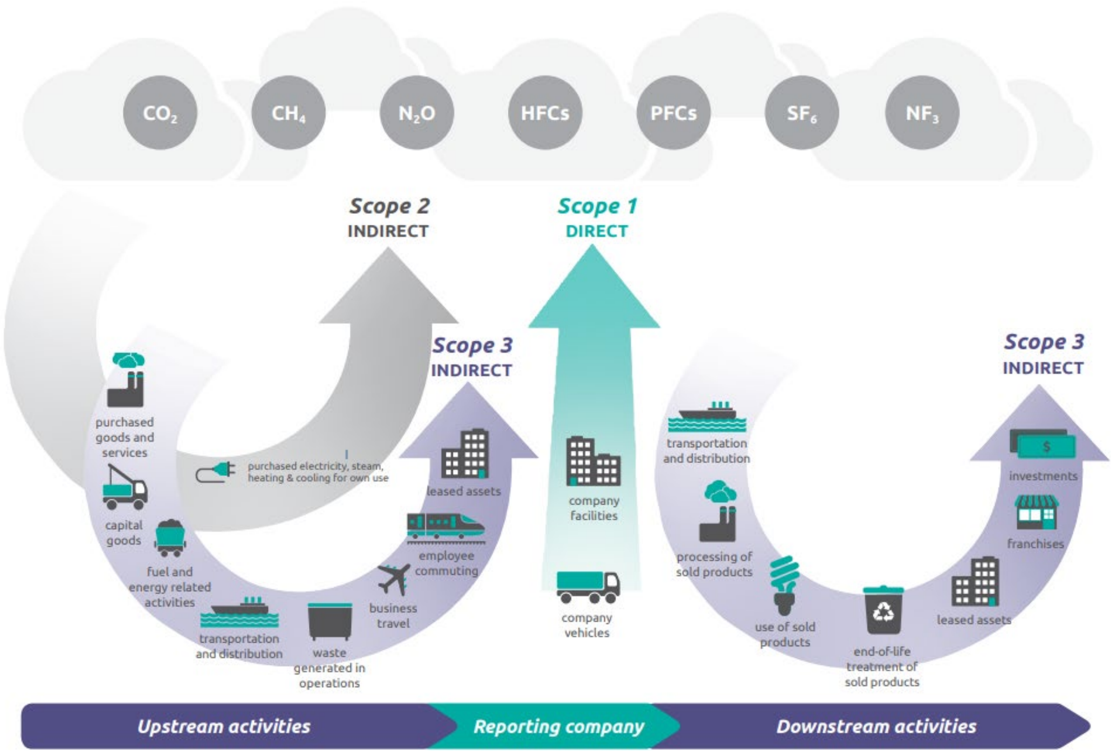

Figure 4.1 Overview of GHG emission scopes (WRI & WBCSD 2013)

In this assessment, GHG emissions are presented as carbon dioxide equivalents (CO_2-e) and include emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and sulfur hexafluoride (SF_6), calculated based on the global warming potentials (GWPs) adopted by the Parties to the UNFCCC and its Kyoto Protocol. Hydrofluorocarbons (HCFs), perfluorinated compounds (PFCs) and nitrogen trifluoride (NF_3) were not relevant to the project, and were therefore not included in the emission calculations.

4.2 Boundaries of the assessment

For the purpose of this GHG assessment, the operations relating to the Eco Precinct were taken to include the transfer of waste by rail from the terminals at Banksmeadow and Clyde to the Crisps Creek IMF, the subsequent transfer of the waste by road to the Eco Precinct, the transfer of local waste to the Eco Precinct, and on-site operations at the Eco Precinct.

The following activities were not included in the assessment:

- electricity consumption for waste sorting at the Banksmeadow and Clyde terminals;
- diesel consumption for waste sorting at the Banksmeadow and Clyde terminals; and
- process water consumption for waste sorting at the Banksmeadow and Clyde terminals.

4.3 Construction phase

The construction of the project is expected to be undertaken over a period of three years and will include the following stages:

- site establishment;
- civil works;
- high-voltage transmission works;
- ARC construction and plant installation;
- commissioning and completion; and
- operational licensing.

Key project durations are as follows:

- 2021-2023: environmental assessment and approval;
- 2023-2026: project construction (approximately three years); and
- 2026: commencement of project operation.

Throughout the three year construction period, energy consumption will be lower than the operational phase of the project. The operational phase scenarios (Section 4.4) focus on the anticipated peak GHG emissions year and therefore conservatively account for the potential emissions generated during any point of the construction phase.

Construction phase GHG emissions are not considered further in this assessment.

4.4 Operational scenarios

Three different operational scenarios were considered in the assessment:

- Baseline Scenario. This scenario represented the current operation of the Eco Precinct, based mainly on the data for the 2019-2020 NGER period and inputs from Veolia.

- Scenario 1. This scenario represented the future operation of the Eco Precinct, but with no ARC. The throughput of waste received at the Eco Precinct and sent to the Bioreactor applied to this scenario was the existing approved limit of landfilling (ie 1.18 Mtpa).

- Scenario 2. This scenario represented the future operation of the Eco Precinct with the ARC. Again, the approved limit of waste to the Eco Precinct was used, but in this case a proportion of the waste was diverted to the ARC and not placed in the Bioreactor.

The two future scenarios were intended to be representative of maximum future annual GHG emissions from the Eco Precinct, with and without the ARC in operation.

The assumptions on which the scenarios were based are summarised in Table 4.1. It should be noted that not all the parameters were required for the GHG calculations, but are presented for completeness and to aid understanding.

Table 4.1 Scenario assumptions

Parameter	Baseline (current operation, 2020)	Scenario 1 (future operation, no ARC)	Scenario 2 Future operation, with ARC)
Inbound waste to Eco Precinct			
From Sydney to Eco Precinct from Sydney (t/year)	813,755[a]	1,180,000	1,180,000
From local area to Eco Precinct (t/year)[d]	130,000[a]	130,000	130,000
Total	***943,755***	***1,310,000***	***1,310,000***
Transfer of waste to Bioreactor or ARC			
From IMF (t/year)	671,630[a]	900,000	900,000
From MBT (t/year)	68,398[a]	100,000	100,000
From local area (t/year) [d]	130,000[a]	130,000	130,000
Total	***870,028***	***1,130,000***	***1,130,000***
To Bioreactor (t/year)	870,028[b]	1,130,000	750,000
To ARC (t/year)	0	0	380,000
Total	***870,028***	***1,130,000***	***1,130,000***
Electricity generation			
Bioenergy Power Station (MWh/year)	52,845[b]	113,328©	75,492[c]
ARC (MWh/year)	0	0	240,000

(a) Provided by Veolia

(b) From NGER submission for 2019-2020.

(c) See Section 5.3.

(d) Waste from the regional area is also approved to be transported to the Eco Precinct by road, up to 130,000 tpa (with written consent).

5 Calculation methodology

5.1 Overview

Scope 1, Scope 2 and Scope 3 emissions were included in the GHG assessment. Emissions were calculated using a variety of approaches, but the calculation mainly involved reference to the following documents:

- the *National Greenhouse Gas Accounting Factors* (NGAFs) (DISER 2021a);
- the *National Greenhouse and Energy Reporting (Measurement) Determination 2008*, as amended in July 2021 (DISER 2021b);
- the NGER submission for the Woodlawn Eco Precinct for 2019-2020; and
- the characteristics of the project.

GHG emissions were calculated for the following:

- operation of the Eco Precinct, with and without the project; and
- substituted electricity, derived from both the Bioenergy Power Station and the ARC.

5.2 Operational emissions

The most significant emission-generating activities were included in the assessment, and these are summarised by scenario and by scope in Table 5.1. For each activity the details of the calculation approach are given in Appendix A.

5.3 Substituted electricity

The export of electricity from the Eco Precinct to the grid would effectively substitute electricity produced from other sources, and represents a GHG offset (negative emission) for the project.

According to the NGER submission for 2019-2020, the Bioenergy Power Station exported 52,845 MWh per year to the grid, and this value was used in the Baseline Scenario. The amounts of electricity exported from the Bioenergy Power Station in Scenarios 1 and 2 were scaled from the value in the Baseline Scenario, and in proportion to the number of engines being used to generate electricity, taken from the Veolia model (7 engines in the Baseline Scenario, 15 engines in Scenario 1, and 10 engines in Scenario 2).

In Scenario 2, the ARC was assumed to have an electricity production of 240,000 MWh per year.

For each scenario, the single-year GHG offsets for substituted electricity were calculated by multiplying the numbers of MWh above by the unit emission factor for grid electricity in NSW from DISER (2021a)[2]. This unit emission factor was 0.79 tCO_2-e/MWh.

[2] Table 5 of DISER (2021a): Indirect (scope 2) emission factors for consumption of purchased electricity or loss of electricity from the grid.

Table 5.1 Operational activities included in the GHG assessment

Scope	Activity	Scenario		
		Baseline	Scenario 1	Scenario 2
Scope 1	On-site combustion of liquid fuels (diesel, petrol, petroleum oil)	✓	✓	✓
	On-site combustion of landfill gas	✓	✓	✓
	On-site flaring of landfill gas	✓	✓	✓
	On-site fugitive emissions of landfill gas	✓	✓	✓
	On-site sulfur hexafluoride (SF_6) emissions	✓	✓	✓
	On-site thermal treatment of waste for electricity generation (ARC)	-	-	✓
	On-site transport of residue to the encapsulation cell	-	-	✓
Scope 2	Purchased electricity[a]	✓	✓	✓
Scope 3	Transport of waste from Banksmeadow/Clyde to IMF by rail	✓	✓	✓
	Transport of waste from IMF to Eco Precinct by road	✓	✓	✓
	Transport of local waste to Eco Precinct by road	✓	✓	✓
	Combustion of liquid fuels[b]	✓	✓	✓
	Purchased electricity[a]	✓	✓	✓
	Employee travel[c]	✓	✓	✓

(a) Indirect emissions from electricity lost in delivery in the transmission and distribution network.
(b) Indirect emissions from the extraction, production and transport of diesel, petrol and petroleum oils used on-site.
(c) Indirect emissions from fuel use for employee travel.

6 Results

6.1 Operational emissions

Operational GHG emissions for the Baseline Scenario, Scenario 1 and Scenario 2 are presented in Table 6.1, Table 6.2 and Table 6.3 respectively, with a breakdown of emissions by scope and activity in each case.

It is noted that the assessment of GHG emissions from the project has also considered changes to emissions across the Eco Precinct. The approach is considered appropriate due to the interdependencies between many of the sources. For example, the waste feedstock for the ARC is diverted from the approved waste receival amount for the Bioreactor, and therefore the introduction of the project influences GHG emissions generated by the Bioreactor.

In the Baseline Scenario and Scenario 1, the fugitive emission of landfill gas was by far the largest contributor, being responsible for approximately 85 % of total CO_2-e emissions. In Scenario 2, fugitive emissions were still responsible for 46 % of the total, but in this scenario the thermal treatment of residual waste to produce electricity also contributed 46 % of all CO_2-e emissions. In all scenarios the majority of emissions (88-94 %) were Scope 1.

Compared with the baseline of 117,228 t CO_2-e/year, total operational GHG emissions increased to 238,072 t CO_2-e/year in Scenario 1 (future, no ARC), and to 323,850 t CO_2-e/year in Scenario 2 (future, with ARC). The difference between Scenario 1 and the Baseline Scenario was driven almost entirely by an increase in fugitive methane emissions. The difference between Scenario 2 and Scenario 1 was dependent on the trade-off between an increase in emissions due to the thermal treatment of residual waste, and a reduction in fugitive methane emissions.

Table 6.1 Estimated annual GHG emissions (baseline – Eco Precinct operations)

Scenario	Source	GHG emissions (t CO_2-e/year)			
		Scope 1	Scope 2	Scope 3	Total
Baseline	Transport: waste from Sydney to IMF by rail	-	-	5,525.1	5,525.1
	Transport: waste from IMF to Eco Precinct by road	-	-	522.6	522.6
	Transport: local waste to Eco Precinct by road	-	-	576.1	576.1
	Combustion: diesel (Bioreactor)	2,108.8	-	108.1	2,217.0
	Combustion: diesel (MBT)	209.9	-	10.8	220.7
	Combustion: diesel (ARC)	-	-	-	-
	Combustion: petrol (Bioreactor)	5.5	-	0.3	5.8
	Combustion: petrol (MBT)	15.3	-	0.8	16.1
	Combustion: ethanol (MBT)	0.0	-	-	0.0
	Combustion: petroleum oils (Bioreactor)	3.2	-	0.8	4.1
	Combustion of landfill gas	3,397.7	-	-	3,397.7
	Flaring of landfill gas	486.6	-	-	486.6
	Fugitive emissions of landfill gas	97,344.0	-	-	97,344.0
	SF_6 emissions	3.0	-	-	3.0

Table 6.1 Estimated annual GHG emissions (baseline – Eco Precinct operations)

Scenario	Source	GHG emissions (t CO_2-e/year)			
		Scope 1	Scope 2	Scope 3	Total
	Thermal treatment of residual waste for electricity (ARC)	-	-	-	-
	On-site transport of residue to the encapsulation cell	-	-	-	-
	Purchased electricity (Bioreactor)	-	3,146.1	278.8	3,424.9
	Purchased electricity (MBT)	-	2,987.5	264.7	3,252.2
	Purchased electricity (ARC)	-	-	-	-
	Employee travel	-	-	232.3	232.3
	TOTAL	**103,574.2**	**6,133.7**	**7,520.5**	**117,228.3**

Table 6.2 Estimated annual GHG emissions (Scenario 1- approved future Eco Precinct operations without project)

Scenario	Source	GHG emissions (t CO_2-e/year)			
		Scope 1	Scope 2	Scope 3	Total
Scenario 1	Transport: waste from Sydney to IMF by rail	-	-	8,011.8	8,011.8
	Transport: waste from IMF to Eco Precinct by road	-	-	757.8	757.8
	Transport: local waste to Eco Precinct by road	-	-	576.1	576.1
	Combustion: diesel (Bioreactor)	2,739.0	-	140.5	2,879.4
	Combustion: diesel (MBT)	413.5	-	21.2	434.7
	Combustion: diesel (ARC)	-	-	-	-
	Combustion: petrol (Bioreactor)	7.2	-	0.4	7.6
	Combustion: petrol (MBT)	30.2	-	1.6	31.8
	Combustion: ethanol (MBT)	0.0	-	-	0.0
	Combustion: petroleum oils (Bioreactor)	4.2	-	1.1	5.3
	Combustion of landfill gas	7,771.6	-	-	7,771.6
	Flaring of landfill gas	1,113.1	-	-	1,113.1
	Fugitive emissions of landfill gas	205,302.1	-	-	205,302.1
	SF_6 emissions	3.0	-	-	3.0
	Thermal treatment of residual waste for electricity (ARC)	-	-	-	-
	On-site transport of residue to encapsulation cell	-	-	-	-
	Purchased electricity (Bioreactor)	-	4,086.2	362.1	4,448.3
	Purchased electricity (MBT)	-	5,885.7	521.5	6,407.2

Table 6.2 Estimated annual GHG emissions (Scenario 1- approved future Eco Precinct operations without project)

Scenario	Source	GHG emissions (t CO_2-e/year)			
		Scope 1	Scope 2	Scope 3	Total
	Purchased electricity (ARC)	-	-	-	-
	Employee travel	-	-	322.4	322.4
	TOTAL	**217,383.8**	**9,972.0**	**10,716.5**	**238,072.2**

Table 6.3 Estimated annual GHG emissions (Scenario 2- approved future Eco Precinct operations with project)

Scenario	Source	GHG emissions (t CO_2-e/year)			
		Scope 1	Scope 2	Scope 3	Total
Scenario 2	Transport: waste from Sydney to IMF by rail	-	-	8,011.8	8,011.8
	Transport: waste from IMF to Eco Precinct by road	-	-	757.8	757.8
	Transport: local waste to Eco Precinct by road	-	-	576.1	576.1
	Combustion: diesel (Bioreactor)	1,817.9	-	93.2	1,911.1
	Combustion: diesel (MBT)	413.5	-	21.2	434.7
	Combustion: diesel (ARC)	1,639.1	-	83.9	1,723.1
	Combustion: petrol (Bioreactor)	4.8	-	0.3	5.0
	Combustion: petrol (MBT)	30.2	-	1.6	31.8
	Combustion: ethanol (MBT)	0.0	-	-	0.0
	Combustion: petroleum oils (Bioreactor)	2.8	-	0.7	3.5
	Combustion of landfill gas	5,537.3	-	-	5,537.3
	Flaring of landfill gas	793.1	-	-	793.1
	Fugitive emissions of landfill gas	146,274.6	-	-	146,274.6
	SF_6 emissions	3.0	-	-	3.0
	Thermal treatment of residual waste for electricity (ARC)	146,891.3	-	-	146,891.3
	On-site transport of residue to encapsulation cell	84.3	-	-	84.3
	Purchased electricity (Bioreactor)	-	2,712.1	240.3	2,952.4
	Purchased electricity (MBT)	-	5,885.7	521.5	6,407.2
	Purchased electricity (ARC)	-	884.8	78.4	963.2
	Employee travel	-	-	488.4	488.4

Table 6.3 Estimated annual GHG emissions (Scenario 2- approved future Eco Precinct operations with project)

Scenario	Source	GHG emissions (t CO_2-e/year)			
		Scope 1	**Scope 2**	**Scope 3**	**Total**
	TOTAL	**303,491.7**	**9,482.6**	**10,875.2**	**323,849.5**

6.2 Emissions for substituted electricity

The annual GHG emissions associated with substituted electricity (Scope 2) are given in Table 6.4. As these effectively represent emission 'savings', the values are negative. The overall saving in GHG emissions in Scenario 2 was 249,239 t CO_2-e/year. Compared with Scenario 1, this equated to a net saving of 159,781 t CO_2-e/year.

Table 6.4 Annual emissions for substituted electricity (Scope 2)

Source	GHG emissions (t CO_2-e/year)		
	Baseline	**Scenario 1**	**Scenario 2**
Bioenergy Power Station	-41,747	-89,458	-59,639
ARC	N/A	N/A	-189,600
TOTAL	**-41,747**	**-89,458**	**-249,239**

6.3 Summary and significance

Operational emissions in each scenario, and the emission benefits associated with substituted electricity in Scenario 2, are summarised in Table 6.5. For each scenario the substituted electricity is presented as a negative emission, and the total is the sum of the operation and substituted electricity. This is also shown graphically in Figure 6.1. When the substitution of electricity is taken into account in Scenario 2 (with the ARC), the net operational emissions were 74,611 t CO_2-e/year. This represents an overall reduction of 50% compared with Scenario 1.

The significance of the project's GHG emissions has been estimated through comparison with NSW and relative to national GHG emission. The NSW and national results were taken from the Australian Greenhouse Emissions Information System (AGEIS)[3], and for the calendar year 2019, Specifically, the 2019 emission totals for NSW and Australia were 136,579.03 kt CO_2-e and 529,297.7 kt CO_2-e respectively.

The net emissions for Scenario 2 of 71,828 t CO_2-e/year represented 0.01% of national GHG emissions, and 0.05% of GHG emissions in NSW.

[3] https://ageis.climatechange.gov.au/SGGI.aspx

Table 6.5 Summary of operational GHG emissions

	GHG emissions (t CO_2-e/year)		
	Baseline	**Scenario 1**	**Scenario 2**
Operation	117,228	238,072	323,850
Substituted electricity	-41,747	-89,458	-249,239
TOTAL (net)	**75,481**	**148,614**	**74,611**

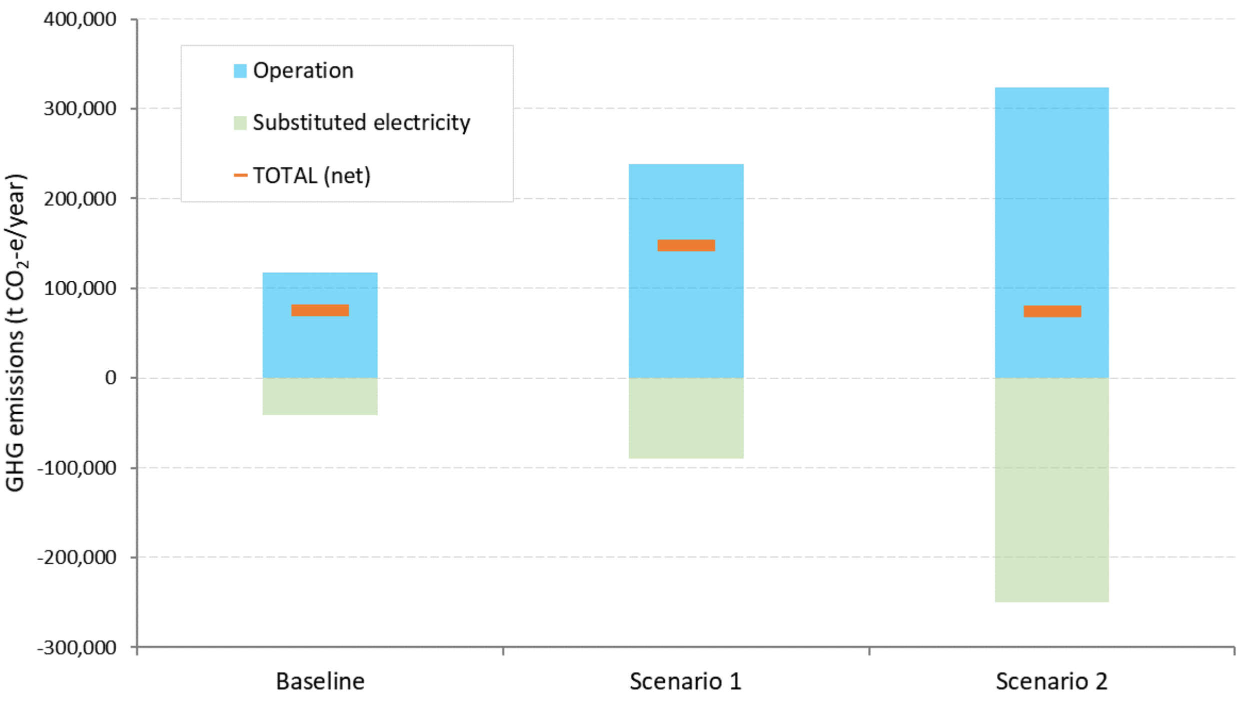

Figure 6.1 Plot of operational GHG emissions

Finally, the emissions intensity of electricity generated by the project only has been quantified by considering all emissions associated with the project, specifically:

- thermal treatment of residual waste for electricity generation (Scope 1);
- the combustion of diesel fuel associated with the project (Scope 1);
- the on-site transportation of residue from the ARC building to the encapsulation cell (Scope 1);
- the consumption of purchased electricity by the project (Scope 2);
- the transportation of waste to the project (Scope 3); and
- employee travel (Scope 3).

The current year full fuel cycle emission factor for purchased grid electricity in NSW is 0.85 kg CO_2-e/kWh (DISER, 2021a). By comparison, the project GHG emissions listed above combined with an annual electricity generation of 240,000 MWh/year, returns an emissions intensity of 0.64 kg CO_2-e/kWh. Consequently, the GHG emissions intensity of electricity generated by the project is lower than the GHG emissions intensity of electricity from the NSW grid. It is noted that this calculation does not account for other emission savings across the Eco Precinct[4] detailed in Table 6.5.

[4] The emissions intensity can also be calculated for the *changes* in GHG emissions and electricity production at the whole Eco Precinct, including the ARC and taking into account fugitive emissions. Based on the differences between Scenario 2 and Scenario 1, this marginal emissions intensity for the project is 0.42 kg CO_2-e/kWh.

7 Summary and conclusions

This GHG assessment supports a development application for the project. It provides baseline and future peak-year estimates without the project (Scenario 1) and with the project (Scenario 2). The assessment covered Scope 1, 2 and 3 GHG emissions, and included a comparison with NSW and national inventories.

The main benefits of the project are a reduction of waste going to the Bioreactor, a reduction of landfill gas generation, and the substitution of grid electricity with electricity derived from a less GHG-intensive process (landfill gas combustion). Compared with Scenario 1, which reflects the existing approval, it is estimated that the project will reduce the amount of residual waste going to the Bioreactor by approximately 380,000 tonnes per year, which will in turn reduce fugitive emissions of methane, and will generate 240,000 MWh/year of partially renewable electricity for export to the grid.

Compared with a current baseline (Scope 1, 2 and 3 emissions) of 117,228 t CO_2-e/year, total operational GHG emissions were 238,072 t CO_2-e/year in Scenario 1 (future, no ARC), and 323,850 t CO2-e/year in Scenario 2 (future, with ARC). The difference between Scenario 1 and the Baseline Scenario was driven almost entirely by an increase in fugitive methane emissions. The difference between Scenario 2 and Scenario 1 was dependent on the trade-off between an increase in emissions due to the thermal treatment of residual waste, and a reduction in fugitive methane emissions.

When the substitution of electricity was taken into account in Scenario 2, the net operational GHG emissions were 74,611 t CO_2-e/year. This represented an overall reduction of 50% compared with Scenario 1, noting that Scenario 1 was based on peak generation of landfill gas.

The net emissions for Scenario 2 of 74,611 t CO_2-e/year represented 0.01% of national GHG emissions, and 0.05% of GHG emissions in NSW. When viewed on the scale of total emissions from all sources in NSW and Australia, the emissions from the Eco Precinct are not considered significant. Relative to Scenario 1 emissions, the project represents an opportunity to save up to 74,000 t CO_2-e per year. This is equivalent to the annual emissions from about 32,400 cars in Australia.[5]

The GHG emissions intensity of electricity generated by the project (0.64 kg CO_2-e/kWh) is lower than the GHG emissions intensity of electricity from the NSW grid (0.85 kg CO_2-e/kWh).

It is therefore concluded that, through the reduction of fugitive methane emissions and the substitution of grid electricity, the project has the potential to eliminate a substantial quantity of CO_2-e emissions, relative to a 'business-as-usual' future scenario.

On the basis of quantified annual GHG emissions, Veolia will continue to report annual GHG emissions from operations at the Eco Precinct under the NGER scheme.

[5] Based on an average emission rate of 181 g CO2-e per vehicle-km, and an annual distance of 12,600 km (2018, pre-COVID), for an average Australian car.

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Abbreviations

AR5	(IPCC) Fifth Assessment Report
AR6	(IPCC) Sixth Assessment Report
APCr	air pollution control residue
ARC	Advanced Energy Recovery Centre
CH_4	methane
CO_2-e	carbon dioxide equivalent
DISER	Department of Industry, Science, Energy and Resources
ERF	energy recovery facility
GHG	greenhouse gas
GWP	global warming potential
IMF	(Crisps Creek) intermodal facility
IPCC	Intergovernmental Panel on Climate Change
kW	kilowatt
MSW	municipal solid waste
MW	megawatt
N_2O	nitrous oxide
NGAF	National Greenhouse Accounts Factors
NGER	National Greenhouse and Energy Reporting
NSW	New South Wales
tpa	tonnes per annum
UNFCCC	United Nations Framework Convention on Climate Change
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Annexure A

Operational greenhouse gas calculations

creating opportunities

A.1 Scope 1 emissions

A.1.1 Emissions from liquid fuel combustion (on-site)

Scope 1 emissions from liquid fuel combustion are associated with the following on-site activities:

- diesel combustion (stationary sources, excluding electricity generation);
- diesel combustion (mobile sources);
- petrol combustion (mobile sources); and
- petroleum oil combustion (stationary sources, excluding electricity generation).

GHG emissions for liquid fuel combustion were estimated using Equation A1.

$$E_{liq} = \frac{Q_{liq} \times EC_{liq} \times EF_{liq}}{1000}$$

Equation A1

where:

E_{liq}	=	emission of a given GHG	(t CO_2-e/year)
Q_{liq}	=	quantity of fuel	(kL/year)
EC_{liq}	=	energy content of fuel	(GJ/kL)[6]
EF_{liq}	=	emission factor for GHG	(kg CO_2-e/GJ)[7]

For each activity, the energy content of the fuel and the scope 1 emission factors are given in Table A.1. The estimated fuel use for each activity and scenario is given in Table A.2. For Scenarios 1 and 2, the baseline fuel use for the Bioreactor and MBT was scaled according to relative waste inputs, and the scaling factors are given in Table A.3.

Table A.1 Energy content and emission factors: liquid fuel combustion (scope 1)

Activity	Energy content (GJ/kL)	Scope 1 emission factors (kg CO_2-e/GJ)			Source/method
		CO_2	CH_4	N_2O	
Diesel combustion (stationary sources)	38.6	69.9	0.1	0.2	DISER (2021a), Table 3
Diesel combustion (mobile sources)	38.6	69.9	0.01	0.5	DISER (2021a), Table 4 (post-2004 vehicles)
Petrol combustion (mobile sources)	34.2	67.4	0.02	0.2	DISER (2021a), Table 4 (post-2004 vehicles)
Petroleum oil combustion (stationary sources)	38.8	13.9	0	0	DISER (2021a), Table 3

6 GJ = gigajoules

7 kg CO_2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

Table A.2 Fuel use: liquid fuel combustion (scope 1)

Activity/scenario	Location	Fuel use (kL/year)	Source/method
Diesel combustion (stationary sources)			
Baseline	Bioreactor	768.5	2019-2020 NGER submission
	MBT	77.5	2019-2020 NGER submission
Scenario 1	Bioreactor	998.1	Baseline scaled according to input waste to Bioreactor for Scenario 1
	MBT	152.6	Baseline scaled according to input waste to MBT for Scenario 1
Scenario 2	Bioreactor	662.5	Baseline scaled according to input waste to Bioreactor for Scenario 2
	MBT	152.6	Baseline scaled according to input waste to MBT for Scenario 2
	ARC	300.0	Data from Veolia
Diesel combustion (mobile sources)			
Baseline	Bioreactor	9.7	2019-2020 NGER submission
Scenario 1	Bioreactor	12.6	Baseline scaled according to input waste to Bioreactor for Scenario 1
Scenario 2	Bioreactor	8.4	Baseline scaled according to input waste to Bioreactor for Scenario 2
	ARC	335.0[(a)]	Data from Veolia
Petrol combustion (mobile sources)			
Baseline	Bioreactor	2.4	2019-2020 NGER submission
	MBT	6.6	2019-2020 NGER submission
Scenario 1	Bioreactor	3.1	Baseline scaled according to input waste to Bioreactor for Scenario 1
	MBT	13.0	Baseline scaled according to input waste to MBT for Scenario 1
Scenario 2	Bioreactor	2.1	Baseline scaled according to input waste to Bioreactor for Scenario 2
	MBT	13.0	Baseline scaled according to input waste to MBT for Scenario 2
Ethanol combustion (mobile sources)			
Baseline	MBT	0.16	2019-2020 NGER submission
Scenario 1	MBT	0.3	Baseline scaled according to input waste to MBT for Scenario 1
Scenario 2	MBT	0.3	Baseline scaled according to input waste to MBT for Scenario 2
Petroleum oil combustion (stationary sources)			
Baseline	Bioreactor	6.0	2019-2020 NGER submission
Scenario 1	Bioreactor	7.8	Baseline scaled according to input waste to Bioreactor for Scenario 1
Scenario 2	Bioreactor	5.2	Baseline scaled according to input waste to Bioreactor for Scenario 2

(a) Including the transport of APCr to the encapsulation cell.

Table A.3 Projected waste to Bioreactor and MBT and scaling factors

Scenario	Input waste (t/year)	Scaling factor (relative to baseline)
Bioreactor		
Baseline	870,028	1.000
Scenario 1	1,130,000	1.299
Scenario 2	750,000	0.862
MBT		
Baseline	142,125[a]	1.000
Scenario 1	280,000	1.97
Scenario 2	280,000	1.97

(a) Provided by Veolia

A.1.2 Combustion and flaring of landfill gas

Scope 1 emissions from landfill gas combustion were associated with the following on-site activities:

- landfill gas combustion for electricity generation; and
- flaring.

GHG emissions were estimated using Equation A2.

$$E_{gas} = \frac{Q_{gas} \times EC_{gas} \times EF_{gas}}{1000}$$

Equation A2

where:

E_{gas}	=	emission of a given GHG	(t CO_2-e/year)
Q_{gas}	=	quantity of landfill gas	(m^3/year)
EC_{gas}	=	energy content of landfill gas	(GJ/m^3)
EF_{gas}	=	emission factor for GHG	(kg CO_2-e/GJ)

For each activity, the energy content of the fuel and the scope 1 emission factors are given in Table A.4. The estimated landfill gas volumes for each activity and scenario are given in Table A.5.

The volumes were derived from the outputs of a landfill gas model developed by Veolia. In the Veolia model, the 'generated methane' and 'captured methane' are calculated by year. Captured methane is subject to either combustion for electricity generation, or flaring. However, the model does not provide this split, and the volumes for combustion and flaring were therefore derived for all years based on the ratio in the 2019-2020 NGER submission (ie approximately 87% combustion for electricity generation, and 13% for flaring). The historical data for flaring from the previous NGER submissions followed no systematic pattern, and therefore the application of the ratio from 2019-2020 to future years is subject to some uncertainty.

For Scenarios 1 and 2, the corresponding peak projected flow rates between 2025 and 2064 were used.

Table A.4 Energy content and emission factors: landfill gas combustion (scope 1)

Activity	Energy content (GJ/m³)	Scope 1 emission factors (kg CO_2-e/GJ)			Source/method
		CO_2	CH_4	N_2O	
Landfill gas – combustion for electricity production	0.0377	0	6.4	0.03	DISER (2021a), Table 2 (landfill biogas)
Landfill gas – flaring	0.0377	0	6.4	0.03	DISER (2021a), Table 2 (landfill biogas)

Table A.5 Volume for landfill gas combustion (scope 1)

Activity/scenario	Volume (m^3/year)	Source/method
Landfill gas – combustion for electricity production		
Baseline	14,016,359	2019-2020 NGER submission
Scenario 1	32,059,773[a]	Veolia model: maximum volume in any year (2025-2064)
Scenario 2	22,842,433[a]	Veolia model: maximum volume in any year (2025-2064)
Landfill gas – flaring		
Baseline	2,007,435	2019-2020 NGER submission
Scenario 1	4,591,628(b)	Veolia model: maximum volume in any year (2025-2064)
Scenario 2	3,271,513(b)	Veolia model: maximum volume in any year (2025-2064)

(b) Based on 87% of captured methane.

(c) Based on 13% of captured methane.

A.1.3 Fugitive emissions of landfill gas

Fugitive methane emissions are generated from the Bioreactor.

For the Baseline Scenario, the GHG emissions associated with fugitive methane were taken directly from the directly from the 2019-2020 NGER submission.

For Scenarios 1 and 2, the GHG emissions in the Baseline Scenario were scaled according to the Veolia landfill gas model. It was assumed that fugitive methane emissions accounted for the difference between the generated methane and captured methane in the Veolia model. Given that the model assumed that 80% of the generated methane is captured, the fugitive emissions were 20% of the generated methane.

The resulting gas volumes and GHG emissions for fugitive methane are given in Table A.6.

Table A.6 Volume and GHG emissions for fugitive methane (scope 1)

Activity/scenario	Volume (m^3/year)	CO_2-e (t/year)	Source/method
Fugitive methane			
Baseline	4,344,567	97,344	Veolia model for 2020 (volume) / NGER 2019-2020 (CO2-e)
Scenario 1	9,162,850	205,302	Veolia model for peak methane flow in scenario (2050)
Scenario 2	6,528,487	146,275	Veolia model for peak methane flow in scenario (2025-2064)

A.1.4 SF_6 emissions

SF_6 emissions (in CO_2-e) were taken directly from the 2019-2020 NGER submission, and were assumed to remain at the same level in the future. The values used are given in Table A.7.

Table A.7 SF_6 emissions (scope 1)

Scenario/activity	CO_2-e (t/year)	Source/method
SF_6 emissions		
Baseline	3.0	2019-2020 NGER submission
Scenario 1	3.0	2019-2020 NGER submission
Scenario 2	3.0	2019-2020 NGER submission

A.1.5 Thermal treatment of waste for electricity

Scope 1 emissions from the combustion of solid waste relate to the following on-site activities:

- combustion of non-biomass waste; and
- combustion of biomass waste.

GHG emissions were estimated using Equation A4.

$$E_{solid} = \frac{Q_{solid} \times EC_{solid} \times EF_{solid}}{1000}$$

Equation A4

where:

E_{solid}	=	emission of a given GHG	(t CO_2-e/year)
Q_{solid}	=	quantity of waste	(t/year)
EC_{solid}	=	energy content of waste	(GJ/t)
EF_{solid}	=	emission factor for GHG	(kg CO_2-e/GJ)

For each activity, the energy content of the fuel and the scope 1 emission factors are given in Table A.8. The estimated material weight for each activity and scenario is given in Table A.9.

Table A.8 Energy content and emission factors: solid waste combustion (scope 1)

Activity	Energy content (GJ/t)	Scope 1 emission factors (kg CO_2-e/GJ)			Source/method
		CO_2	CH_4	N_2O	
Non-biomass waste, combustion for electricity generation	10.5	87.1	0.8	1.0	DISER (2021a), Table 1 (non-biomass)
Biomass waste, combustion for electricity generation	12.2	0	0.8	1.0	DISER (2021a), Table 1 (biomass)

Table A.9 Weight of combusted waste (scope 1)

Activity/scenario	Weight (t/year)	Source/method
Non-biomass waste – combustion for electricity production		
Baseline	-	Not applicable
Scenario 1	-	Not applicable
Scenario 2	152,000(a)	See note
Biomass waste – combustion for electricity production		
Baseline	-	Not applicable
Scenario 1	-	Not applicable
Scenario 2	228,000(a)	See note

(d) Based on the assumption that 60% of the waste going to the ARC (380,000 t/year) was biomass, as estimated from Arcadis (2021).

A.2 Scope 2 emissions

Scope 2 emissions associated with the consumption of purchased electricity were estimated using Equation A5.

$$E_{elec} = \frac{Q_{elec} \times EF_{elec}}{1000}$$

Equation A5

where:

E_{elec}	=	emission of a given GHG	(t CO_2-e/year)
Q_{elec}	=	quantity of electricity	(MWh/year)[8]
EF_{elec}	=	emission factor for electricity consumption	(kg CO_2-e/GJ)[9]

[8] MWh = megawatt hours

[9] kg CO_2-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

The scope 2 emission factors are given in Table A.10, and the amount of electricity purchased for each scenario is given in Table A.11. For Scenarios 1 and 2, the baseline electricity for the Bioreactor and MBT was scaled according to relative waste inputs.

Table A.10 Emission factors: electricity consumption (scope 2)

Activity	Scope 1 emission factors (kg CO_2-e/kWh)			Source/method
	CO_2	CH_4	N_2O	
Consumption of purchased electricity	0.79	0	0	DISER (2021a), Table 5 (NSW)

Table A.11 Purchased electricity (scope 2)

Scenario	Location	Electricity (kWh/year)	Source/method
Baseline	Bioreactor	3,982,449	2019-2020 NGER submission
	MBT	3,781,686	2019-2020 NGER submission
Scenario 1	Bioreactor	5,172,440	See Table A.3
	MBT	4,911,687	See Table A.3
Scenario 2	Bioreactor	3,433,035	See Table A.3
	MBT	4,911,687	See Table A.3
	ARC	1,120,000	Veolia

A.3 Scope 3 emissions

Scope 3 emissions are associated with the following on-site activities:

- diesel combustion
  - transfer of waste by rail from Banksmeadow and Clyde to the IMF at Crisps Creek;
  - transfer of waste by road from the IMF at Crisps Creek to the ARC;
  - transfer of local waste by road;
- upstream emissions associated with on-site (scope 1) liquid fuel combustion;
- purchased electricity; and
- employee travel.

A.3.1 Emissions from diesel combustion (transfer of waste)

i Rail transport

Waste is transferred by rail from the Banksmeadow and Clyde terminals to the IMF at Crisps Creek. For each route and direction of travel, diesel consumption in the baseline scenario was calculated using Equation A6.

$$FC = \frac{GTKM}{1000} \times L_{rail}$$

Equation A6

where:

FC	=	diesel consumption (litres per year)
GTKM	=	gross tonne-km of transport
L_{rail}	=	diesel consumption factor (litres per 1,000 gross tonne-km)

The value for L (4.034 litres per 1,000 gross tonne-km) was taken from the NSW EPA emissions inventory for the Greater Metropolitan Region (NSW EPA 2012).

For each route and direction of travel, the baseline gross tonne-km were calculated using Equation A7 in combination with the values in Table A.12.

$$GTKM = D \times (W_{loco} + W_{wagon} + W_{cont} + W_{waste}) \times N$$

Equation A7

where:

GTKM	=	gross tonne-km per year	(tkm/year)
D	=	distance (one way)	(km)
W_{loco}	=	total weight of locomotives	(tonnes per train)
W_{wagon}	=	total weight of wagons	(tonnes per train)
W_{cont}	=	total weight of empty containers	(tonnes per train)
W_{waste}	=	total weight of waste	(tonnes per train)
N	=	number of trains per year	(trains/year)

Table A.12 Parameters for calculation of baseline gross tonne-km (rail transport)

Parameter	Banksmeadow		Clyde	
	Inbound (loaded)	Outbound (unloaded)	Inbound (loaded)	Outbound (unloaded)
D (km)	250	250	230	230
W_{loco} (t/train)	252[(a)]	252	252[(a)]	252
W_{wagon} (t/train)	507[(b)]	507	609[(b)]	609
W_{cont} (t/train)	203[(c)]	203	244[(f)]	244
W_{waste} (t/train)	1,598[(d)]	-	1,918[(g)]	-
N (trains/year)	313[(e)]	313	313[(e)]	313

(e) Assuming two 81-Class locomotives per train, with a weight per locomotive of 126 tonnes.

(f) Assuming an unladen wagon weight of 20 tonnes, and two containers per wagon.

(g) Based on 15,875 containers per year (Hyder 2014), the number of trains per year and an assumed empty container weight of 4 tonnes.

(h) Based on 412,966 t/year of waste (45% of 908,525 tpa) and number of trains per year.

(i) Based on 6 inbound trains per week at the IMF (NSW Government 2019).

(j) Estimate based on scaling of Banksmeadow value.

(k) Based on 495,559 t/year of waste (55% of 908,525 tpa) and number of trains per year.

For Scenarios 1 and 2 the baseline gross tonne-km and diesel consumption were scaled according to the total amount of waste transported. The resulting gross tonne-km and diesel consumption values are given in Table A.13.

Table A.13 Gross tonne-km and diesel consumption per year (rail)

Scenario	Route	Gross tonne-km/year	Diesel consumption kL/year
Baseline	Banksmeadow, inbound	167,744,659	676.6
	Banksmeadow, outbound	75,272,500	303.6
	Clyde, inbound	181,563,464	732.4
	Clyde, outbound	79,474,200	320.6
	Total	504,054,823	2,033.2
Scenario 1[(a)]	Total	730,913,716	2,948.3
Scenario 2[(a)]	Total	730,913,716	2,948.3

(l) Based on ratio of total waste in scenario (1,180,000 t/year) to total waste in baseline (813,755 t/year).

ii Road transport

Waste is transferred by road between the IMF at Crisps Creek and the Eco Precinct. Local waste is also processed at the Eco Precinct, and again this is transported by road. In each case, annual diesel consumption was calculated using Equation A8. The parameters for the diesel consumption calculation are given in Table A.14.

$$FC = D \times N \times L_{road}$$

Equation A8

where:

FC	=	diesel consumption	(litres per year)
D	=	distance (round trip)	(km)
N	=	number of vehicles per year	(vehicles/year)
L_{road}	=	diesel consumption factor	(litres per vehicle-km)

Table A.14 Parameters for calculation of baseline diesel consumption (road transport)

Parameter	IMF to Eco Precinct	Local waste to Eco Precinct
D (km)	14[(a)]	60[(d)]
N (vehicles per year)	24,895[(b)]	16,597[(b)]
L_{road} (L/100 vehicle-km)	55.2[(c)]	21.3[(e)]

(a) Based on a distance from the IMF to Eco Precinct of 7 km.

(b) Based on data from the IMF weighbridge, with an estimate of 40% of waste being local.

(c) From BITRE (2019), Australian average for articulated trucks.

(d) Estimated by EMM.

(e) From BITRE (2019), Australian average for non-freight trucks.

For the transport of waste from the IMF to the Eco Precinct in Scenarios 1 and 2, the baseline gross tonne-km and diesel consumption were scaled according to the total amount of waste transported. The amount of local waste transported to the Eco Precinct (and hence the associated vehicle-km and diesel consumption) were ass assumed to remain at the baseline levels. The resulting and the resulting vehicle-km and diesel consumption values are given in Table A.15.

Table A.15 Vehicle-km and diesel consumption per year (road)

Scenario	IMF to Eco Precinct		Local waste to Eco Precinct	
	Vehicle-km/year	Diesel consumption (kL/year)	Vehicle-km/year	Diesel consumption (kL/year)
Baseline	348,533	192.4	995,808	212.1
Scenario 1[(a)]	452,667	279.0	995,808	212.1
Scenario 2[(a)]	452,667	279.0	995,808	212.1

(a) Based on ratio of total waste in scenario (1,180,000 t/year) to total waste from Banksmeadow/Clyde in baseline (813,755 t/year).

A.3.2 Upstream emissions for liquid fuels

For each activity, the upstream (scope 3) emission factors associated on on-site liquid fuel use are given in Table A.16. These emission factors were used in combination with the corresponding energy content in Table A.1 and fuel use in Table A.2.

Table A.16 Emission factors: liquid fuel combustion (scope 3)

Activity	Scope 3 emission factors (kg CO_2-e/GJ)			Source/method
	CO_2	CH_4	N_2O	
Diesel combustion (stationary sources)	3.6	0	0	DISER (2021a), Table 45
Diesel combustion (mobile sources)	3.6	0	0	DISER (2021a), Table 45
Petrol combustion (mobile sources)	3.6	0	0	DISER (2021a), Table 45
Petroleum oil combustion (stationary sources)	3.6	0	0	DISER (2021a), Table 45

A.3.3 Purchased electricity

The scope 3 emission factor for purchased electricity is given in Table A.17. This emission factors was used in combination with the corresponding purchased electricity in Table A.11.

Table A.17 Emission factor: electricity consumption (scope 3)

Activity	Scope 3 emission factor (kg CO_2-e/kWh)	Source/method
Consumption of purchased electricity	0.07	DISER (2021a), Table 46 (NSW, latest estimate)

A.3.4 Employee travel

Emissions from the transport of employees between their homes and the project were included under scope 3. Emissions were calculated based on the 'average data' method from WRI & WBCSD (2013).

Annual employee vehicle-km were estimated using Equation A9.

$$VKM = \frac{D \times C}{1000}$$

Equation A9

where:

VKM	=	total vehicle-km for all employees	(vehicle-km/year)
D	=	average daily commuting distance	(km/day)
C	=	commuting days per year	(day/year)
N	=	number of employees	(-)

It was assumed that the average vehicle occupancy was 1.0.

The values used in the calculations are given in Table A.18, and the resulting annual vehicle-kilometres for employees by scenario are given in Table A.19.

Table A.18 Parameter values for VKM calculation

Parameter	Value	Source/method
D	97.5[(a)] km	See footnote
C	235 day/year	Estimated by EMM
N	56 (Bioreactor)	Veolia
	40 (ARC)	Veolia

(a) Weighted estimate based on employees by postcode of residence and distance to the Eco Precinct, estimated using Google Maps.

Table A.19 Employee vehicle-km

Scenario	Vehicle-km/year	Source/method
Baseline	1,283,382	Equation A6
Scenario 1	1,666,868	Baseline scaled by total waste projection for Scenario 1
Scenario 2	1,666,868 (Bioreactor)	Baseline scaled by total waste projection for Scenario 2
	916,701 (ARC)	

The emission factor used in the calculations is given in Table A.20.

Table A.20 Emission factor: employee travel (scope 3)

Activity	Scope 3 emission factor (kg CO_2-e/vehicle-km)	Source/method
Employee travel	0.181	NTC (2020), average Australian car

Australia

SYDNEY
Ground floor 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500

NEWCASTLE
Level 3 175 Scott Street
Newcastle NSW 2300
T 02 4907 4800

BRISBANE
Level 1 87 Wickham Terrace
Spring Hill QLD 4000
T 07 3648 1200

CANBERRA
Level 2 Suite 2.04
15 London Circuit
Canberra City ACT 2601

ADELAIDE
Level 4 74 Pirie Street
Adelaide SA 5000
T 08 8232 2253

MELBOURNE
Suite 8.03 Level 8 454 Collins Street
Melbourne VIC 3000
T 03 9993 1900

PERTH
Suite 9.02 Level 9 109 St Georges Terrace
Perth WA 6000

Canada

TORONTO
2345 Younge Street Suite 300
Toronto ON M4P 2E5

VANCOUVER
60 W 6th Ave Suite 200
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