Attachment 10: Greenhouse Gas Assessment (Katestone, 2023)

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Melbourne Energy and Resource Centre: Greenhouse Gas Assessment

Prepared for:

Cleanaway Operations Pty Ltd

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Final

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Contents

Tables

Figures

Glossary

Term	Definition
CO_2-e	carbon dioxide equivalents
ha	hectares
GJ	gigajoules
kg	kilograms
kL	kilolitres
kt	kilotonnes
kWh	kilowatt hours
L	litres
m	Metres
MJ	megajoules
MW	megawatt
MWh	megawatt hours
MWh/y	megawatt hours per year
t	tonnes
tC	tonnes carbon
TJ	terajoules
tpa	tonnes per annum
y	year
Nomenclature	**Definition**
CH_4	methane
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
N_2O	nitrous oxide
Abbreviations	**Definition**
C&I	Commercial and industrial
CC Act Vic	Climate Change Act Victoria
CCCA Act	Climate Change (Consequential Amendments) Act
DELWP	Department of Environment, Land, Water and Planning
ECF	Energy content factor
EF	Emission factor
EP Act	Environmental Protection Act
EPA	Environmental Protection Agency
GED	General Environmental Duty
GHG	Greenhouse gas
FOGO	Food organics and garden organics
IBA	Incinerator bottom ash
MERC	Melbourne Energy and Resource Centre
MSW	Municipal solid waste
NEM	National Energy Market
NGER	National Greenhouse and Energy Reporting
PEM	Protocol for the Environmental Management
SEPP	State Environmental Protection Policies
WtE	Waste-to-Energy

EXECUTIVE SUMMARY

Cleanaway Operations Pty Ltd (Cleanaway) commissioned Katestone Environmental Pty Ltd (Katestone) to conduct a greenhouse gas assessment for the proposed waste-to-energy (WtE) facility to be known as the Melbourne Energy and Resource Centre (MERC). Waste-to-energy is an acceptable method for waste management and electricity generation in Victoria if it does not displace waste reduction and recycling efforts and where it may result in avoided greenhouse gas emissions from other waste or generation sources.

The MERC will incinerate up to 380,000 tonnes of residual municipal solid waste (MSW) and commercial and industrial (C&I) waste per year, reducing the volume of waste going to landfill. The MERC will have a nameplate capacity of 46.3 MW. 4.7MW (37,600 MWh/year) will be used to power the facility and 41.6MW (328,726 MWh/year) will be exported to the grid. Construction and operation of the facility will generate greenhouse gas emissions but will also offset greenhouse emissions arising from electricity generation by combustion of fossil fuels.

The projected greenhouse gas emissions are nominal figures based on data provided. Actual waste incinerated (and associated emissions) will change based on waste throughput and waste composition (calorific value), and other factors that may change over the life of the life of the project.

Combustion of waste during operation of the MERC is projected to contribute most of the Scope 1 emissions, at just over 187,000 tCO_2-e/y. Approximately 3% of these emissions are due to combustion of organic (renewable) materials. Diesel combustion at boiler start-up or shutdown will contribute to just over 1,500 tCO_2-e/y. This is reduced to 6 tCO_2-e/y if biodiesel is used instead of diesel.

Scope 2 emissions arising from electricity purchased from the grid during start up and shut down of the boiler are projected to be just over 1,100 tCO_2-e/y.

These Scope 1 and Scope 2 emissions will contribute to a 14.9% and 2.3% increase, respectively, to Cleanaway's current reportable (NGER) emissions.

Scope 3 emissions are dominated by materials and diesel used in construction of the MERC and are not reportable by Cleanaway. Concrete and steel have the greatest embodied emissions at >9,000 tCO_2-e and >5,000 tCO_2-e respectively. Diesel consumption by construction vehicles accounts for just over 800 tCO2-e. Procurement choices during construction for lower emissions materials can reduce the MERC's Scope 3 emissions.

Operation of the MERC will contribute to avoided emissions through:

- Diverting organic material from landfill and potentially avoiding ~50,000–450,000 tCO_2-e/y of methane production from anaerobic decomposition (contingent on methane emissions factor and landfill gas capture efficiency)
- Producing electricity with an emissions intensity of 0.5-0.8 tCO_2-e/MWh less than Victorian coal-fired power stations
- Recovering recyclable materials including ferrous and non-ferrous metals and bottom ash which can be substituted for virgin materials and avoiding ~55,000 tCO_2-e/y.

Net GHG emissions range from -251,000 tCO_2-e/y to -274,000 tCO_2-e/y where the methane emissions factor is 28, and -565,000 to -601,000 tCO_2-e /y where the methane global warming potential is 79.7. However, the relative value of avoided emissions will probably reduce over time as government policy to divert organic

material from landfill is implemented, landfill gas capture efficiency improves, and Victoria's coal-fired power stations are retired.

With the initial anticipated waste stream, the emissions intensity of the facility is projected to be 0.59 tCO_2-e/MWh. Projected changes in the waste stream (i.e., shifting to a higher proportion of MSW) may result in a reduction in emissions intensity to 0.53 tCO_2-e/MWh (i.e., equivalent to the most efficient gas-fired power stations) due to increased levels of organic material in the waste stream. This projection considers Government policy to divert Food Organic and Garden Organic (FOGO) waste from landfill.

The proposed Melbourne Energy and Resource Centre meets the definition of an appropriate waste-to-energy (WtE) facility through its contribution to the reduction of residual waste to landfill and through avoided emissions, however the relative value of the facility will likely reduce over its proposed 30-year lifetime.

1. INTRODUCTION

Cleanaway Operations Pty Ltd (Cleanaway), an Australian waste management, recycling, and industrial services company, is developing a waste-to-energy (WtE) facility in Victoria (the Proposal). This facility will be known as the Melbourne Energy and Resource Centre (MERC).

The Victorian Government's waste to energy policy recognises that there is a role for WtE facilities in reducing waste volumes going to landfill where they create clear net benefits and do not displace waste reduction and recycling efforts (DELWP 2020). The policy sets a cap of 1 million tonnes per year of waste that can be sent for WtE purposes, as defined in the Victorian WtE framework (DELWP 2021).

The MERC will have a nameplate capacity of 46.3MW and will thermally process 380,000 tonnes per annum (tpa) of waste feedstock, primarily consisting of residual Municipal Solid Waste (MSW) and residual Commercial and Industrial (C&I) waste, that would otherwise be sent to landfill. 4.7MW (37,600 MWh/y) will be used to power the MERC and 41.6MW (328,726 MWh/year) will be exported to the grid.

The MERC will also incorporate maturation and processing of bottom ash to recover recyclable metals, and with the possibility to utilise the remaining ash as an aggregate in road construction.

The Proposal involves the building of all onsite infrastructure needed to support the WtE facility at 510 Summerhill Road, Wollert, approximately 35 kilometres from Melbourne. Onsite infrastructure will include site utilities, internal roads, weighbridges, parking and hardstand areas, stormwater infrastructure, fencing and landscaping.

Katestone Environmental Pty Ltd (Katestone) has been commissioned by Cleanaway to conduct a greenhouse gas (GHG) assessment for the construction and operation of the facility.

1.1 GHG Emissions

GHG emissions are calculated and reported according to the Scope in which they occur.

Scope 1 GHG emissions are those emissions released to the atmosphere as a direct result of the activity conducted at a facility and that are under the direct control of the facility or operation. These include emissions from:

- Diesel combustion in road-registered vehicles owned by Cleanaway and stationary plant, and
- Combustion of waste material to produce electricity.

The emissions value is obtained by multiplying, for example, the total volume of diesel used during the reporting period with its emission factor.

Scope 2 GHG emissions are those associated with the production of electricity that is purchased and used by the facility. The emissions value is obtained from the total electricity used, in kilowatt hours (kWh), during the reporting period, or that projected to be used in future, multiplied by the emission factor of the state in which the facility operates.

Scope 3 GHG emissions are those associated with the provision of goods and services purchased by the facility or operation but that are not owned or controlled by the entity responsible for the facility or operation. These can include:

- Diesel combusted during transport of construction materials to the site
- Diesel combusted during transport of workers to and from the site
- Embedded emissions in major construction materials including:

- Steel
- Concrete
- Gravel aggregates

- Electricity produced at the proposed facility sent to the grid.

The emissions values are obtained, for example, from the volume or mass of construction materials multiplied by their emissions factor.

1.2 Avoided Emissions

The combustion of waste to generate electricity produces GHG emissions, however, it also has the potential to avoid some emissions that might otherwise occur. These include fugitive landfill gas emissions (methane, CH_4) from decaying organic matter (including paper, cardboard, wood) and emissions from fossil fuel combustion for grid electricity generation. Materials recovered from the combustion process may also be used to offset emissions from the production of virgin materials. For example, incinerator bottom ash (IBA) can be used as supplementary aggregate for road construction. Ferrous and non-ferrous metals may also be recovered from the IBA and recycled.

The relative value of avoided emissions from a WtE plant are likely to change over time due to:

- Increased capture and combustion of landfill gas for electricity production
- Progressive diversion of organic matter away from landfill due to policy and regulatory change
- Progressive replacement of fossil fuel generated electricity with renewable electricity.

1.3 Objectives

The objectives of this GHG assessment are to:

- Document the State and Federal policy, legislation, standards, and guidelines applicable to GHG emissions from the MERC
- Analyse Scope 1 and Scope 2 emissions (tCO_2-e) of the proposed facility during the construction and operation phases of the MERC
- Assess significant Scope 3 emissions associated with major construction materials and transport of primary input and output materials to and from site
- Assess the potential for avoided emissions

2. THE PROPOSAL

2.1 Overview

Cleanaway Operations Pty Ltd (Cleanaway) is an Australian waste management, recycling, and industrial services company. Cleanaway is developing a waste-to-energy (WtE) facility in Victoria known as the Melbourne Energy and Resource Centre (MERC) (the Proposal).

The MERC has been designed to thermally treat a design capacity of 380,000 tonnes per annum (tpa) of waste feedstock, consisting of residual Municipal Solid Waste (MSW) and residual commercial waste, which is waste that would otherwise be sent to landfill. Waste feedstock processed by the MERC will be subject to a Waste Acceptance Protocol to determine eligibility and suitability for processing both prior to arrival and upon arrival on-site. The Proposal will also incorporate maturation and processing of bottom ash to recover recyclable metals, with the intent to utilise the remaining ash as an aggregate in construction.

Residual waste is waste that is left over from recycling and resource recovery operations and waste from source separated collections. Source separation involves separating waste into common material streams or categories for separate collection. Waste processed at the site will be subject to a Waste Acceptance Protocol to ensure only appropriate waste is used as feedstock.

The WtE process would generate approximately 46.3MW gross of electricity, 4.74MW of which would be used to power the facility itself and the associated on-site by-product and residue handling processes, with 41.6MW (328,700 MWh/year) exported to the grid as base load electricity. In addition to supplying electricity to the grid, there is also potential to supply energy in the form of heat and/or process steam to local industrial users.

Some residual materials are produced because of the WtE process, including Incinerator Bottom Ash (IBA), boiler ash and flue gas treatment residue. The boiler ash and flue gas treatment residue are typically combined and together are referred to as Air Pollution Control residue (APCr). Overall, the WtE process typically leads to about 90% reduction in the volume, or 80% reduction in mass (tonnes), of waste that would otherwise go to landfill. If IBA is reused as an alternative construction product to virgin materials, this percentage increases further to approximately 95% reduction in volume and mass of waste that would otherwise go to landfill. The final volume of waste diverted from landfill is dependent on the classification and market for the residues and by-products generated by the WtE facility.

The Proposal includes the construction and operation of an IBA maturation and processing facility on site. The purpose of this facility is to store the IBA to mature (stabilise) it, before mechanically processing IBA from the WtE facility into an aggregate for reuse. As part of this process, both ferrous and non-ferrous metals will be recovered from the IBA for recycling and sale to market.

The Proposal also includes a stabilisation facility for APCr, a necessary treatment step to immobilise leachable components of the APCr prior to removal from site by vehicle and disposal at an appropriately licenced landfill.

The Proposal will use best available techniques and technologies in the engineering design, operation, maintenance and monitoring activities associated with the MERC. Moving grate technology has been chosen as the means to thermally treat incoming waste to recover energy and other resources. Current international best-practice techniques, including automated combustion controls and advanced flue gas treatment technology will be applied so that air emissions meet stringent emission. The moving grate combustion system is a common form of thermal WtE technology in which the waste is fed through the combustion chamber on a travelling grate. This enables efficient and complete combustion of the waste, with primary combustion air introduced from below the grate and secondary combustion air introduced directly into the combustion zone above the grate. Moving grate technology has been used globally for over 100 years, and in that time the technology has been subject to continual improvement responding to regulatory, industry and public demands. There are approximately 500 similar operational examples across Europe alone, the majority of which use the moving grate-type technology being proposed for the MERC.

The Proposal involves the building of all onsite infrastructure required to support the WtE facility, including site utilities, internal roads, weighbridges, parking and hardstand areas, stormwater infrastructure, fencing and landscaping. The Proposal will also include a visitor and education centre to help educate and inform the community on the circular economy, recycling, resource recovery, the benefits of landfill diversion and the WtE process. The intent behind this education is to drive a shift in community thinking and actions around waste management.

The Victorian Waste to Energy Framework (2021) recognises the role of WtE to divert waste from landfills, helping Victoria transition to a circular economy. Recycling Victoria recognises a role for WtE investment and supports WtE facilities where they meet best-practice environment protection requirements. This includes reducing waste to landfill, supporting waste avoidance, reusing and recycling, and demonstrating social license with affected communities. The Victorian Environment Protection Authority (EPA) Energy from Waste Guideline (Publication 1559, 1 July 2017) also notes that efficient recovery of energy from the thermal processing of waste is considered a resource recovery as opposed to a waste disposal option.

The EPA VIC Guideline: Energy from Waste stipulates that 'Proponents of EfW proposals…will be expected to demonstrate that the siting, design, construction, and operation of EfW facilities will incorporate best practice measures for the protection of the land, water, and air environments as well as for energy efficiency and greenhouse gas emissions management. Facilities should be able to provide evidence of how they minimise and manage emissions (including pollutants, odour, dust, litter, noise, and residual waste) in accordance with relevant statutory requirements.'

The WtE facility has been designed to meet the European Industrial Emissions Directive (IED) (2010) and the associated Best Available Techniques Reference (BREF) Document for Waste Incineration published December 2019, which sets the European Union environmental standards for waste. The facility will also comply with the technical criteria set out in the EPA Victoria Guideline: Energy from Waste publication 1559.1.

The purpose of this specialist assessment is to demonstrate compliance with the various authority requirements, develop community support and social license.

2.2 MERC layout

The MERC will be in the Whittlesea Local Government Area in the suburb of Wollert, approximately 25 km north of Melbourne CBD. The Proposal layout is depicted in Figure 1 and will incorporate the following elements (Figure 2):

- Two-line WtE facility, with each line comprising: a combustion chamber, boiler, flue gas treatment system, Induced Draft (ID) fan, Continuous Emissions Monitoring System (CEMS) and a dedicated flue. The processing capacity of each line will be approximately 190,000 tpa. The two lines will supply steam to a single steam turbine while flue gas will be discharged through a single stack containing two internal flues.
- Incinerator Bottom Ash (IBA) treatment area incorporating: a fully enclosed sorting facility, stockpiles for sorted and matured IBA, conveyor for delivery of IBA from WtE facility to the IBA treatment area, open-air IBA maturation piles (1-2 months) with dust control using spraying, and water capture system around the IBA treatment area.
- Air Pollution Control residues (APCr) stabilisation facility where treated APCr (a slurry of APCr, cement and water) is allowed to cure into solid blocks prior to transport offsite for landfill disposal.
- Site infrastructure including roads, weighbridges, inspection bays, dangerous goods tanks, firewater and process water tanks, electrical substation, truck movement areas, offices, and parking spaces.
- A space will be allocated for future Carbon Capture (CC) (not part of this Proposal).

Construction is anticipated to take 36 months to complete.

Figure 1 Proposed MERC site layout

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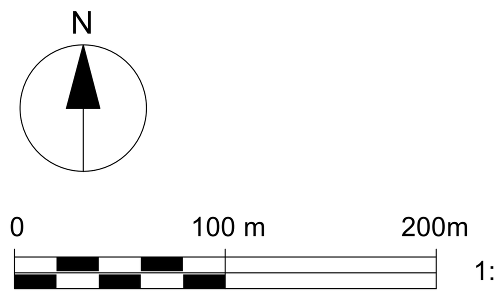

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Issue	Date	By	Chkd	Appd
Final Draft	20/03/23	ZR	GF	BP
Final Draft	10/02/23	ZR	GF	BP
DLA Draft	07/12/22	ZR	GF	BP

Client: CLEANAWAY — Making a sustainable future possible

Architectural Certification
Name: ....
Signature: .... Date: ....

Job Title: MELBOURNE ENERGY AND RESOURCE CENTRE, 50 SUMMERHILL RD, WOLLERT, VICTORIA 3750

Scale at A1: 1 : 3000

Discipline: ARCHITECTURE

ARUP
Wurundjeri Woiwurrung Country
Sky Park, One Melbourne Quarter
699 Collins Street Docklands
VIC 3008 Australia

CONSULT AUSTRALIA Member Firm
Arup Pty Ltd ABN 18 000 966 165

Drawing Title: GENERAL ARRANGEMENT SITE INCLUDING AREA OF FUTURE PROVISIONING

Drawing Status: S0 - FOR INFORMATION ONLY

Job No	Drawing No	Issue
287710-00	MERC-ARU-MEL-ARAR-DRG-1003	C

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2.3 Operation of the MERC

Figure 2 provides an overview of the operational features of the MERC.

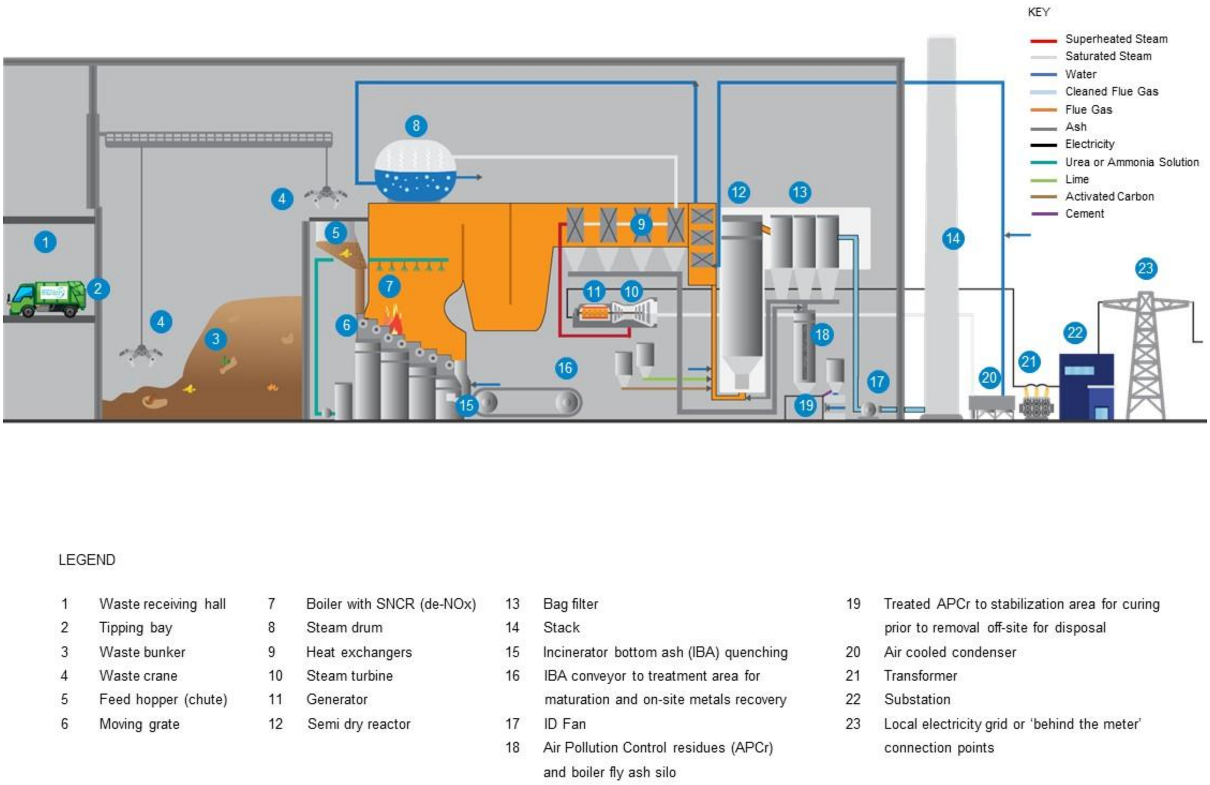

Figure 2 Key operating features of the MERC

2.3.1 Waste Arrival

Waste deliveries will enter the MERC via a security gate house and proceed to the weighbridge where the vehicle will be weighed, and delivery details recorded. Waste delivery vehicles may be selected at random to proceed to a designated pre-inspection area to allow the MERC operations staff to verify the waste and where feasible, visually inspect the load to confirm its suitability as acceptable waste.

2.3.2 Waste Volumes and Waste Acceptance

Only wastes which are consistent with the Victorian waste to energy framework (2021) definition of permitted waste will be accepted as feedstock. Feedstock supplied by Cleanaway and third-party suppliers will be managed in accordance with the MERC Waste Acceptance Protocol (WAP) which defines both acceptable and unacceptable waste types, along with waste arrival and inspection protocols and provisions to divert or remove unacceptable waste or waste loads. The WAP involves inspection of the waste at various stages for size and suitability aiming to maintain the calorific value of waste and to remove unacceptable materials that may result in unacceptable contaminant levels or may cause damage to plant and equipment. Periodic sampling of waste will also be undertaken to determine certain key parameters of the waste profile including ash, moisture, chlorine, sulphur, and metallic aluminum.

2.3.3 Tipping Hall and Waste Bunker

Waste will be delivered to the Proposal via a tipping hall, expected to operate 12 hours per day, 6 days/week.

The tipping hall will be designed to cope with the facility 'peak hour', which is the hour in the day where the largest number of vehicles is expected to require processing. The preliminary estimate of peak waste delivery vehicle movements is 17-18 vehicles per hour. The tipping hall will be enclosed and will include quick shutting roller doors for odour control. Negative pressure will be maintained in the hall and waste bunker areas by preferentially drawing potentially odorous air from within the tipping hall and waste bunker area into the boiler furnace as combustion air. Adjustable louvres in the façade of the Tipping Hall will allow air inflow (for the furnace combustion air system), even if the entry and exit roller doors are closed.

The waste bunker shall be designed to store approximately seven days of waste at full capacity. The waste bunker is monitored by CCTV in the plant control room.

2.3.4 Combustion System and Process Firing

The boiler is a moving grate design suitable for combustion of MSW and C&I wastes and will generate superheated steam suitable for driving the steam turbine. The boiler system will include auxiliary diesel burners for start-up, shutdown, and to ensure that two seconds residence time at 850°C is maintained.

The boiler is designed to operate across a range of calorific values to accommodate variability in waste make-up and associated changes in LHV.

2.3.5 Emission Controls and Flue Gas Treatment (FGT)

Primary emission control involves:

- Mixing of the waste in the waste bunker prior to feeding each combustion system
- An automatic combustion control system which adjusts the feeder speed, movement of the grate (residence time and thickness of waste on the grate), primary and secondary combustion air flows, in order to maintain a desired steam generation set point from the boiler
- Careful control of combustion air injection such that excess air levels are controlled, helps to control the primary formation of NO_X, though there is a trade-off with CO formation if combustion air levels are too low
- Maintaining stable combustion conditions and ensuring the flue gas temperature remains above 850 degrees Celsius for at least two seconds residence time helps to ensure the destruction of VOCs, dioxins and furans, and other similar organic compounds commonly found in solid fuel combustion systems.

The MERC Proposal also includes a secondary NO_X abatement system within the boiler known as Selective Non-Catalytic Reduction (SNCR). SNCR involves injecting ammonia or urea solution into the flue gas within a temperature range of ~900 – 1050 degrees Celsius. In this temperature range, the ammonia or urea will reduce most of the NO_X that may be present in the flue gas to nitrogen and water.

After the SNCR system, hot flue gas passes through the boiler where it is cooled by both raising steam and then superheating steam. At the exit of the boiler economiser section, the cooled flue gas will be treated using an air emissions control system that consists of semi-dry flue gas treatment, and a bag house filter.

Lime injection will be used to control emissions concentrations of acid gas pollutants via chemisorption (in particular HCl, HF, and SO_2) while activated carbon injection is used to control volatile heavy metals (such as mercury, lead and cadmium) and any residual organic compounds through adsorption, when coupled with a baghouse filter. Expected quantities of lime, urea, and activated carbon are detailed in Table 1.

The flue gas treatment (FGT) and air emissions control system will be designed to ensure stack emissions at least meet the upper end of the range of associated emission levels of the best available techniques (BAT-AELs) as detailed in the latest Best Available Techniques Reference Document (BREF) for Waste Incineration (Newahl et.al., 2019) and European IED, consistent with international best practice.

Table 1 FGT consumables (figures understood to be +/- 20%)

Consumable	Consumption (kg/t waste)	Annual consumption assuming 380,000 tpa waste (tpa)
Quicklime (~90% purity)	13.6	5,170
40% Urea (or NH_3-H_2O)	5.5	2,080
Activated carbon	0.5	200

2.3.6 Bottom Ash and Residue management

IBA will be collected from below the grate and transported to the IBA Treatment area where it will undergo maturation and sorting including the removal of ferrous and non-ferrous metals.

APCr consists of two separate ash streams:

- Boiler ash (recovered in the hoppers below the horizontal pass/convective section of the boiler)
- Air pollution control residues (essentially a purge stream of baghouse filter cake, consisting of flue gas treatment residue and residual fly ash).

Boiler ash from the convective section of the boiler may be considered hazardous. To be conservative and align with precedents set for other waste-to-energy facilities in development in Australia, boiler ash will be mixed with APCr. APCr is hazardous and must be treated as such. APCr must be immobilised to avoid the leaching of heavy metals and other hazardous compounds into the surrounding area. This will be achieved through blending with cement and water, which cures to form a solid concrete, immobilising the hazardous elements. Once fully cured, APCr will be transported to and disposed of in an appropriately classed landfill.

3. REGULATORY FRAMEWORK AND POLICY CONTEXT

3.1 Australia

The Australian Government has committed that Australia will reduce GHG emissions by 43% below 2005 levels by 2030 and will achieve net zero GHG emissions by 2050. It is developing new policies to drive the transition to net zero and will build on existing programs such as the Emissions Reduction Fund. The Australian Government is also reviewing the Safeguard Mechanism, which requires Australia's largest emitters to keep net emissions within baseline levels, to ensure that it will conform to Australia's climate targets.

3.1.1 Climate Change Act 2022

The *Climate Change Act* 2022 (CC Act) provides the legislative framework to implement Australia's net-zero commitments and codifies Australia's 2030 and 2050 net GHG emissions reductions targets under the Paris Agreement. The legislated targets are to reduce net GHG emissions to 43% below 2005 levels by 2030, and to reduce net GHG emissions to zero by 2050.

The CC Act establishes that 2030 GHG emissions reduction target as a national point target and an emissions budget. The CC Act does not impose obligations directly on companies, but it does signal sector-based reforms to achieve the GHG emissions reduction targets.

3.1.2 Climate Change (Consequential Amendments) Act 2022

The *Climate Change (Consequential Amendments) Act* 2022 (CCCA Act) embeds the GHG emissions reduction targets into fourteen Commonwealth Acts, including the *Clean Energy Regulator Act 2011*, *Infrastructure Australia Act 2008*, *National Greenhouse and Energy Reporting Act* 2007, and the *Renewable Energy (Electricity) Act 2000*.

3.1.3 National Greenhouse and Energy Reporting (NGER)

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) (Cwlth) established a national framework for corporations to report GHG emissions and energy consumption.

NGER registration and emissions reporting are mandatory for corporations or facilities that have energy production, energy use, or GHG emissions that exceed specified thresholds (Table 2). These entities are required to report on their Scope 1 and Scope 2 emissions, where:

- Scope 1 emissions – the release of GHG into the atmosphere from a facility as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility. GHG emissions associated with land clearing are not covered by the NGER scheme
- Scope 2 emissions – means the release of GHG into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling, or steam at a facility and that is consumed by the facility.

Scope 3 emissions are not included in NGER reporting due to the potential for double counting. Scope 3 emissions are defined as indirect GHG emissions, other than Scope 2 emissions, that are generated in the wider economy by a facility's supply chain or value chain. They occur because of the activities of a facility, but from sources not owned or controlled by that facility's business. Business may choose to engage with their suppliers or customers to help them or require them to reduce Scope 3 emissions. Procurement choices such as the purchase of low emissions concrete can also influence a project's Scope 3 emissions.

Table 2 NGER annual reporting thresholds – greenhouse gas emissions and energy use

Threshold level	Threshold type	
	GHG ($ktCO_2$-e)	Energy production and/or consumption (TJ)
Facility	25	100
Corporate	50	200
Notes: $ktCO_2$-e = kilotonnes of carbon dioxide equivalent. TJ = terajoules.		

Cleanaway triggers the corporate reporting threshold with existing waste management operations and reported 860,332 tCO_2-e of Scope 1 emissions and 47,168 tCO_2-e of Scope 2 emissions in the 2020 -2021 NGER reporting period. It has projected total Scope 1 and Scope 2 emissions of 1,212,000 tCO_2-e in 2022[1].

3.2 Victoria

The Victorian Government has committed to achieving net zero GHG emissions by 2050 relative to the level of the State's emissions in 2005 (120 million tCO_2-e)[2]. Victoria's emissions rose to a high of ~140 million tCO_2-e in 2010; however, the interim target of a 15-20% net reduction by 2020 was exceeded, with a reduction of nearly 30% to 83 million tCO_2-e.

The electricity generation sector accounted for just over 50% of Victoria's emissions in 2020, at 41.7 million tCO_2-e. The waste sector accounted for just over 3% of the emissions in 2020, at 2.8 million tCO_2-e.

3.2.1 Climate Change Act 2017 (Victoria)

The *Climate Change Act 2017* (I) sets the legislative foundation to manage Victoria's climate change risks, and drive Victoria's transition to net zero emissions by 2050. A key condition under the CC Act Vic is the requirement of the Victorian Government to develop a Climate Change Strategy every five years with interim targets to enable Victoria to reach its long-term net-zero emissions goal. In May 2021 the Victorian Government released Victoria's Climate Change Strategy, with key targets being to reduce the State's greenhouse gas emissions from 2005 levels by:

- 28-33% by 2025
- 45-50% by 2030.

The strategy also has a target of 50% renewable energy supply by 2030.

The objectives will be achieved through:

- Increasing renewable energy generation
- Reducing transport emissions by accelerating the transition to zero emission vehicles
- Halving the amount of organic waste going to landfill
- Restoring degraded landscapes and planting trees to remove emissions from the atmosphere.

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[1] www.listcorp.com/asx/cwy/cleanaway-waste-management-limited/news/2022-sustainability-report-2765903.html
[2] https://www.climatechange.vic.gov.au/victorias-greenhouse-gas-emissions-and-targets

3.2.2 Renewable Energy (Jobs and Investment) Act 2017 (Victoria)

The *Renewable Energy (Jobs and Investment) Act* 2017 (Vic) legislates that 50% of Victoria's electricity will come from renewable sources by 2030. The Victorian Government has indicated that it intends to legislate updated targets of 65% by 2030 and 95% by 2035.

Electricity produced from the combustion of organic materials sourced from biomass is currently considered to be renewable.

3.2.3 Environment Protection Act 2017 (Victoria)

The revised *Environment Protection Act 2017* (Victoria) (EP Act) came into effect on July 1st, 2021, replacing the *Environment Protection Act 1970*. The new EP Act introduces the concept of the 'general environmental duty' (GED), which is the obligation of Victorians and Victorian businesses to reduce the risk of activities with the potential to harm human health or the environment through pollution or waste. Under the EP Act GHG are expressly defined as waste, and as such the minimisation of harm from GHG emissions is required to comply with the GED.

Under the previous *Environment Protection Act 1970,* State Environment Protection Policies (SEPPs) were tools used to set standards and expectations of government, industry and businesses relating to the environment. Under the new EP Act, SEPPs are discontinued, however they can still be used to inform the state of knowledge, where the state of knowledge is defined as an understanding of the:

- Risks your business may pose to human health and the environment
- Steps you should take to eliminate or reduce those risks.

The state of knowledge changes over time. This is because ways of working develop, and new hazards and risks emerge.

3.2.4 Protocol for Environmental Management – Greenhouse Gas Emissions and Energy Efficiency

The Protocol for the Environmental Management (PEM): Greenhouse Gas Emissions and Energy Efficiency in Industry (PEM GHG) is an incorporated document of the SEPP for Air Quality Management (SEPP AQM) that is still relevant in contributing to the state of knowledge. Under the PEM GHG, all license applicants are required to:

- Step 1: Estimate energy consumption in GJ, by energy type and the associated GHG emissions in CO_2-equivalent terms
- Step 2: Estimate direct greenhouse emissions in CO_2-equivalent terms for non-energy sources
- Step 3: Identify and evaluate opportunities to reduce greenhouse gas emissions.

3.2.5 Guideline for Managing Greenhouse Gas Emissions

The *Guideline for managing greenhouse gas emissions* (EPA 2017) for businesses and industries outlines a risk management approach that can be applied to GHG emissions. The general process of the approach is as follow:

- Step 1: Identify GHG emission sources and group them according to Scopes
- Step 2: Assess risks from GHG emissions
- Step 3: Implement controls to eliminate risks (or reduce risks so far as reasonably practicable) of harm from GHG emissions
- Step 4: Review controls to ensure they are effective.

3.2.6 Recycling Victoria. A new economy

Recycling Victoria. A new economy (DELWP 2020) outlines the Victorian Government's 10-year policy and action plan for waste reduction, recycling and residual waste management. This includes an 80% landfill diversion target and the development of appropriate WtE facilities.

Appropriate WtE facilities will:

- Meet best-practice environment protection
- Requirements including air pollution controls
- Reduce the amount of waste sent to landfill
- Do not displace reuse or recycling
- Do not inhibit innovation in reuse or recycling of materials
- Meet best-practice energy efficiency standards
- Reduce greenhouse gas emissions compared to the waste and energy services they displace
- Have sustainable business models that create jobs and economic development
- Work well with local communities in which they operate.

The strategy also includes a cap of 1 million tonnes of waste per year than can be sent for processing in WtE facilities.

3.2.7 Victorian Waste to Energy Framework

The Victorian waste to energy framework (DELWP 2021) describes how the WtE cap will apply. This includes a WtE facility operator holding a cap licence to recover energy from permitted waste. Allocation of the cap licences will be through a competitive process.

4. ASSESSMENT METHODS

4.1 Limitations and Assumptions

This desktop assessment has been conducted using data provided by Cleanaway. Katestone makes no claim as to the accuracy of this data. Assumptions used in calculating GHG emissions are provided in the sections below. These include that vehicle fuel combustion during construction is the responsibility of contractors and emissions are therefore included as Scope 3, while vehicle fuel combustion during operation is the responsibility of Cleanaway and these emissions are included as Scope 1.

4.2 GHG Emissions

Projected Scope 1, Scope 2, and Scope 3 GHG emissions for the MERC during construction and operation have been estimated from projected activity data provided by Cleanaway and the methods and factors described in the following resources:

- The National Greenhouse Accounts Factors, October 2021 (DISER, 2021)
- *National Greenhouse and Energy Reporting (Measurement) Determination* 2008
- The Greenhouse Gas Protocol (WRI/WBCSD, 2004)
- Electricity sector emissions and generation data 2019-20 (Clean Energy Regulator, 2021).

The values in Table 3 (Scope 1 and Scope 2 sources) and Table 4 (Scope 3 sources) have been provided to Katestone by Cleanaway. The MERC may use diesel or biodiesel to fuel stationary equipment, for example, during boiler line start up and shutdown procedures. Emissions factors (Table 5) and calculations are considered and presented for both options.

Table 3 Summary of activity data for estimation of Scope 1 and Scope 2 emissions

Scope	Activity	Units	Construction Phase	Operation Phase Option 1[1]	Operation Phase Option 2[1]
Scope 1	Diesel consumption (vehicles)	L/annum	0	828,372	828,372
	Diesel consumption (stationary)	L/annum	15,600[2]	581,327	6,582
	Biodiesel consumption (stationary)	L/annum	0	0	622,698
	Combustion of C&I waste[3]	tpa	0	228,000	228,000
	Combustion of MSW waste[3]	tpa	0	152,000	152,000
Scope 2	Electricity use (Victorian grid)	MWh	0	1,371	1,371

Table notes:

[1]Either diesel or biodiesel will be used (depending upon cost effectiveness, emissions comparison, etc.)

[2]It is assumed 4 diesel generators are used for earthworks and 4 diesel generators for construction using 1.5 L/hr. Working hours of 10 hours/per, 5 days/week, 52 weeks per year are assumed. It is assumed 20% of the construction phase period will be for earthworks, and 80% will be for construction itself.

[3]Combustion of waste will begin with a 60/40 split between C&I waste and MSW and will progress towards a 40/60 split.

The potential emissions from vegetation clearance and soil disturbance have not been included in this Scope 1 analysis because:

- Analysis by the Full Carbon Accounting Model[3] (FullCAM) significantly overestimates the amount of woody vegetation onsite and gives an emissions value that is high and inaccurate. Emissions from the clearance of existing trees onsite is unlikely to be material, however this could be determined through survey and/or the carbon may be sequestered.

- Assessment of soil carbon stocks and emissions without representative sampling can be inaccurate due to high spatial and temporal variability[4], and emissions from soil disturbance or management are not considered Scope 1 emissions for the purposes of NGER reporting.

Table 4 summarises the quantity of consumables during the operations phase and materials during the construction phase that have Scope 3 emissions associated with them. Diesel used during the construction phase appears as a Scope 3 emission as the trucks hauling materials to the site and construction waste from the site will be owned and operated by a third party, i.e., these are Scope 1 emissions for the company responsible for the trucks. Similarly, the emissions associated with the production of quicklime and cement are not the responsibility of Cleanaway.

Table 4 Summary of materials quantity data relevant to estimating Scope 3 GHG emissions

Component	Units	Construction Phase	Operation Phase
Imported materials	t/yr	5,000	0
Concrete[a]		12,900	0
Steel		1,200	0
Quicklime		0	5,168
Powdered activated carbon		0	200
Cement (for APCr stabilisation)		0	3,420
Urea (100%)		0	832
Diesel	L/yr	1,940,000	60,387

Table notes
[a]The total volume of concrete per year expected is 5,375 m^3; the density of concrete is assumed to be 2.4 t/m^3

The Scope 3 diesel emissions during the operations phase relate to the delivery of consumables to site and the transportation of some by-products away from site[5]. Additional Scope 3 emissions not listed in Table 4 will occur due to the demolition of an existing residential building onsite. These emissions are classed as Scope 3 as a contractor will be brought onto site to conduct the demolition. Expected emissions are expected to arise from the combustion of diesel for machinery and the disposal of waste materials. Emissions could potentially be avoided through the recycling of any materials salvageable from the demolition of the building. The total Scope 3 emissions

[3] The Department of Industry, Science, Energy and Resources FullCAM Guidelines: Requirements for using the Full Carbon Accounting Model (FullCAM) in the Emissions Reduction Fund (ERF) methodology determination Carbon Credits (Carbon Farming Initiative) (Native Forest from Managed Regrowth) Methodology Determination 2013 https://www.dcceew.gov.au/sites/default/files/documents/final_fullcam_guideline_native_forest_from_managed_regrowth.pdf

[44] The Carbon Credits (Carbon Farming Initiative — Estimation of Soil Organic Carbon Sequestration using Measurement and Models) Methodology Determination 2021. https://www.legislation.gov.au/Details/F2021L01696

[5]It is assumed that Cleanaway operate the stabilised APCr dispatch vehicles

from the demolition are expected to be small compared to the Scope 3 emissions of the construction of the MERC, and insignificant compared to total Scope 1 and 2 emissions from the operations of the MERC.

Table 5 provides the energy content in gigajoules per kilolitre (GJ/kL) and emissions factors in kilograms of carbon dioxide equivalent (kgCO_2-e) per unit energy (GJ), area (ha), or mass (t) used in the calculation of GHG emissions. The total emission factors are presented, which are calculated from summing the individual emission factors for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

For all emission calculations, Katestone employs Method 1 as outlined in the NGER Determination. In general, the formula applied is:

$$E = \frac{Q \times ECF \times EF}{1000},$$

where E represents the total emissions in tCO_2-e, Q is the quantity of the emission source (e.g., with units kL), ECF is the energy content factor of the emission source (e.g., with units GJ/kL), EF is the emission factor that describes the total amount of equivalent carbon dioxide emissions associated with the emission source (i.e., with units kgCO_2-e/GJ), and the 1000 returns the correct units for the emissions.

For the purposes of this assessment, Method 1 encapsulates all the information required to perform a rigorous GHG assessment of the proposed MERC facility. Higher order methods only need to be used when certain criteria are met (e.g., diesel is the main fuel source burned for electricity generation where the primary use of the facility is electricity generation). In the case of the proposed MERC facility, none of these criteria are met.

The last assumption Katestone makes is the composition of waste. Two scenarios are developed where the waste stream split is 60:40 for MSW:C&I and C&I:MSW. For municipal solid waste, Katestone assumes a makeup of 63.9% organic waste and 36.1% non-organic waste. For commercial and industrial waste, this is assumed to be 37.9% organic waste and 62.1% non-organic waste. This is equivalent to the initial waste stream having a total organic fraction of 48.3% and a non-organic fraction of 51.7%, and the future waste stream having a total organic fraction of 53.5% and a non-organic fraction of 46.5%. These values are derived from an audit of Melbourne waste streams from two different seasons carried out by Ramboll for this Project (Ramboll unpublished data).

Table 5 Summary of energy content and Scope 1, Scope 2, and Scope 3 emissions factors of relevance to the proposed MERC

Emission source	Energy content	Units	Emission factor				Units
			Scope 1	Scope 2	Scope 3	Avoided	
Diesel (transport)	38.6	GJ/kL	70.4	-	3.6	-	kgCO_2-e/GJ[1]
Diesel (stationary)	38.6	GJ/kL	70.2	-	-	-	kgCO_2-e/GJ[1]
Biodiesel (stationary)	34.6	GJ/kL	0.28	-	-	-	kgCO_2-e/GJ[1]
Electricity (Victoria)	0.0036	GJ/kWh	-	0.85	-	-	kgCO_2-e/kWh[1]
Organic waste combustion	12.2	GJ/t	1.8	-	-	-	kgCO_2-e/GJ[2]
Fossil waste combustion	10.5	GJ/t	88.9	-	-	-	kgCO_2-e/GJ[2]
Landfill - MSW	-	-	-	-	-	1,600	kgCO_2-e/t[2]
Landfill – C&I	-	-	-	-	-	1,300	kgCO_2-e/t[2]
Bottom ash	-	-	-	-	-	105	kgCO_2-e/t[2]
Ferrous metal recovery	-	-	-	-	-	1,700	kgCO_2-e/t[3]
Non-ferrous metal recovery	-	-	-	-	-	17,000	kgCO_2-e/t[3]
Aggregate	-	-	-	-	5.67		kgCO_2-e/t[4]
Cement	-	-	-	-	250.6		kgCO_2-e/t[4]
Steel	-	-	-	-	1547		kgCO_2-e/t[4]
Urea (100%)	-	-	-	-	320	-	kgCO_2-e/t[5]
Quicklime	-	-	-		790	-	kgCO_2-e/t[6]
Activated carbon					22000		kgCO_2-e/t[7]

Table notes:

[1]*National Greenhouse and Energy Reporting (Measurement) Determination 2008*, as amended in July 2022

[2]*National Greenhouse Accounts Factors* (Department of Industry, Science, Energy and Resources, 2021).

[3]*Lifecycle assessment of kerbside recycling 2015 Calculator* (Victoria Government, Updated 19 September 2022).

[4]*Infrastructure Sustainability Materials Calculator,* v 1 (Infrastructure Sustainability Council of Australia, 2020), concrete is assumed to be precast concrete with a strength of 65MPa.

[5]Perdaman Urea Project, Greenhouse Gas Assessment (Environmental Technologies & Analytics, 23 September 2019)

[6]Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Table 2-2 on Page 2.9 of the Reference Manual)

[7]Liao, et al., ACS Sustainable Chem. Eng. 8, 1252-1261 (2020).

4.3 Avoided Emissions

The purpose of the MERC is to reduce the volume of residual waste going to landfill, avoid the release of methane from decomposing organic waste, and to substitute for electricity generated from coal or gas.

The three main sources of avoided emissions associated with waste being sent directly to landfill are:

- Avoided emissions from landfill gas
- Avoided emissions from electricity generated by Victoria's current coal and gas infrastructure
- Avoided emissions from recyclable materials recovered after waste incineration.

4.3.1 Landfill Gas

Landfill gas (LFG) that is captured and combusted for electricity generation is considered a part of the natural carbon cycle (methane from decomposing organic material converted to carbon dioxide by combustion) so this must be accounted for in calculating avoided landfill emissions due to waste diversion to the MERC.

To calculate avoided landfill emissions of methane, the direct emissions from landfill with no capture are first calculated as per the following formula:

$$GHG_{LFG} = m_{MSW} \times EF_{MSW} + m_{C\&I} \times EF_{C\&I},$$

where m_{MSW} is the total mass of MSW, EF_{MSW} is the emission factor for MSW (c.f. Table 5) and similarly for C&I. In this calculation, the waste is assumed to be composed as stated in the NGA factors (Department of Industry, Science, Energy and Resources, 2021).

Avoided emissions are then calculated per the following formula:

$$AE = ([1 - C] \times GHG_{LFG}) - ([1 - C] \times GHG_{LFG} \times M) - E$$

Where AE represents the total avoided emissions in tCO_2-e, C is capture rate of landfill gas as a percentage, GHG_{LFG} is the direct landfill gas emissions based on the waste throughput in tCO_2-e, M is the methane oxidation rate, and E is the electricity generation emissions avoided from landfill gas (Table 5).

Katestone calculates avoided emissions for the following scenarios:

- Waste composition is 60/40 C&I/MSW, LFG capture is 65%, and GWP is 28
- Waste composition is 60/40 C&I/MSW, LFG capture is 65%, and GWP is 79.7
- Waste composition is 60/40 C&I/MSW, LFG capture is 75%, and GWP is 28
- Waste composition is 60/40 C&I/MSW, LFG capture is 75%, and GWP is 79.7
- Waste composition is 40/60 C&I/MSW, LFG capture is 65%, and GWP is 28
- Waste composition is 40/60 C&I/MSW, LFG capture is 65%, and GWP is 79.7
- Waste composition is 40/60 C&I/MSW, LFG capture is 75%, and GWP is 28
- Waste composition is 40/60 C&I/MSW, LFG capture is 75%, and GWP is 79.7.

Key assumptions are:

- Cleanaway have indicated that the relative proportion of C&I waste to MSW will change from 40/60 to 60/40 over time.
- The average LFG capture rate across Australia is 45%, however, the NGER Determination assumes capture rates between 60%-95%. Katestone assumes a low to mid-range LFG capture rate for Victorian landfills of 65% and 75%.
- The GWP for methane is 28 (over a 100-year period) (DISER 2021). However, methane has a shorter lifetime and greater impact than carbon dioxide, so Katestone also apply the 20-year GWP of 79.7 for methane of non-fossil fuel origin (IPCC, 2021) for comparison.

4.3.2 Electricity Generation

Avoided emissions from electricity generation assume that the electricity generated at the MERC proportionately substitutes for electricity generated from fossil fuels, e.g., 1 MWh produced from WtE replaces 1 MWh produced from fossil fuel. Emissions are not avoided if the electricity produced from WTE is additional to that produced from fossil fuels. Katestone calculates the emissions intensity of electricity produced by the MERC in tCO_2-e/MWh produced. This value is subtracted from the reported emissions intensity of, for example, coal-fired power generators in Victoria (1.14 – 1.33 tCO_2-e/MWh) to give the emissions avoided by producing electricity from the MERC rather than a coal-fired power station.

Avoided emissions can also be provided through the substitution of electricity generated from fossil fuels with electricity generated from renewable sources. Combustion of organic materials including in waste to produce electricity is considered renewable. Katestone calculates the projected emissions from the mass of assumed fossil and organic fractions in the waste stream multiplied by their emission factors in Table 5.

4.3.3 Recovered Recyclable Materials

Scope 3 avoided emissions are calculated by multiplying the projected mass of recyclable or substitutable materials by the emissions released in producing the virgin equivalent (Table 5). The expected recovered recyclable materials during operation of the proposed facility are presented in Table 6.

Table 6 By-products of the MERC facility to be recovered for recycling purposes

Recoverable materials	Value (t/yr)
Ferrous metals	10,716
Non-ferrous metals	1,900
Incinerator bottom ash aggregate (use in aggregate materials)	96,630

5. EMISSIONS RESULTS

5.1 Scope 1 and Scope 2 Emissions

Projected Scope 1 and Scope 2 GHG emissions associated with construction and operation of the MERC have been estimated on an annual basis (Table 7). There are very few Scope 1 or 2 emissions attributable to the MERC during construction as most emissions are produced by independent contractors and are therefore regarded as Scope 3 emissions (Table 8).

Approximately 192,400 tCO_2-e/y (Scope 1 and Scope 2) are projected to be emitted during operation of the MERC while the waste stream is 60% C&I waste and 40% MSW. This decreases to 174,400 tCO_2-e/y when the waste stream changes to 40% C&I and 60% MSW. The combustion of waste is the largest Scope 1 emission source during operation with nominal emissions of 187,400 tCO_2-e/y (60:40 C&I:MSW) reducing to 169,400 tCO_2/y (40:60 C&I:MSW), based on incineration of 380,000 tpa of waste with a fixed calorific value.

Total emissions are projected to decrease as the waste stream changes from 60% C&I and 40% MSW to 40% C&I and 60% MSW over time. This is due to a reduction in the proportion of non-organic material in the waste such as soft plastics. However, changes in Government policy requiring food organic and garden organic (FOGO) waste to be diverted from the MSW stream may also have a balancing effect.

The use of diesel as a supplementary fuel during start up or shut down periods produces approximately 1,500 tCO_2-e/y more than if biodiesel was used for the same process.

Table 7 Summary of projected Scope 1 and Scope 2 GHG emissions (tCO_2-e) for the project with an evolving waste stream with an option for biodiesel substituting for diesel.

Emissions Scope	**Emission source**	**Construction Phase**	**Operation Phase** Diesel	**Operation Phase** Biodiesel
Scope 1	Diesel usage (vehicles)	0	2,251	2,251
	Diesel usage (stationary)	42	1,575	18
	Biodiesel usage (stationary)	0	0	6
	Waste combustion (60:40 C&I: MSW)	0	187,416	187,416
	Waste combustion (40:60 C&I: MSW)	0	169,405	169,405
Total Scope 1	60:40 C&I: MSW	0	191,242	189,691
Total Scope 1	40:60 C&I: MSW	0	173,231	171,680
Total Scope 2	Electricity	0	1,165	1,165
Total Scope 1 and 2	60:40 C&I: MSW	42	192,407	190,856
Total Scope 1 and 2	40:60 C&I: MSW	42	174,396	172,845

5.2 Scope 3 Emissions

Scope 3 emissions are primarily associated with the embedded emissions of major construction materials, transport of major construction materials, and the associated emissions with the production of consumables (Table 8). Cement production is the largest contributor to Scope 3 emissions for the facility during construction at >9,000

tCO_2-e and steel is the second largest at 5,000 tCO_2-e. Cement used for the stabilisation of APCr is the largest contributor to Scope 3 emissions during operation, at just over 2,000 tCO_2-e per year. The emissions projected for diesel use during construction are relatively small at just over 700 tCO_2-e.

Table 8 Summary of projected Scope 3 GHG emissions (tCO_2-e) per year for the Operations phase and for the entire Construction phase (three years)

Component	Construction phase	Operation phase
Imported materials	85	0
Concrete	9,698	0
Steel	5,569	0
Diesel (construction)	809	0
Diesel (worker's commute)	0	7
Diesel (delivery of consumables)	0	8
Cement (for APCr stabilisation)	0	2,056
Quicklime	0	4,083
Urea	0	266
Activated carbon	0	4,400
Total Scope 3 (tCO_2-e)	**16,161**	**10,821**

5.3 Contribution of Emissions to Victoria and Australia's Carbon Accounts

Cleanaway currently reports its emissions under the NGER Act (Table 2). Scope 1 and 2 emissions from the MERC will increase its reportable emissions by 14.9% and 2.3% respectively (Table 9).

Table 9 Contribution of MERC's expected GHG emissions for diesel option and 40:60 C&I:MSW waste stream to Cleanaway reporting

Scope	Cleanaway	
	Current[1]	% Increase
Scope 1 ($ktCO_2$-e)	1,162	14.9%
Scope 2 ($ktCO_2$-e)	50	2.3%

[1]https://www.listcorp.com/asx/cwy/cleanaway-waste-management-limited/news/2022-sustainability-report-2765903.html

The projected Scope 1 and 2 emissions associated with the MERC would contribute less than 0.25% to Victoria's current emissions account and less than 0.04% to Australia's current emissions account (Table 10). These contributions do not account for potential avoided emissions which are detailed in section 5.4.

Table 10 **Contribution of MERC's projected GHG emissions for diesel option and 40:60 C&I:MSW waste stream to Victoria and Australia's current emission accounts**

Emissions	MERC	Victoria		Australia	
		Current[2]	% Increase	Current[3]	% Increase
Total (ktCO_2-e)	175	83,800	0.21%	487,100	0.036%

[2]2020 data, includes Land Use, Land-Use Change and Forestry UNFCCC offsets (DCCEE&W, 2020c)
[3]Data for year to March 2022 (DCCEE&W, 2022).

5.4 Avoided Emissions

5.4.1 Landfill Gas

Methane emissions avoided by diverting organic matter away from landfill will depend on the management of the landfill, the efficiency of LFG capture for use in electricity generation, and the proportion of FOGO buried in the landfill. The relative composition of the organic fraction in C&I and MSW may also determine the amount of methane that could have been produced by that waste if it was landfilled.

Figure 3 shows that approximately 100,000 tCO_2-e/y will be avoided per year regardless of waste type and composition, when the methane GWP of 28 is applied and there is 65% efficiency in LFG capture at landfill. This increases to between 400,000 and 450,000 tCO_2-e/y avoided when the 20-year methane GWP of 79.7 is applied.

Increasing the LFG capture rate at landfill to 75% reduces the avoided emissions to just under 50,000 tCO_2-e/y regardless of waste type when the methane GWP is 28, and to between 250,000 and 290,000 tCO_2-e/y when the methane GWP is 79.7 (Figure 3).

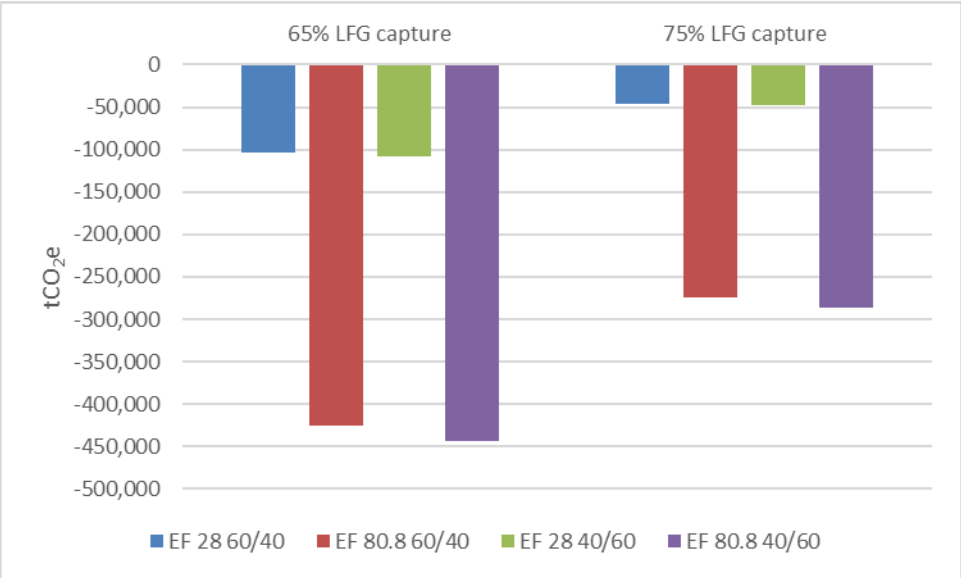

Figure 3 **Avoided methane emissions per year (tCO_2-e/y) with methane GWP of 28 and 79.7, 65% and 75% LFG capture rate, and C&I: MSW of 60:40 and 40:60**

5.4.2 Electricity Generation

Emissions from electricity generation are avoided if the electricity produced by a high emitting source is substituted with electricity produced by a lower emitting source. The emissions intensity of the MERC relative to the coal-fired power stations means that approximately 0.5 – 0.8 tonnes fewer of CO_2-e would be emitted by the MERC per MWh produced (Table 13). Consequently, by not combusting coal to produce 328,726 MWh/y that the MERC facility will provide, approximately 437,000 tonnes of GHG emissions will be avoided per year.

When applying the current Victorian emissions factor for electricity produced from all sources, 279,417 tonnes of GHG emissions will be avoided per year.

Approximately 3% of the projected operational GHG emissions could be considered avoided emissions in global accounting as they come from combustion of renewable biogenic materials. However, consideration of biomass combustion as renewable may change as the scale of biomass combustion for energy increases globally (Pulles *et al*. 2022).

5.4.3 Recovered Recyclable Materials

Recyclable materials recovered from the bottom ash may provide more than 50,000 tCO_2-e of avoided emissions per year. Recovered metals are expected to be the largest contributor at just over 45,000 tCO_2-e/y, however 10,000 tCO_2-e/y are potentially avoided if the bottom ash is used as a partial replacement for aggregate in concrete.

Table 11 Avoided emissions per year (tCO_2-e/y) through recovery of recyclable materials (regardless of waste stream make-up)

Recoverable materials	Value (tCO_2-e/y)
Ferrous metals	18,217
Non-ferrous metals	32,300
Incinerator bottom ash aggregate (use in aggregate materials)	10,146
Avoided emissions from virgin material	**60,663**

5.4.4 Net Emissions

Table 12 provides a summary of the net (avoided) emissions achieved by diverting the waste away from landfill to the MERC facility of combustion. Each of the figures presenting in Table 12 are derived using the method presented in Section 4.3.

Table 12 Summary of net emissions per year (tCO_2-e/y) through residual waste combustion where diesel is used for auxiliary fuel

Emission source	Details	60:40 C&I: MSW GWP 28	40:60 C&I: MSW GWP 28	60:40 C&I: MSW GWP 79.7	40:60 C&I: MSW GWP 79.7
Landfill gas	Avoided methane	-104,315	-108,722	-418,159	-435,828
Electricity	Avoided emissions[6] (avoided emissions from coal only)	-279,417 (-437,205)			
Construction materials	Avoided emissions from virgin material	-60,663			
Total direct emissions	Direct emissions from MERC	192,407	174,396	192,407	174,396
Net emissions (Scope 1 + Scope 2 – avoided)		**-251,988**	**-274,406**	**-565,832**	**-601,512**

5.5 Comparison of MERC to Fossil Fuel and LFG Electricity Generators in Victoria

The relative electricity production capacity, total emissions, and emissions intensity of the current fossil-fuel based electricity generators in Victoria are provided in Table 13. The three coal-fired power stations (Loy Yang A, Loy Yang B, and Yallourn) have the greatest electricity production capacity, but also the greatest emissions and emissions intensity profile at 1.14 – 1.33 t CO_2-e/MWh. These plants are scheduled for closure between 2028 and 2046.

Approximately 97% of the total MERC emissions from waste combustion are from non-renewable materials. The projected emissions intensity of the MERC with 60/40 C&I to MSW feedstock is within the reported range of the seven gas powered plants, (Bairnsdale, Jeeralang, Laverton North, Mortlake, Somerton, Valley Power, and Newport), at 0.59 t CO_2-e/MWh (Table 13). The emissions intensity drops into the low-range of the gas plants, at 0.53 t CO_2-e/MWh when the waste feedstock changes to 40/60 C&I to MSW.

Electricity production from LFG is less energy efficient than other means of production, but it is considered a renewable energy source and is reducing the global warming potential of the methane from 28 (or 79.7) to 1 (Table 13).

[6] Using current Victorian electricity grid emission intensity

Table 13 **Relative electricity production capacity (MW) and Scope 1 emissions intensity (tCO2-e/MWh) for existing electricity generators in Victoria (2019-2020) and the proposed MERC where diesel is used as auxiliary fuel**

Electricity generation method (number operating)	Capacity (MW)	Total emissions (MtCO2-e)	Emissions intensity (tCO_2-e/MWh)
Coal (3)[1]	1,050 – 2,200	12.4 – 16.7	1.14 – 1.33
Gas turbine (6)	92 - 550	0.006 – 0.531	0.53 – 0.76
Gas thermal (1)	500	0.487	0.53
MERC[2]	**46.3**	**0.193**	**0.59**
MERC[3]	**46.3**	**0.175**	**0.53**
Landfill gas (10)	1 – 8.7	-	0.05 – 0.06
Sewage gas (2)	1.1	-	0.05 – 0.06

Table notes:
[1]scheduled for closure in 2028, 2035, and 2046
[2]C&I/MSW 60/40
[3]C&I/MSW 40/60

6. MEASURES TO MINIMISE GREENHOUSE GAS EMISSIONS

The greatest source of emissions from the MERC is due to the combustion of waste. The relative fraction of fossil-fuel based materials to renewable organic materials in the residual waste stream is assumed to be beyond the control of the MERC and to be responsive to changes in Government policy. For example, the requirement to divert FOGO material towards composting and away from residual waste streams will result an increased fraction of non-organic material in the waste stream. However, government policies to reduce plastic waste will counter this effect and ultimately the proportion of fossil-fuel based materials in the waste stream will slightly decrease.

Biodiesel use rather than diesel use will reduce emissions by a small proportion of the overall Scope 1 emissions from the MERC.

Designing the plant for maximum energy efficiency will reduce the amount of electricity required to run the plant and reduce reportable Scope 2 emissions. The co-benefit is that more electricity will be available for export to the NEM.

Procurement decisions in the construction of the MERC are a means to reduce the Scope 3 emissions attributable to the embodied emissions in construction materials. For example, approximately 5% of the emissions can come from cement and concrete. Low emissions concrete which substitutes cement with alternative binders such as coal ash, biochar, and new polymers, can have the same or superior structural characteristics and have significantly fewer embodied emissions. The future supply of bottom ash from the MERC to the market for use as aggregate in roading can also contribute to avoided emissions in the future.

7. DISCUSSION AND CONCLUSION

The proposed MERC is intended to incinerate 380,000 tpa of residual MSW and residual C&I waste streams to produce 366,326 MWh/y of electricity. The Victorian Government's waste to energy policy recognises that there is a role for WtE facilities in reducing waste volumes going to landfill where they create clear net benefits and do not displace waste reduction and recycling efforts (DELWP 2020). Cleanaway is expected to demonstrate that the construction and operation of the facility will incorporate best practice measures for, amongst other things, the management of GHG emissions.

The Victorian Government has committed to achieving net zero GHG emissions by 2050 relative to the level of the State's emissions in 2005 (120 million tonnes CO_2-e), with interim targets being 28-33% reductions by 2025 and 45-50% reductions by 2030. WtE is established in the Victorian Government's recycling strategy as appropriate if it can reduce greenhouse gas emissions compared to the waste and energy services they displace (DELWP 2020). GHGs are defined as waste in the Environment Protection Act 2017 (EP Act) and Cleanaway has a general environmental duty to minimise harm from GHG emissions, i.e., global warming and resulting climate change. The *Guideline for managing greenhouse gas emissions* outlines a risk management approach that suggests identifying GHG emission sources and grouping them according to Scopes.

This analysis has used data supplied by Cleanaway to calculate expected Scope 1 and Scope 2 GHG emissions under two waste composition scenarios (initially 60/40 C&I to MSW transitioning to 40/60 C&I to MSW) using diesel or biodiesel for operations. Emissions from diesel use during construction have been classed as a Scope 3 emission as it is assumed that the construction company will be independent of Cleanaway. Combustion of the 380,000 tpa of residual waste is the largest source of GHG emissions, as expected, with the initial waste stream producing just over 187,000 tCO2-e per year and diesel fuel consumption contributing a further 3,990 tCO_2-e per year.

Steel and concrete used for construction are the largest sources of Scope 3 emissions during construction. These may be reduced through procurement of low emissions alternatives. Operational Scope 3 emissions can be reduced through the supply of recyclable materials in lieu of virgin materials. For example, incinerator bottom ash (IBA) can be used as supplementary aggregate for road construction.

While combustion of waste produces GHG emissions, the process allows for the offsetting or avoidance of emissions that might otherwise have occurred. This includes avoidance of future generation of methane from decomposing organic matter in landfills and as a lower emissions substitute for electricity production from primary fossil fuels. Under current conditions ~104,000–445,000 tCO_2-e/y of avoided methane emissions can be achieved However, the relative value of these avoided emissions will change as the policy and operational environment, particularly as the fraction of C&I waste to MSW changes, landfill gas harvesting improves, and FOGO is removed from the MSW waste stream.

Considering all avoided emissions detailed in this assessment, the predicted net emissions from the facility are estimated to be at least -251,000 tCO_2/y; this forecast will potentially improve as the waste stream changes to include more municipal solid waste.

The projected emissions intensity of waste combustion to produce electricity would place the MERC at the mid to lower end of the range of existing gas-fired power stations in Victoria with significantly lower emissions intensity than Victorian coal-fired power stations.

The proposed MERC can meet the definition of an appropriate WtE facility through its contribution to the reduction of residual waste to landfill and through avoided emissions, however the relative value of the facility will likely reduce over its proposed 30-year lifetime if decarbonisation of the electricity grid increases as expected in coming decades.

REFERENCES

Clean Energy Regulator (CER), 2021. National greenhouse and energy reporting data. https://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/electricity-sector-emissions-and-generation-data/electricity-sector-emissions-and-generation-data-2019-20?Paged=TRUE&p_ID=330&View=%7b99112075%2dD30F%2d4B8B%2dB0F6%2d30051836B0A2%7d&PageFirstRow=331 Accessed 17 October 2022.

DCCEE&W, 2020a. *State and Territory Greenhouse Gas Inventories 2020*. Department of Climate Change, Energy, the Environment, and Water; Canberra. https://www.dcceew.gov.au/climate-change/publications/state-and-territory-greenhouse-gas-inventories Accessed 17 October 2022

DCCEE&W, 2020b. *National Waste Report 2020*. Department of Climate Change, Energy, the Environment, and Water; Canberra. https://www.dcceew.gov.au/environment/protection/waste/national-waste-reports/2020 Accessed 20 October 2022

DCCEE&W, 2020c. *Emissions by state and territory, Australia's National Greenhouse Accounts*. Department of Climate Change, Energy, the Environment, and Water; Canberra. https://www.greenhouseaccounts.climatechange.gov.au/ Accessed 26 October 2022

DCCEE&W, 2021. *National Greenhouse Accounts Factors*. Department of Industry, Science, Energy and Resources, Canberra. https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-factors-2021 Accessed 17 October 2022

DCCEE&W, 2022. *Quarterly Update of Australia's National Greenhouse Gas Inventory: March 2022*. Department of Industry, Science, Energy and Resources, Canberra. https://www.dcceew.gov.au/sites/default/files/documents/nggi-quarterly-update-march-2022.pdf Accessed 26 October 2022

DELWP, 2020. Recycling Victoria. A new economy. Department, of Environment, Land, Water and Planning, Melbourne, Victoria. https://www.vic.gov.au/sites/default/files/2020-02/Recycling%20Victoria%20A%20new%20economy.pdf Accessed 17 October 2022

DELWP, 2021. Victorian waste to energy framework. Supporting sustainable and appropriate investment. Department, of Environment, Land, Water and Planning, Melbourne, Victoria. https://www.vic.gov.au/sites/default/files/2022-02/Victorian%20waste%20to%20energy%20framework_0.pdf Accessed 17 October 2022

EPA 2017. Guideline: energy from waste. Environment Protection Authority Victoria. 1559.1. https://www.epa.vic.gov.au/about-epa/publications/1559-1

Infrastructure Sustainability Council, 2020. 'Infrastructure Sustainability Materials Calculator, v.1

IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.

Neuwahl, F., Cusano, G., Gómez Benavides, J., Holbrook, S., and Roudier, S. 2019. Best Available Techniques (BAT) Reference Document for Waste Incineration; EUR 29971 EN; Luxembourg: Publications Office of the European Union; doi:10.2760/761437

Pulles, T., Gillenwater, M., Radunsky, K. (2022) CO_2 emissions from biomass combustion Accounting of CO_2 emissions from biomass under the UNFCCC. *Carbon Management* 13:1, 181-189, DOI: 10.1080/17583004.2022.2067456

World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD), 2004, The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition March 2004. Available online: http://www.ghgprotocol.org/corporate-standard. Accessed 17 October 2022.