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Bromelton Energy and Resource Centre: Greenhouse Gas Assessment

Prepared for:

Cleanaway Operations Pty Ltd

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REV D – Issue for Approval

Prepared by:

Katestone Environmental Australia Pty Ltd
ABN 21 680 559 095
Level 4, 154 Melbourne Street, South Brisbane
Queensland, 4101, Australia

www.katestone.global
admin@katestone.com.au
Ph +61 7 3369 3699

katestone
www.katestone.global

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Prepared by:	Carlo Bunin and Sarah Mott
Reviewed by:	Craig Miller
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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
Mt	million tonnes
$MtCO_2$-e	Million tonnes carbon dioxide equivalents
MW	megawatt
MWh	megawatt hours
MWh/y	megawatt hours per year
t	tonnes
tC	tonnes carbon
tCO_2-e	tonnes carbon dioxide equivalents
TJ	terajoules
tpa	tonnes per annum
y	year
Nomenclature	**Definition**
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
HCl	hydrochloric acid
HF	hydrofluoric acid
N_2O	nitrous oxide
NOx	nitrous oxides
SO_2	sulphur dioxide
Abbreviations	**Definition**
APCr	Air pollution control residue
AR5	Fifth assessment report
BC	Base case
BERC	Bromelton Energy and Resource Centre
BREF	Best available techniques reference
CC Act	*Climate Change Act 2022*
C&I	Commercial and industrial
CCCA Act	*Climate Change (Consequential Amendments) Act 2022*
DCCEEW	Department of Climate Change, Energy, the Environment, and Water
EA	Environmental authority
ECF	Energy content factor
EF	Emission factor
EfW	Energy from Waste
EIS	Environmental impact statement
EP Act	*Environmental Protection Act 1994*
FGT	Flue gas treatment
FOGO	Food organics and garden organics

Term	Definition
GED	General Environmental Duty
GHG	Greenhouse gas
IBA	Incinerator bottom ash
IED	Industrial emissions directive
IPCC	Intergovernmental panel on climate change
KRA	Key results area
LOP	Life of project
LHV	Lower heating value
LULUCF	Land use, land use change, and forestry
MSW	Municipal solid waste
NEM	National Energy Market
NGER	National Greenhouse and Energy Reporting
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
OC	Overload case
SDA	State development area
SMCs	Safeguard mechanism credits
SNCR	Selective non-catalytic reduction
SPP	State planning policy
TEEP	Technically, environmentally and economically practical
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

EXECUTIVE SUMMARY

Katestone Environmental Australia Pty Ltd (Katestone) was commissioned by Cleanaway Operations Pty Ltd (Cleanaway) to conduct a Greenhouse Gas (GHG) Assessment for the construction and operation of a proposed Energy from Waste (EfW) facility in Queensland known as the Bromelton Energy and Resource Centre (BERC/ the Project). The Project will be located within the Special Industry Precinct of the Bromelton State Development Area (SDA), west of Beaudesert.

The Queensland Government's energy from waste (EfW) policy recognises that there is a role for EfW facilities in reducing waste volumes going to landfill where they create clear net benefits and do not displace waste reduction and recycling efforts. Under nominal operation, the Project is designed to incinerate 760,000 tpa of residual Municipal Solid Waste (MSW) and residual commercial and industrial (C&I) waste streams to produce 668,002 Megawatt hours per year (MWh/y) of electricity (base case, BC). Cleanaway have also considered a maximum operation case (overload case, OC) which increases the waste throughput and produced electricity to 836,000 tpa and 731,249 MWh/y respectively.

The Queensland Government has committed to achieving net zero GHG emissions by 2050 relative to the level of the State's emissions in 2005 (197.3 million tonnes of carbon dioxide equivalent emissions ($MtCO_2$-e)). Cleanaway is expected to demonstrate that the construction and operation of the facility will incorporate best practice measures for, *inter alia*, the management of GHG emissions.

This analysis has used data supplied by Cleanaway to calculate expected Scope 1, Scope 2, and Scope 3 GHG emissions during construction and operation.

Diesel combustion for transporting materials to site is estimated to be the largest source of Scope 1 emissions during the 39-month construction phase (5,961 t CO_2-e), while employee commuting, purchased capital goods, and upstream diesel combustion for transport activities account for most Scope 3 emissions at 23,215 t CO_2-e, 20,023 t CO_2-e, and 13,046 t CO_2-e respectively during construction.

The BC and OC are evaluated over two time periods that reflect legislated net zero targets by 2050: 2030 - 2050 and 2051 - 2065. The total annual BC Scope 1 emissions for each period are calculated to be 396,683 t CO_2-e/y and 323,494 t CO_2-e/y respectively. The total annual OC Scope 1 emissions for each period are calculated to be 436,042 t CO_2-e/y and 355,533 t CO_2-e/y, respectively. Combustion of waste accounts for 98% of total annual BC and OC Scope 1 emissions across both time periods.

Scope 2 emissions remain relatively constant across BC and OC at 454 - 468 t CO_2-e/y and 477 - 492 t CO_2-e/y for the periods 2030 – 2050 and 2051 - 2065, respectively.

Scope 3 emissions during operation are estimated for the BC and OC as 31,459 t CO_2-e/y and 34,160 t CO_2-e/y, respectively.

The emissions intensity of production for the BC and OC is within the range of Queensland's gas generators and less than Queensland's coal fired generators, at 0.60 t CO_2-e/MWh.

Projected total BC operational emissions for 2025–2050 are expected to account for >0.61%, >0.20%, and >0.002% of the remaining state, national and global carbon budgets to achieve net zero by 2050, respectively.

The facility will be subject to the electricity sector Safeguard Mechanism threshold and will not be required to progressively reduce its GHG emissions unless the threshold is exceeded by all electricity generation in Australia. However, Cleanaway will evaluate and incorporate best practice measures for the management of GHG emissions where practicable, as required by the GHG Guidelines, including:

- Seek options for the supply of low emission steel and concrete by tendering contractors
- Use biodiesel instead of diesel for facility startup processes, subject to review of biodiesel fuel availability and supply chain reliability
- Designing the plant for high energy recovery and electricity generation efficiency
- Explore options for offtake agreements and supply of heat to other industries in the Bromelton SDA
- Supply of recovered recyclable or reusable materials to the market after combustion, subject to approvals for IBAA reuse

Of the assessed emissions reduction scenarios:

- Combustion of diesel for the BC transport of waste by B-Double trucks (BD) to the facility accounts for 4,099 t CO_2-e/yr, and OC transport accounts for 4,499 t CO_2-e/y. Cleanaway is seeking provisional approval for A-Double trucks (AD) to transport waste to the site. This change would result in 49 t CO_2-e/y fewer BC emissions and 13 t CO_2-e/y fewer OC emissions.
- The use of biodiesel for boiler black starts would result in 11 t CO_2-e, which is 2,940 t CO_2-e fewer than if diesel were used. The current availability of biodiesel constrains this option.

While combustion of waste produces GHG emissions, the process allows for the offsetting or avoidance of emissions that might otherwise have occurred in the economy, including avoidance of methane (CH_4) generation from decomposing organic matter in landfills and from the supply of recyclable materials.

The BC would avoid ~253,000 t CO_2-e/y of fugitive CH_4 emissions under current waste streams to LFG-managed landfills. The OC is estimated to avoid a further ~10%. However, the relative value of these avoided emissions is likely to reduce over time as the fraction of organic material going to landfill reduces, the capacity to harvest legacy methane increases, and as electricity generation in the grid becomes more renewable. Avoided emissions from recycling of recovered materials are estimated to be between 121,000 and 158,000 t CO_2-e, with non-ferrous metals contributing the greatest fraction of these.

Development of the GHG mitigation design measures demonstrates that Cleanaway complies with Section 2.5.10 of the SDA Development Scheme.

1. INTRODUCTION

Cleanaway Operations Pty Ltd (Cleanaway) is developing an Energy from Waste (EfW) facility in Queensland known as the Bromelton Energy and Resource Centre (BERC / the Project). The Project will be located within the Special Industry Precinct of the Bromelton State Development Area (SDA), west of Beaudesert within the Scenic Rim Regional Council local government area (Figure 1).

Queensland's Energy from Waste policy[1] provides a framework to help ensure that any EfW facilities developed in Queensland meet technical, environmental, regulatory and community expectations and are in the best interest of Queenslanders. Thermal EfW is considered an acceptable method for energy recovery from municipal solid waste (MSW), commercial and industrial (C&I) waste, and construction and demolition (C&D) waste that is unsuitable for reuse or recycling, and this is preferred over the continued landfilling of organic waste.

The Project has been designed to thermally treat a design capacity of 760,000 tonnes per annum (tpa) of waste feedstock, consisting of residual Municipal Solid Waste (MSW) and residual commercial and industrial (C&I) waste, which would otherwise be sent to landfill. Waste feedstock processed by the Project 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 Project will also incorporate maturation and processing of bottom ash to recover recyclable metals, with the intent to also utilise the remaining ash as an aggregate in construction.

Katestone Environmental Australia Pty Ltd (Katestone) has been commissioned by Cleanaway to conduct a greenhouse gas (GHG) assessment that meets the requirements of the *Climate-EIS information guideline* (ESR/2020/5298) and consistent with the *Guideline Greenhouse gas emissions ESR/2024/6819* (GHG Guideline). The requirements are to:

- Document the State and Federal policy, legislation, standards, and guidelines applicable to GHG emissions from the Project
- Analyse Scope 1 and Scope 2 emissions (tCO_2-e) generated during the construction and operation phases of the Project
- 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
- Demonstrate how the Project will minimise its GHG emissions
- Demonstrate compliance with regulatory and best practice requirements for the construction and operation of an EfW facility.

[1] https://www.qld.gov.au/__data/assets/pdf_file/0020/118433/energy-from-waste-policy.pdf

Figure 1 **Site location**

2. PROJECT OVERVIEW

2.1 The Project

The Project has been designed to thermally treat approximately 760,000 tonnes per annum (tpa) of waste feedstock, consisting of residual Municipal Solid Waste (MSW) and residual Commercial and Industrial (C&I) waste. Residual waste is waste that is not technically, environmentally and economically practical, which would otherwise be sent to landfill for disposal. The facility's actual annual throughput will vary depending on the calorific value of the feedstock and plant availability. To account for variability in feedstock energy content, the facility will be designed for a maximum processing capacity of up to 10% above the nominal figure (836,000 tpa). The EfW process is summarised in Figure 2.

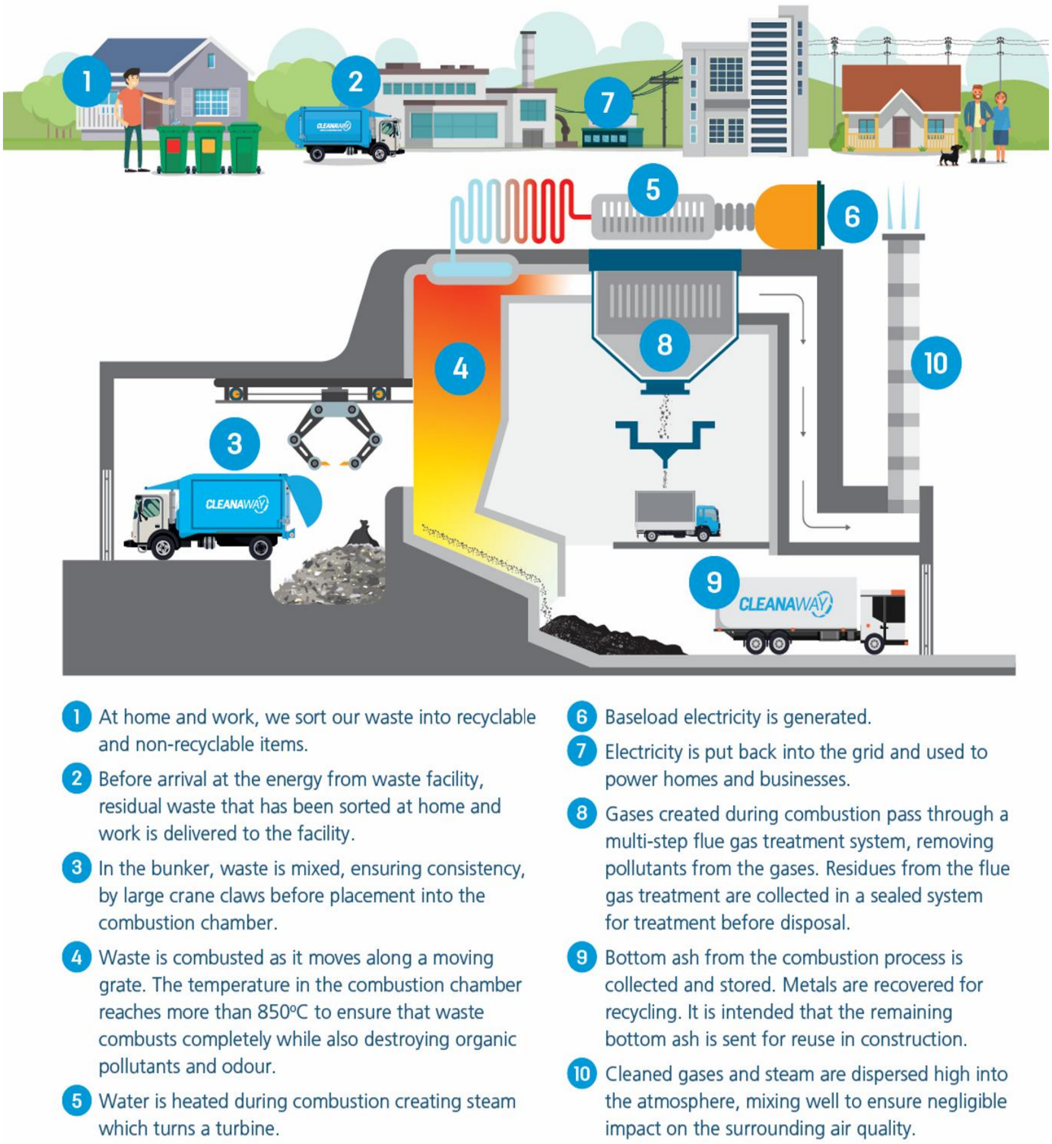

Figure 2 Energy from Waste Process

2.2 Proponent

Cleanaway, an Australian owned company, has operated for more than 50 years, supporting industry, government, communities, and households across Australia. Its mission is to make a sustainable future possible, achieved through action across all levels of the waste hierarchy. Waste generation is minimised through extensive education programs, with Cleanaway's 50 education officers reaching over 120 businesses, 30 councils, and almost 33,000 school participants in the last financial year.

Cleanaway invests heavily in recycling, operating several Material Recovery Facilities nationwide and has partnered with Pact Group, Asahi Beverages, and Coca-Cola to deliver two large-scale PET (polyethylene terephthalate) recycling facilities and a HDPE (high density polyethylene) recycling facility with Pact Group. In addition, in collaboration with Viva Energy, Cleanaway is developing a soft plastics recycling plant. EfW is recognised by Cleanaway as an important part of the future waste management framework, enabling recovery of energy and other resources from residual waste that cannot otherwise be recycled.

2.3 Policy Alignment

The Project aligns with the Queensland EfW Policy and the Queensland EfW Guideline (2021) by diverting residual waste from landfill and delivering economic and social benefits through employment and local business opportunities in South East Queensland.

In accordance with Policy outcome 7 of the Queensland EfW Policy, the Project will be designed to meet the best practice emission standards and requirements of the European Industrial Emissions Directive (IED) (2010) and the associated Best Available Techniques Reference (BREF) Document for Waste Incineration (2019), which sets the European Union environmental standards for waste incineration.

The Project also supports the Queensland Waste Strategy contributing to its 2050 targets to reduce household waste by 25%, recycle 75% of all waste, and divert 90% from landfill. In doing so, the Project will play a key role in advancing Queensland's transition to a circular economy and reducing long-term reliance on landfill.

2.4 Key Components

The key components of the Project are summarised in Table 1.

Table 1 Key Project Components

Project Component	Detail
Address	Lot 1 Beaudesert Boonah Road, Bromelton, Queensland, 4285 (Lot 1 on RP45234). Refer Figure 2.
Site Area	63 hectares
Summary of proposed works	The Project includes the construction of a main EfW facility for waste processing, incinerator bottom ash (IBA) maturation and processing facility and an air pollution control residue (APCr) facility. It also includes all onsite infrastructure needed for the EfW facility, such as site utilities, internal roads, weighbridges, parking and hardstand areas, stormwater infrastructure, fencing and landscaping. The Project will include a visitor centre to help educate and inform the community on circular economy principles, the waste hierarchy, including waste avoidance,

	recycling, resource recovery, the benefits of landfill diversion and the EfW process. The intent behind this education is to drive a shift in community awareness and attitudes toward waste management and resource recovery.
Technology Used	The proposed technology is moving grate combustion technology. This has been used globally for over 100 years and is common in many of the 500 similar operational examples across Europe.
Facility Outputs	Approximately 73.2 MW (577,600 MWh/year, corrected for ambient temperature) exported to the grid as baseload electricity. Potential to supply energy in the form of heat and/or process steam to local industrial users. Residual materials include IBA and APCr. It is intended that the IBA will be mechanically processed on site to create incinerator bottom ash aggregate (IBAA). During this process, both ferrous and non-ferrous metals are recovered for recycling and sale. It is intended that the remaining material is repurposed for use as an aggregate in construction. The Project includes a facility to stabilise APCr before removal and disposal at a licensed landfill.
Key infrastructure	EfW facility including administration and visitor's centre IBA maturation and processing facility (2 x pads and 2 x sheds) APCr facility (1 x pad, 1 x shed) Transformer yard and switchyard De-coupling area for trucks Weighbridges Internal road network and carparking 2 x combined storm water treatment and detention basin 1 x lined retention basin Access from Beaudesert Boonah Road via a signalised intersection with Recycling Street
Hours of Operation	24 hours per day, seven days per week (365 days per year)
Operational Staff	Approximately 60 staff

2.5 Project layout

The proposed development is situated within the locality of Bromelton, Queensland, approximately 47 km inland of the Gold Coast and around 56 km south-southwest of Brisbane CBD. Situated in the Scenic Rim region of Queensland, the Project sits near the base of hills directly to the west, with the township of Beaudesert 7 km to the east.

The Project site will incorporate the following key elements:

- Two-line (2 x 140 MW_{th}) EfW facility, with each line comprising: a combustor, 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 380,000 tpa (760,000 tpa cumulative) at the design CV of 10.6 MJ/kg (LHV) and assuming 8,000 hours per annum boiler availability. 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. Moving grate combustion will be employed as the preferred thermal treatment technology.
- Incinerator Bottom Ash (IBA) treatment area and sorting plant incorporating: a fully enclosed sorting facility, an enclosed conveyor for delivery of IBA from EfW facility to the IBA treatment area, IBA maturation stockpiles (1-2 months) contained within a 3-sided building and open-air stockpiles for sorted and matured IBA aggregate (IBAA) (1-2 months) with dust control using water spraying, and water capture system around the IBA treatment area, segregated from the site stormwater management system.
- APCr undercover stabilisation and storage facilities 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, on-site car parking areas and a separate main staff and visitor car park. A visitor and education centre is also proposed, to be integrated within the site administration building.

2.6 Construction

Construction is anticipated to take approximately 39 months (exclusive of commissioning and proof of performance testing prior to operations) to complete.

2.7 Operation

Figure 2 provides an overview of the operational features of the Project, which are described further below.

2.7.1 Waste Arrival

Waste deliveries will enter the Project via a security gate house at 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 Project operations staff to verify the waste and where feasible, visually inspect the load to confirm its suitability as acceptable waste.

2.7.2 Waste volumes and waste acceptance

The Project will receive approximately 760,000 tpa of a combination of mainly residual MSW and residual C&I waste. The EfW facility is designed to maintain availability of 8,000 h/yr per operational line with a nominal throughput for each line of 47.5 tph.

Only waste that is consistent with the definition of residual waste under the EfW Guideline (DES, 2021) outcome 4 will be accepted as waste feedstock. Examples of non-residual waste include, but are not limited to, uncontaminated comingled recyclables from yellow lid bins; source-separated green waste; and MSW, C&I and C&D waste that has not been source separated.

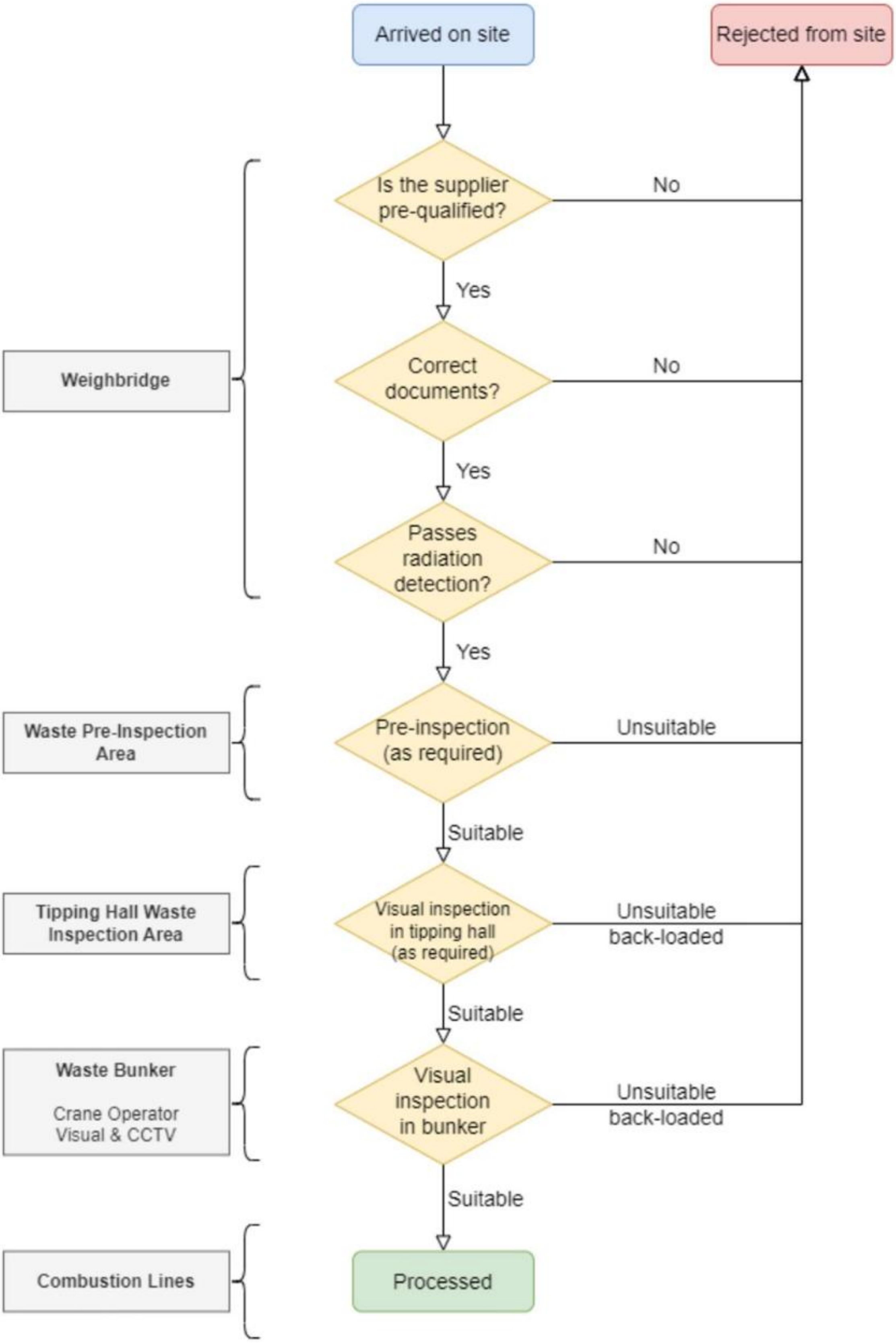

Figure 3 **Process on arrival for a waste delivery to the EfW facility**

Waste feedstock supplies by Cleanaway and third-party suppliers will be managed in accordance with the BERC 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 waste acceptance process essentially involves pre-qualification of waste suppliers and waste types through contractual Waste Supply Agreements, identification and logging of all waste deliveries, radiation detection and inspection of the waste at various stages (Figure 3) for size and suitability, aiming to maintain the composition and combustion characteristics of the waste feedstock within an acceptable range and to remove unacceptable materials that may result in unacceptable contaminant levels or may cause damage or blockages 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. Oversized acceptable waste can be fed to an onsite shredder before being fed to the boiler.

2.7.3 Waste arrival

Waste deliveries will enter the BERC site via a security gate house at the weighbridge where the vehicle will be checked for excessive levels of radiation, weighed, and have their delivery details recorded. Waste delivery vehicles may be selected at random to proceed to a designated pre-inspection and quarantine area to allow the BERC operations staff to verify the waste and where feasible, visually inspect the load to confirm its suitability as acceptable waste.

2.7.4 Tipping hall and waste bunker

Waste will be delivered via a tipping hall, expected to operate seven days per week with the majority of deliveries occurring during a 12 hour-a-day window (6 am – 6 pm) although the facility will be able to accept waste 24/7, if required.

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 total waste deliveries is up to approximately 119 waste trucks per day at 10% mechanical overload. 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 tipping hall shall include a waste inspection area where random waste loads arriving in compactor size vehicles can be temporarily unloaded for inspection and shall include a waste rejection point to allow removal of unsuitable waste from the bunker.

Tipping hall bays shall include a protection mechanism to mitigate the risk of vehicles overreaching into the bunker.

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.

During delivery hours, the waste crane operators will monitor the operation of the grab cranes, to mix and distribute the waste, and move oversize acceptable waste into the shredder for resizing. The grab cranes will also be used to remove unacceptable waste from the waste bunker. The mixing operation of the grab crane is important for the stable operation of the combustion system and flue gas treatment system, by working to ensure that individual waste loads are mixed together prior to being fed to each grate combustion system.

2.7.5 Combustion system and waste firing

The combustion system will be of a typical moving grate design suitable for combustion of MSW and C&I wastes. The boiler will generate superheated steam suitable for driving the steam turbine. The boiler will be designed to maintain a flue gas temperature of at least 850 degrees Celsius for a residence time of at least two seconds (after last injection of combustion air) to comply with the requirements of EU IED, as required by the EfW Policy (DES, 2021) and EfW Guideline (DES, 2021). The system will include online boiler tube cleaning.

The boiler system will include an allowance for auxiliary fossil fuel burners (e.g., auxiliary diesel fuel burners) for start-up, shutdown and to ensure that the 850 degree Celsius for two seconds residence time criteria is maintained when waste is being combusted.

The Project is designed to operate across a range of CVs with a reasonably selected design point. This is done to accommodate normal variabilities in waste make-up and associated changes in waste CV. Although the plant has a design point of 760,000 tpa with a waste CV of 10.6 MJ/kg (LHV) and 8,000 hours per annum boiler availability, in reality the plant could potentially process up to 836,000 tpa if the waste CV is 10.6 MJ/kg (LHV) (i.e. 10% mechanical overload scenario) and the facility hypothetically maintains a boiler availability of 100% and/or between 100-110% thermal input.

Mixed waste streams such as MSW and C&I waste are expected to constantly fluctuate in composition and combustion characteristics, however, the automated combustion control system will act to maintain stable boiler operation by controlling each boiler to a steam flow setpoint. This setpoint will ideally correspond to the 100% thermal input load for each grate-boiler system.

2.7.6 Emission controls and flue gas treatment

The concentrations of some air pollutants in the flue gas leaving the combustion system, such as nitrogen oxide, nitrogen dioxide (together referred to as NOx), carbon monoxide (CO), volatile organic compounds (VOCs), and dioxins and furans, are directly linked to the performance of the combustion system as well as the composition of the waste. Primary emission control involves:

- Mixing of the waste in the waste bunker prior to feeding each combustion system
- An automatic combustion control system that adjusts the feeder speed, movement of the grate (residence time and thickness of waste on the grate), primary and secondary combustion air flows, to maintain a desired steam generation set point from each boiler
- Careful control of combustion air injection such that excess air levels are controlled, helps to control the primary formation of NOx, 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 Project also includes a secondary NOx 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 the majority of the NOx 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 used to raise steam and then superheat steam and finally, preheat the boiler feedwater in an economiser section. At the exit of the boiler economiser section, the cooled flue gases will be treated using an air emissions control system that consists of semi-dry flue gas treatment (FGT), and a baghouse filter.

Lime injection will be used to control emissions 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. Indicative quantities of lime, urea, and activated carbon are detailed in Table 2.

The 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 (WI) (BREF WI) (Neuwahl *et.al.*, 2019) and the short-term (half-hourly average) emission limits specified in the European IED, consistent with international best practice.

Table 2 Indicative quantities of FGT consumables

Consumable	Consumption (kg/h)	Base Case 100% MCR (760,000 tpa @ 10.6 MJ/kg (LHV) - Nominal throughput scenario	10% Mechanical Overload Case (836,000 tpa @ 10.6 MJ/kg (LHV) - Maximum throughput scenario
Quicklime (~90% purity)	1,100 – 1,300	9,200	10,100
40% Urea (or NH_3-H_2O)	480 - 530	3,800	4,200
Activated carbon	51 - 52	410	420

2.7.7 Bottom ash and residue management

The Project will generate two primary residue streams: IBA and APCr.

IBA will be collected from below the grate using a wet ash extraction system. Wetted IBA will be transported via a long, fully enclosed conveyor to the IBA Treatment area where it will undergo maturation and sorting including the removal of ferrous and non-ferrous metals. Sorting and metals recovery will occur indoors, after a period of maturation. Figure 4 illustrates the process.

After maturation and metals recovery, the IBA aggregate (IBAA) is typically considered (after suitable testing and confirmation during commissioning) to be non-hazardous. Recovered IBAA can then be used as an aggregate in construction (such as road bases). This is common practice for recycled IBAA in Europe and the UK. BERC will repurpose the IBAA in accordance with EfW Policy (DES, 2021).

APCr consists of two separate ash streams:

- Boiler ash (recovered in the hoppers below the horizontal pass/convective section of the boiler)
- Flue gas treatment or 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 EfW facilities currently at the development phase in Australia, this boiler ash will be mixed with APCr, which 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 environment. This will be achieved through blending with cement and water, which cures to form a solid concrete block, immobilising the hazardous elements. Once fully cured, the cement stabilised APCr will be transported to and disposed of in an appropriately classed landfill.

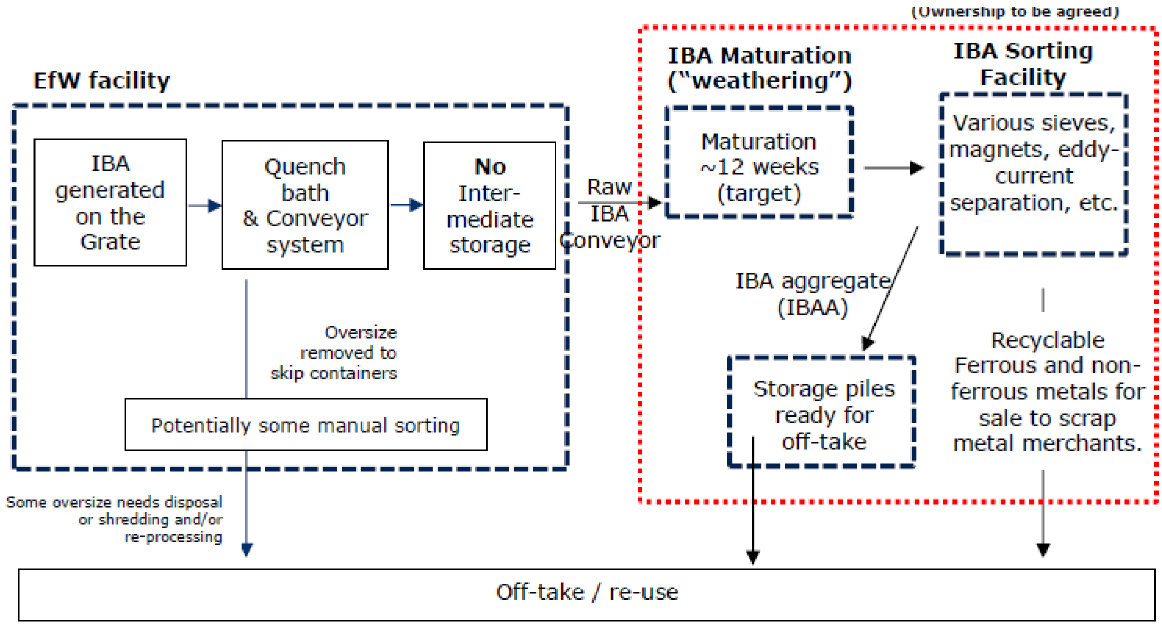

Figure 4 **IBA / IBAA process (Source: REN2021N00922-RAM-ME-00020 BERC IBA Memo v2.0 Issued 09JUL2025)**

3. POLICY CONTEXT AND REGULATORY FRAMEWORK

3.1 Policy, Guidelines, and Strategy

3.1.1 State Planning Policy

Queensland's State Planning Policy (SPP)[2] expresses the State's interests in land use planning and development. The SPP notes that Queensland's largest source of GHG emissions comes from energy generation and that planning to enable the development of renewable energy will play a key role in reducing emissions.

3.1.2 Energy from Waste Policy 2021 and Energy from Waste Guideline 2021

The Energy from Waste Policy[3] and Energy from Waste Guideline[4] provides guidance for establishing EfW facilities in Queensland. They outline the technical, environmental, regulatory, and social or community outcomes that proponents of EfW facilities are expected to achieve. These include demonstrating the operational performance of proposed facilities, engaging appropriately with potentially affected communities and being good neighbours, using only residual waste for energy recovery, and achieving high levels of energy recovery and environmental protection.

The Policy considers that waste combustion with energy recovery is preferable to landfill gas capture and combustion, as the latter relies on the continued disposal and decomposition of organic material in landfills.

The Policy applies the Precautionary Principle and highlights the importance of siting EfW facilities in locations that reduce potential impacts and unintended consequences. EfW facilities cannot be located within or near sensitive land uses in the urban footprint such as (but not limited to) residential, aged care or childcare facilities.

Three guiding principles outline where development of EfW facilities would be supported, namely where:

- The proposed facility is consistent with the intended or planned development for the proposed location
- Situated away from current and future sensitive land uses
- Economic benefits can be realised through colocation with resource recovery industries in precincts supported by existing or planned infrastructure

3.1.3 Waste Management & Resource Recovery Strategy 2019 – 2022 (Qld)

Queensland's current Waste Management and Resource Recovery Strategy 2019 - 2022, underpinned by a waste disposal levy, provides the strategic framework for Queensland to become a zero-waste society, where waste is avoided, reused, and recycled to the greatest possible extent.

It provides the framework to help deliver coordinated, long-term, and sustained growth for the recycling and resource recovery sector while reducing the amount of waste produced and ultimately disposed of, by promoting more sustainable waste management practices for business, industry, and households. These practices will also contribute to achieving the environmental vision, goals and targets identified in The Queensland Plan.

The Queensland Government is currently seeking submissions on its Waste Reduction and Recycling Plan 2025-2028.

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[2] https://dsdmipprd.blob.core.windows.net/general/spp-july-2017.pdf

[3] https://www.qld.gov.au/__data/assets/pdf_file/0020/118433/energy-from-waste-policy.pdf

[4] https://www.qld.gov.au/__data/assets/pdf_file/0018/227241/waste-strategy-guideline-energy-from-waste.pdf

3.1.4 The Bromelton State Development Area (SDA) Scheme

In 2008 the Coordinator-General of Queensland declared the Bromelton State Development Area (SDA) (Figure 1) in accordance with the *State Development and Public Works Organisation Act 1971* (SDPWO Act). The Bromelton SDA comprises an area of approximately 15,610 ha of land located in the Scenic Rim Regional Council local government area, approximately 6 km west of the town of Beaudesert

The purpose of the SDA is to promote and facilitate economic development in Queensland, and more specifically to support the growing demand for medium to large scale industries and difficult to locate industries. The Bromelton SDA Development Scheme (Development Scheme') was prepared, outlining a development assessment framework and processes for making, assessing, and deciding SDA applications. Section 2.5 of the SDA Development Scheme sets out SDA Wide assessment criteria. This includes Section 2.5.10 which seeks to ensure that Development minimises its emission of greenhouse gases.

The SDA is divided into six land use precincts and one sub-precinct to ensure that difficult-to-locate industries are appropriately located and buffered by other industrial and rural land uses.

Industries currently established in the Bromelton SDA include:

- Beaudesert Central Waste Management Facility – Scenic Rim Regional Council waste transfer station
- GELITA Australia Pty Ltd – gelatine manufacturer
- A.J. Bush and Son's (Manufactures) Pty Ltd – protein meal and tallow rendering, and biogas production for electricity generation
- SCT Logistics – a $30 million intermodal rail freight facility and warehouses
- Bromelton Quarry – supplier of blue rock
- The Neilsen Group quarry – general quarry and gravel products
- Quickcell Technology Products Pty Ltd – manufacturer of prestressed and precast concrete products.

The proposed Project constitutes a Material Change of Use for Special Industry and is assessable development under the Development Scheme. The SDA application will be assessed against the following parts of the Development Scheme to the extent relevant:

- Strategic vision for the Bromelton SDA
- Overall objectives for development in the Bromelton SDA
- Preferred development intent for the applicable development precinct.
- SDA wide assessment criteria, including:
  - Natural hazards – flooding
  - Natural hazards – other
  - Climate change
  - Other government matters
  - Engineering standards.

3.1.5 Environmentally Relevant Activities (ERA) Guidelines

Environmentally relevant activities (ERAs) are prescribed activities with the potential to release emissions which can impact on the environment and surrounding land uses. The Project will require assessment by the Department of Environment and Science. A development application for a ERA is also an application for an environmental authority (EA), according to s 115 (2) of the EP Act.

The following ERAs will be conducted as part of the Project:

- ERA 14 Electricity generation
- ERA 54 Mechanical waste reprocessing
- ERA 61 Thermal waste reprocessing and treatment.

3.2 International Agreements

3.2.1 Paris Agreement

The Australian Government signed the legally binding Paris Agreement[5] to take actions to keep global warming to 'well below' 2°C and strive to limit warming to 1.5°C. The current Australian target (Nationally Determined Contribution) is to reduce emissions by 43% below 2005 levels by 2030, including LULUCF and using Global Warming Potential (GWP) values from the IPCC's Fifth Assessment Report (AR5). The intention is to have net zero GHG emissions by 2050.

3.2.2 Global Methane Pledge

The Australian Government has signed the Global Methane Pledge[6] to reduce Australia's methane emissions by at least 30% below 2020 levels by 2030.

3.3 Legislation

3.3.1 *Climate Change Act* 2022 (Cwlth)

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.

3.3.2 *Climate Change (Consequential Amendments) Act* 2022 (Cwlth)

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*.

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[5] https://unfccc.int/process-and-meetings/the-paris-agreement

[6] https://www.globalmethanepledge.org/

3.3.3 *National Greenhouse and Energy Reporting Act* 2007 (Cwlth)

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) 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 3). 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 another 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.

Table 3 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 1,062,303 t CO_2e of Scope 1 emissions and 50,310 t CO_2e of Scope 2 emissions in the 2021 - 2022 NGER reporting period. It had projected total Scope 1 and Scope 2 emissions of 1,212,000 t CO_2e in 2022[7], approximately 100,000 t CO_2e more than actual.

3.3.4 *Safeguard Mechanism (Crediting) Amendment Act* 2023 (Cwlth)

The Safeguard Mechanism provides a framework for Australia's largest emitters to measure, report and manage their emissions. It does this by requiring large facilities, whose net emissions exceed the Safeguard threshold of 100,000 t CO_2e per year, to keep their emissions at or below emissions baselines set by the Clean Energy Regulator.

A sectoral approach has been adopted for the electricity generation sector as it behaves more like a single entity, where the energy produced is centrally coordinated to meet demand in real-time. A sectoral baseline of 198 million t CO_2e will apply collectively to grid-connected generators unless this baseline is exceeded. Emissions reduction will be required if the sectoral baseline is exceeded.

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

3.3.5 *Environmental Protection Act* 1994 (Qld)

The *Environmental Protection Act 1994* (EP Act)[8] seeks to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.

The EP Act does not explicitly regulate the emission of GHG, other than with reference to the storage of GHG regulated under the *Greenhouse Gas Storage Act 2009*. However:

- Regarding air emissions, a contaminant can be a gas (11(a))
- Waste is defined in a way which may include CO_2 or CH_4, i.e., "Waste includes any thing, other than an end of waste resource, that is left over, or an unwanted by-product, from an industrial, commercial, domestic, or other activity" (13(1)(a)), and "Waste can be a gas …" (13(2)).
- GHG emissions may constitute an environmental harm (14(1)(2)), i.e., "… any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value …" "whether the harm is a direct or indirect result of the activity; or whether the harm results from the activity alone or from the combined effects of the activity and other activities or factors".

3.3.6 Environmental Protection Regulation 2019 (Qld)

The Environmental Protection Regulation 2019 prescribes the detail for processes contained in the EP Act.

3.3.7 Environmental Protection (Air) Policy 2019 (Qld)

The purpose of Environmental Protection (Air) Policy 2019 is to achieve the object of the EP Act in relation to the air environment by:

- Identifying environmental values to be enhanced or protected
- Stating indicators and air quality objectives for enhancing or protecting the environmental values
- Providing a framework for making consistent, equitable and informed decisions about the air environment.

3.3.8 DETSI Guideline Greenhouse Gas Emissions

The DETSI *Guideline Greenhouse gas emissions ESR/2024/6819* (GHG Guideline) describes requirements under the EP Act and provides information about how to meet these requirements in relation to GHG emissions for new and amended environmental authority (EA) applications.

The GHG Guideline sets out the minimum expectations for GHG emissions information to be provided with applications and supports rigorous, defensible, and transparent decision making in relation to these emissions. The required information includes:

- An inventory of expected GHG emissions resulting from the Project including the stage at which the emissions will occur and a breakdown by source
- An estimate of projected Scope 1 and Scope 2 CO_2-e emissions over the life of Project (LOP), including an unabated and abated emissions scenario

[8] https://www.legislation.qld.gov.au/view/pdf/inforce/current/act-1994-062

- An estimate of annual Scope 3 emissions and total Scope 3 emissions over the LOP
- A description of the method used for estimating GHG emissions
- A GHG abatement (decarbonisation) plan in alignment with recommendations made in Appendix A of the GHG Guideline
- A description of risks and the likely magnitude of impacts on environmental values resulting from the Project, including qualitatively describing the impacts of climate change on environmental values and the likely magnitude of such impacts based on the relative scale of the Project's net GHG emissions.

The GHG Guideline identifies expected GHG emission rates for activities as:

- **Low emitters** if expected annual GHG emissions are less than 25,000 t CO_2-e.
- **Medium to high emitters** if expected annual GHG emissions are 25,000 t CO_2-e or more at any time during the LOP.

3.4 Emission targets

3.4.1 Queensland

Queensland has committed to achieving net zero emissions by 2050, with an interim target to reduce annual emissions to 138.1 Mt CO2e by 2030, i.e., a 30% reduction below 2005 levels (197.3 Mt CO_2e). Queensland's total emissions were 159.2 Mt CO_2e in 2020[9], with waste contributing 1.72%, stationary and industrial energy 15.81%, and public electricity 31.06%.

3.4.2 Cleanaway

Cleanaway has aligned its emissions reduction strategy[10,11] to the 2015 Paris Agreement and the Global Methane Pledge, recognising the role of the waste and resource recovery sector in both generating and reducing CH_4 and CO_2 emissions. Approximately 80% of Cleanaway's GHG emissions to date is CH_4 generated by waste decomposition in active and closed landfills, and approximately 20% is CO_2 from combustion of diesel associated with fleet operation, natural gas burnt at facilities, and electricity purchased from the grid.

Cleanaway has established science based GHG emissions reduction targets (Table 4) and has reported a reduction by 9% from financial year (FY) 2022, adjusted for the acquisition of assets during the reporting period[12].

Table 4 Cleanaway's emissions reduction targets

Greenhouse Gas	2030	2050
CO_2	↓34%	↓57%
CH_4	↓43%	↓100%

9 https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020/state-and-territory-greenhouse-gas-inventories-2020-emissions

10 https://cleanaway2stor.blob.core.windows.net/cleanaway2-blob-container/2021/09/Sustainability-Report-2021-2266810.pdf

11 https://www.cleanaway.com.au/sustainable-future/methane-pledge/

12 https://www.cleanaway.com.au/sustainability-report/

4. METHOD

4.1 Scope 1, Scope 2, and Scope 3 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 and stationary plant owned by Cleanaway
- Combustion of waste material to produce electricity
- Land clearing for construction of the proposed facility.

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.

Emissions are categorised according to Scope 3 Standard. The Scope 3 emissions categories relevant to the Project include:

- Category 1: Purchased goods and services
- Category 2: Capital goods
- Category 3: Fuel and energy related activities
- Category 4: Upstream transportation and distribution
- Category 7: Employee commuting

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

4.2 Limitations and assumptions

This desktop assessment has been conducted using projected activity data provided by Cleanaway (Table 5). Katestone makes no claim as to the accuracy of this data.

4.3 Scenarios

Four scenarios are considered in this assessment:

Base case and overload case: Under nominal operation, the Project is designed to incinerate 760,000 tpa of residual Municipal Solid Waste (MSW) and residual commercial and industrial (C&I) waste streams to produce 668,002 Megawatt hours per year (MWh/y) of electricity (base case, BC). An overload case (OC) is also assessed where the waste throughput and produced electricity are increased by 10% to 836,000 tpa and 731,249 MWh/y, respectively.

A-Double and B-Double: Under nominal operation B-Double trucks are used to bring waste to the site. Cleanaway has also requested an assessment of the GHG emissions should A-Double trucks be used instead, recognising that A-double trucks are not currently permitted on roads to the site.

Diesel and biodiesel: Diesel is normally used as the accelerant for a black start of the combustion chamber. This scenario considers the emissions if biodiesel is used as the accelerant instead of diesel.

Avoided emissions: Avoided emissions are calculated when the process or products of the Project effectively replace a greater number of emissions that would have occurred in the absence of the Project and its products. The avoided emissions scenario has two parts:

- Avoided landfill gas emissions
- Avoided emissions from recyclable or reusable materials recovered after waste incineration and used to replace virgin materials.

4.4 Method for calculation of GHG emissions

4.4.1 Project Scope 1, Scope 2 and Scope 3 emissions

Projected Scope 1, Scope 2, and Scope 3 GHG emissions for the Project during construction and operation have been calculated using the methods and emission factors described in the following resources:

- The National Greenhouse Accounts Factors 2025 (DCCEEW, 2025)
- National Greenhouse and Energy Reporting (Measurement) Determination 2008, (Compilation 19) (NGER Determination)
- Australia's emissions projections 2025
- The Greenhouse Gas Protocol (WRI/WBCSD, 2004)
- Electricity sector emissions and generation data 2021-22 (Clean Energy Regulator, 2023).
- Australian Transport Assessment and Planning (ATAP, 2020) Guidelines.

Katestone employs Method 1 as outlined in the NGER Determination for all emissions calculations as this method is adequate to perform a rigorous GHG assessment of the Project. The Method 1 formula for Scope 1 emission sources takes the following form:

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

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 kg CO_2-e/GJ), and the 1000 returns the correct units for the emissions.

CO_2 emissions from waste combustion are calculated using Method 1 (section 5.53) of Part 5.5 (Waste incineration) in the NGER Determination, applying the projected waste fractions and weighted emissions factors in Appendix A and Appendix B, and the following formula:

$$\boldsymbol{Ei} = Q \times \boldsymbol{CCi} \times \boldsymbol{FCCi} \times \boldsymbol{OFi} \times \mathbf{3.664}$$

Nitrous oxide (N_2O) and CH_4 emissions (as t/CO_2-e) from waste combustion are calculated using Method 1 of Part 2.2 (Emissions released from the combustion of solid fuels) in the NGER Determination (Division 2.2.2). Default emissions factors are applied (Table 7).

where Q is the quantity of the waste type, $\boldsymbol{CCi}$ is the carbon content of the waste type, $\boldsymbol{FCCi}$ is the proportion of carbon in the waste type that is of fossil origin, and $\boldsymbol{OFi}$ is the oxidation factor for the waste type. Waste fractions and weighted values for calculation of emissions from waste combustion are provided in Appendix B.

Cleanaway is designing the plant to be able to use urea or ammonia as a reducing agent in the SNCR NOx abatement system. Emissions from the thermal decomposition of urea in this process have been included in the inventory as a worst-case assumption. CO_2 emissions from urea decomposition in the SNCR process are estimated at 0.733 tonnes of CO_2-e per tonne of urea, assuming complete conversion of urea carbon to CO_2-e (IPCC, 2006). N_2O emissions are estimated assuming 10% conversion from NOx to N_2O.

The activity data for Scope 1 and Scope 2 emissions calculations for the BC and OC are provided in Table 5. Table 6 summarises the quantity of consumables used during the operations phase and the quantity of materials used during the construction phase that have Scope 3 emissions associated with them.

Table 5 Summary of activity data for estimation of Scope 1 and Scope 2 emissions

Scope	Activity	Units	Construction Phase (39 months)	Operation Phase BC (annual)	Operation Phase OC (annual)
Scope 1	Diesel combustion (transport)	kL/annum	0	1,508	1,655
	Diesel consumption (stationary)	kL/annum	2,200	1,417	1,449
	Combustion of C&I waste	tpa	0	228,000	250,800
	Combustion of MSW waste	tpa	0	532,000	585,200
	Urea decomposition (40% aqueous solution)	tpa	0	3,848	4,232
Scope 2	Electricity use (Queensland grid)	MWh	0	2,034	2,138

During construction, 4,800 kL of diesel is assumed to be consumed over the 39-month period to bring materials to site (Scope 3). During operation:

- Waste deliveries to site assume B-Double Side tippers (33 t), Rear Eject Semi Trailers (20 t) and Compactor trucks (9 t) travel 70 km (one way), 35,529 – 35,916 times (BC - OC) a year (Scope 1)
- Materials delivered from site assume B-Doubles and semi-trailers travel 70 km (one way), 6,213 – 6542 times (BC – OC) a year (Scope 1)

- Consumables delivered to site assume Semi trailers and tanker trucks travel 142 -170 km (return), 503 – 553 times (BC – OC) a year (Scope 3).

Fuel consumption for each vehicle was derived using the ATAP uninterrupted fuel consumption model, with coefficients and base fuel values specified for a road alignment of RF = 0 and curvature of 20°/km (ATAP,2020). The model accounts for gross vehicle mass (tare weight plus payload) and incorporates parameters for speed, road roughness (IRI), curvature, and rise and fall to represent uninterrupted flow conditions at an assumed 80 km/h. The respective fuel consumption of each vehicle was multiped by the distance and number of movements and the respective emissions factor (Table 7).

During construction an assumed 800 employees travel an average return distance of 140 km, 5 days a week for 39 months. This is a maximum figure likely to be reached in year 2 and/or year 3, with actual numbers ramping up to and down from this figure. It is applied to provide a conservative estimate.

During operation an assumed 54 employees each travel an average return distance of 140 km, five days per week, over 333 days per year. All employee vehicles were assumed to be passenger vehicles, averaging 11.1 L/100 km, with 79.9% petrol based on the Australian Bureau of Statistics survey of motor vehicle use (2020) and the remainder assumed to be diesel. The fuel consumption per km and distance was multiped by the number of employees to give total consumed fuel values. Emission factors from Schedule 1 of the NGER (Measurement) Determination were then applied to the estimated total fuel consumption to determine emissions (Table 7).

Table 6 Summary of activity data for estimation of Scope 3 GHG emissions

Component	Units	Construction Phase (39 months)	BC Operation Phase (annual)	OC Operation Phase (annual)
Diesel (materials transport to site)	kL	4,800	90	95
Concrete	m^3	33,800	0	0
Gravel (aggregate)		62,398	0	0
Electricity (Queensland)				
Steel	t	3,750	0	0
Quicklime		0	9,176	10,096
Powdered activated carbon		0	408	416
Cement (for APCr stabilisation)		0	14,657	16,123
Urea (40% aqueous solution)		0	3,848	4,232
Ferrous metals (2025 – 2050)		0	11,980 – 16,640	13,175 – 18,300

Non-ferrous metals (2025 – 2050)		0	5,890 – 6,670	6,480 – 7,340
Bottom ash (2025 – 2050)		0	79,760 – 98,520	87,740 – 108,370
Employee Commuting ~80% unleaded transport and ~20% diesel transport	kL	9,697	279	279
Employee commuting (unleaded transport)	kL	7,748	223	223
Employee commuting (Diesel transport)	kL	1,949	56	56

Waste composition within the two streams is derived from a Brisbane waste audit conducted in May/June and September of 2023 (Appendix A1). Cleanaway projects that the composition will change over time, and this is accounted for in the assessment. Urea, activated carbon, and quicklime are used in pollution control

Table 7 Summary of energy content and Scope 1, Scope 2, and Scope 3 emissions factors of relevance to the Project

Emission source	Energy content	Units	Emission factor				Units
			Scope 1	Scope 2	Scope 3	Scope 3 avoided	
Diesel (transport)	38.6	GJ/kL	70.4	-	17.3	-	kg CO_2-e/GJ[1]
Diesel (stationary)	38.6	GJ/kL	70.2	-	17.3	-	kg CO_2-e/GJ[1]
Biodiesel (stationary)	34.6	GJ/kL	0.28	-	-	-	kg CO_2-e/GJ[1]
Concrete	-	-	-	-	393		kgCO_2-e/m[2, 3]
Electricity (Queensland)	0.0036	GJ/kWh	-	0.17 – 0.23	0.06	-	kg CO_2-e/kWh[1]
Waste incineration – CO_2 fraction – MSW:C&I 70:30 (2030-2050)	-	-	486.17	-	-	-	kg CO_2-e/t[4]

Waste incineration – CO_2 fraction – MSW:C&I 70:30 (2050 and beyond)	-	-	389.87	-	-	-	kg CO_2-e/t[5]
Organic waste/Fossil waste combustion – N_2O and NH_4 fraction only - MSW	12.2	GJ/t	1.8	-	-	-	kg CO_2-e/GJ[5]
Organic waste/Fossil waste combustion – N_2O and NH_4 fraction only – C&I	15.7	GJ/t	1.8	-	-	-	kg CO_2-e/GJ[5]
Landfill	-	-	-	-	-	1.62	t CO_2-e/t[5]
Ferrous metal recovery	-	-	-	-	-	1,700	kg CO_2-e/t[2]
Non-ferrous metal recovery	-	-	-	-	-	17,000	kg CO_2-e/t[2]
Bottom ash	-	-	-	-	-	105	kg CO_2-e/t[6]
Aggregate	-	-	-	-	5.67		kg CO_2-e/t[3]
Cement	-	-	-	-	901		kg CO_2-e/t[3]
Steel	-	-	-	-	1,660		kg CO_2-e/t[6]
Urea (100%)	-	-	733	-	1,300	-	kg CO_2-e/t[7,8]
Activated carbon					10,000		kg CO_2-e/t[9,10]
Quicklime	-	-	-		1,050	-	kg CO_2-e/t[11,12]

Sources:

[1]***National Greenhouse and Energy Reporting (Measurement) Determination 2008*****, as amended in July 2025**

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

[3]***The Australian life cycle inventory database initiative, AusLCI 2023 V1.42 and 2025 V1.45*** **- concrete assumed to be 32 Mpa**

[4] **Appendix B, this document**

[5]***National Greenhouse Accounts Factors*** **(DCCEEW 2025d)**

[6] **Chang *et al.*, 2015, Julcour *et al.*, 2025**

[7] **https://www.massey.ac.nz/~flrc/workshops/11/Manuscripts/Ledgard_2011.pdf**

[8] **https://pubmed.ncbi.nlm.nih.gov/40086355/**

[9] https://apps.carboncloud.com/climatehub/product-reports/id/2249085474186
[10] https://upcommons.upc.edu/entities/publication/424e46a8-73f1-40ea-9f6f-9ad9db9f7d89
[11] https://cement.org.au/wp-content/uploads/2023/06/Decarbonisastion_Pathways_Australian_Lime_Sector.pdf
[12] https://adelaidebrighton.com.au/wp-content/uploads/sites/7/2023/04/Adbri-EPD-Lime.pdf

4.4.2 Avoided landfill gas emissions

Methane is generated from anaerobic decay of organic wastes in landfills and forms ~50% of the gas produced. Approximately 42% of landfill gas (LFG) generated in Australia is captured in LFG-managed landfills, with ~58% released to the atmosphere[13]. Queensland captures ~31% of its LFG[14]. 75% of the captured gas is combusted for electricity generation and 25% is flared, converting the methane to CO_2.

Avoided emissions conservatively consider the LFG produced from organic matter that is not captured and that would naturally diffuse into the atmosphere over time (assumed as 25% for LFG-managed landfills), and the result if the same amount of organic matter was converted to CO_2 through the Project (combustion).

Landfill gas emissions were estimated using a weighted emission factor derived from the 2030 to 2050 waste composition in Table B2 and the relevant waste emission factors in contained in Table 15 of the NGA Account factors (DCCEEW 2025d). This resulted in a weighted landfill emission factor of 1.62 t CO_2-e/t waste. Applying this emission factor to the total waste diverted from landfill under the BC of 760,000 tpa results in 1,231,200 t CO_2-e/y.

The scenario applies a conservative capture rate of 75% of landfill gas with the remaining 25% assumed to be released to the atmosphere. Avoided emissions were calculated by comparing the non-combusted release of landfill gas (CO_2-e) with the CO_2-e produced by combustion of the same proportion of organic material.

Landfill gas was assumed t comprise 50% CH_4 and 50% CO_2 by volume (USEPA, 2025). Under the ideal gas law, this was treated as a 1:1 molar ratio of CH_4 to CO_2. Converting this to a mass basis using the respective molecular weights of the gases gives a mass ratio of 2.744, meaning each tonne of CH_4 in the gas stream is associated with 2.744 t CO_2. Therefore, for each tonne of CH_4 in the untreated gas stream, emissions comprise 28 t CO_2-e from CH_4 and 2.744 t CO_2-e from the associated CO_2. Methane mass is then derived by dividing the non-combusted landfill gas emissions by 30.744 t CO_2-e/t CH_4 and the emission share is derived by multiplying the CH_4 mass by its GWP of 28.

CH_4 was assumed to fully oxidise to CO_2, with no other GHG emission formation or leakage. As one mole of CH_4 produces one mole of CO_2, the CO_2 generated from methane combustion was calculated using the same molecular weight ratio.

4.4.3 Recovered recyclable materials

The market for recyclable metals in Queensland is robust and active[15], and the industry is concentrated around South East Queensland. Conversely, the market for bottom ash is emerging, and includes low value options such as road base[16],[17], and higher value options such as a replacement for cement binder and as a feedstock for minerals harvesting[18]. A value of 105 kg CO_2-e is applied to the bottom ash (Table 7); however, an avoided emissions factor of 800 kg CO_2-e per tonne of cement displaced, with a sensitivity range of 700 – 900 kg CO_2-e per tonne of cement displaced, is justifiable (e.g., Capucha *et al*., 2025).

[13] https://unfccc.int/documents/638240
[14] https://www.energy.gov.au/publications/australian-energy-update-2024
[15] E.g., https://www.scottmetals.com.au/recycling.php
[16] https://wastemanagementreview.com.au/blue-phoenixs-first-year-triumph/
[17] https://hazmatmag.com/2026/05/06/the-value-of-incinerator-bottom-ash/
[18] https://cleancoqueensland.com.au/from-legacy-to-innovation-exploring-new-uses-for-swanbank-coal-ash/

Avoided Scope 3 emissions from recycled materials are calculated by multiplying the projected mass of recyclable materials used by the emissions that would have been released in producing the virgin equivalent (Table 6). A one for one replacement of emissions from production of virgin base materials is assumed.

5. GHG EMISSIONS RESULTS

5.1 Total Scope 1 and Scope 2 emissions

Table 8 presents projected Scope 1 and Scope 2 GHG emissions (t CO_2-e) for the construction phase and operational phase of the Project. Emissions during the construction phase are the cumulative emissions across the full 39-month construction period. Operational emissions are reported on a per annum basis for both the base case and the overload case. Operational emissions are presented for two operational periods that reflect the changing emission factors for waste entering the facility.

Table 8 Scope 1 and Scope 2 emissions (t CO_2-e) reported for the construction phase, the base case, and the overload case

Base Case				
Emissions Scope	**Emission source**	**Construction (39 months)**	**Operation (annual)**	
			2030-2050	**2050 onwards**
Scope 1	Diesel usage (transport)	0	4,099	4,099
	Diesel usage (stationary - machinery and generator)	5,961	890	890
	Diesel Usage (stationary - EfW boilers and plant)	0	2,951	2,951
	Waste combustion – CO_2 fraction	0	369,489	296,300
	Waste combustion – N_2O and CH_4 fraction	0	18,126	18,126
	Urea decomposition	0	1,128	1,128
Total Scope 1 (t CO_2-e)		**5,961**	**396,683**	**323,494**
Total Scope 2	Electricity	0	454	468
Total Scope 1 and 2 (t CO_2-e)		**5,961**	**398,046**	**397,137**
Overload Case				
Emissions Scope	**Emission source**	**Construction (39 months)**	**Operation (annual)**	
			2030-2050	**2050 Onwards**
Scope 1	Diesel usage (transport)	0	4,499	4,499
	Diesel usage (stationary - machinery and generator)	5,961	975	975
	Diesel Usage (stationary - EfW boilers and plant)	0	2,951	2,951
	Waste combustion – CO_2 fraction	0	406,438	325,930
	Waste combustion – N_2O and CH_4 fraction	0	19,939	19,939
	Urea decomposition		1,241	1,241

Total Scope 1 ($t\ CO_2$-e)		**5,961**	**436,042**	**355,533**
Total Scope 2	Electricity	0	477	492
Total Scope 1 and 2 ($t\ CO_2$-e)		**5,961**	**436,519**	**356,025**

The emissions from diesel combustion during the construction period are estimated to be 5,961 t CO_2-e. The total annual Scope 1 emissions arising from the two operational periods in the BC are 396,683 and 323,494 t CO_2-e, respectively. In the OC, the total Scope 1 emissions are approximately 10% more in each operational period.

The combustion of the 70:30 MSW:C&I waste stream is projected to emit between 314,426 — 387,615 t CO_2-e annually for the BC across the LOP. Under the OC, the expected annual emissions range between 345,869 — 426,377 t CO_2-e.

Electricity usage is expected to remain constant in both cases and across the operational periods with Scope 2 emissions estimated at ~450 - 500 t CO_2-e annually, depending on the annual EF. The EF used to calculate Scope 2 will reduce over time as the proportion of renewably generated electricity increases and coal fired generators are retired.

5.1.1 Emissions intensity of production

The emissions intensity of the Project is within the range of Queensland's gas generators and less than the coal fired generators (Table 9). Queensland's lowest emitting coal-fired power stations are the Millmerran Power Station and Kogan Creek Power Station with an emissions intensity of 0.82 t CO_2-e/MWh while the highest emitting stations are Callide B at 0.93 t CO_2-e/MWh and Gladstone Power Station at 1.00 t CO_2-e/MWh. Electricity production from CSG or LFG is less emissions intensive but is also less energy efficient than other means of production (Table 9).

Table 9 Relative electricity production capacity (MW) and Scope 1 emissions intensity (t CO_2-e/MWh) for electricity generators connected to the NEM in Queensland (2024-2025) and the proposed Project

Electricity generation fuel (number operating)	Capacity (MW)	Total Scope 1 emissions (Mt CO_2-e)	Emissions intensity (t CO_2-e/MWh)
Black Coal (7)	750 – 1,680	2.90 – 9.40	0.82 – 1.00
Diesel (2)	15 - 414	>0.002	0.70 – 0.72
Gas (6)	385	0.008 – 0.76	0.40 – 0.92
Waste coal mine gas (7)	15 - 64	0.011 – 0.15	0.52 – 0.67
Coal seam gas (6)	3 - 630	0.003 – 0.24	0.22 – 0.59
BERC (BC)	**84.6**	0.40	**0.60**
BERC (OC)	**92.6**	0.44	**0.60**
Landfill gas (13)	1 - 7	0.0002 – 0.005	0.07 – 0.1
NEM data source https://cer.gov.au/markets/reports-and-data/nger-reporting-data-and-registers/electricity-sector-emissions-and-generation-data-2024-25			

5.2 Transport and stationary fuel use scenarios

5.2.1 Transport

The operational emissions in Table 10 account for waste transport under two scenarios: the B-Double only configuration (BD) and the A-Double (AD) configuration. The largest source of emissions from diesel combustion comes from the annual operation of trucks transporting waste to site and moving byproducts off-site, estimated as 4,099 and 4,499 t CO_2-e for the BC and OC scenarios respectively. Diesel combustion by a front loader produces 845 and 930 t CO_2-e BC:OC or 95% of the projected stationary emissions. A Dolly truck will be required to move the trailers onsite in the event that A-Doubles are permitted, emitting an average of 4 t CO_2-e stationary emissions annually.

The total operational emissions for the BC and OC for the AD scenario is estimated to be 13 and 49 t CO_2-e less than the BD scenario (Table 10).

Table 10 Summary of annual projected Scope 1 GHG emissions (t CO_2-e) for B-Double and A-Double options

Emission Source	B-Double Only Configuration (t CO_2-e)		A-Double Configuration (t CO_2-e)	
	BC	OC	BC	OC
Diesel usage (transport)	4,099	4,499	4,086	4,450
Diesel usage (stationary - machinery and generator)	890	975	894	979
Total Scope 1 emissions (transport and stationary)	**4,989**	**5,474**	**4,980**	**5,429**

5.2.2 Boilers and biodiesel

The substitution of diesel with biodiesel for black starting the boilers would result in 2,940 t CO_2-e fewer Scope 1 emissions.

Table 11 Comparison of emissions from diesel combustion and biodiesel combustion for boiler cold start

Diesel	Biodiesel	Net emissions saving
2,951 t CO_2-e	11 t CO_2-e	2,940 t CO_2-e

5.3 Scope 3 emissions

The Scope 3 emissions inventory for the Project is provided in Table 12. Employee commuting represents the largest share of the Scope 3 inventory during the construction phase, estimated as 23,215 t CO_2-e. The embodied emissions from concrete and steel manufacturing represent the second and third largest share of Scope 3 emissions, estimated as 13,280 t CO_2-e and 6,225 t CO_2-e, respectively, during this period.

Table 12 Summary of projected Scope 3 GHG emissions (t CO_2-e) per year for the Construction phase (39 months) and the Operations phase (BC)

GHG Protocol Category	Item	Construction (39 months)	Average Annual Operation (t CO_2-e)		Operation Category Totals (t CO_2-e)	
			BC	OC	BC	OC
1	Quicklime	-	9,635	10,601	28,919	31,485
	Activated Carbon	-	4,080	4,160		
	Urea	-	2,001	2,201		
	Cement	-	13,203	14,523		
2	Steel	6,225	0	0	0	0
	Aggregate (gravel)	519	0	0		
	Concrete	13,280	0	0		
3	Diesel	1,469	1,954	2,073	2,016	2,138
	Electricity	0	62	65		
4	Trucking of freight	13,046	245	258	245	258
7	Employee commute	23,215	279	279	279	279
Total		**57,754**	**31,459**	**34,160**	**31,459**	**34,160**

Upstream manufacturing of goods is the largest contributing category of Scope 3 emissions during the operational phase, estimated as 28,919 t CO_2-e and 31,485 t CO_2-e in the BC and OC, respectively (Table 12). The upstream production of energy related activities is the second largest contributing operation phase source, estimated as 2,016 t CO_2-e and 2,138 t CO_2-e in the BC and OC, respectively. The Scope 3 emissions arising from the use of A-Doubles instead of B-Doubles (Table 10) are not expected to make a material difference to the Scope 3 inventory. Employee commuting is the third largest contributor of Scope 3 emissions during the operational phase, estimated as 279 t CO_2-e in both cases.

5.4 Avoided emissions

The quantity of fugitive methane released to the atmosphere from LFG-managed landfill that would be avoided by the combustion of organic waste is between 252,800 t CO_2-e and 278,200 t CO_2-e (Table 13). In the BC, recyclable materials recovered from the IBA may provide more than 120,000 t CO_2-e of avoided emissions per year (Table 13) if replacing the production of virgin materials in a one for one relationship.

Table 13 Summary of emissions avoided per year (t CO_2-e/y) due to operation of the Project

Emission source	Details	BC	OC
Landfill gas	Avoided methane	252,860	278,146
Recovered materials	Avoided emissions from recovered recyclable materials	121,653 – 143,107	133,818 – 157,417

Non-ferrous metals are likely to provide the greatest avoided emissions at just over 100,000 t CO_2-e/y from recovered recyclable materials (Table 14). Bottom ash provides the lowest avoided emissions if used as construction aggregate, but higher value options are expected to be technically and commercially feasible by 2030 (e.g., Chang *et al*., 2015, Julcour *et al*., 2025).

Table 14 Summary of BC avoided emissions (t CO_2-e) from recyclable materials

Recoverable materials	2025	2050
	(t CO_2-e/y)	
Ferrous metals	20,366	28,288
Non-ferrous metals	100,130	113,390
Bottom ash	1,157	1,429
Avoided emissions from virgin material	**121,653**	**143,107**

6. GREENHOUSE GAS ABATEMENT PLAN

6.1 Introduction

This GHG Abatement and Mitigation Plan addresses the requirements of the GHG Guideline in line with Queensland's emission reduction targets, supporting Cleanaway in their application for approval. The Project is considered a medium to high emitter, with Scope 1 GHG emissions ranging from ~350,000 — 440,000 t CO_2-e per year (Table 7) and is, therefore, required to identify emissions mitigation and management practices and provide a GHG abatement plan.

The GHG Abatement and Mitigation Plan is framed on the GHG Guidelines abatement hierarchy and applies management controls to Scope 1 and Scope 3 emissions (Table 15). The risks and opportunities associated with each management control are identified (Table 15).

The facility's emissions will be

6.2 GHG Abatement and Mitigation Plan

6.2.1 Avoid

Avoided emissions for the purpose of this assessment are assumed to be Scope 3 emissions that are avoided in the economy as a consequence of the Project's operation (section 5.4).

Cleanaway recognises that combustion of waste releases GHG emissions but notes that a) the waste is residual, i.e., material which is not technically, environmentally, or economically practicable to reuse or recycle, b) CO_2 emissions have a lower GWP than CH_4 produced in landfills, and c) combustion of biogenic materials are considered by the IPCC to be carbon neutral.

Cleanaway currently harvests and combusts methane at landfills under its control but recognises that the Energy from Waste policy (section 3.1.2) considers that waste combustion with energy recovery is preferable to future landfill gas capture and combustion.

The Project will compliment Queensland's recycling and composting options that divert organic material from landfill, thereby avoiding fugitive CH_4 emissions.

6.2.2 Reduce

The production of electricity through waste combustion results in significantly lower emissions intensity per MWh generated when compared to electricity generated by coal combustion and is comparable to the emissions intensity of gas fired electricity generation.

Cleanaway is proposing an efficient concept for the recovery of energy and other resources from residual waste, incorporating a combustion system and boiler driving a steam turbine, with an estimated overall electricity generation efficiency within the range expected for modern EfW facilities as defined in the BREF for Waste Incineration (Neuwahl et. al., 2019). The system is designed to handle waste within a relatively wide range of calorific values, even including higher moisture waste streams, such as FOGO processing residuals, maintaining effective energy recovery despite variable compositions.

Compared to the alternative waste to energy technologies considered (fluidised bed combustion, gasification (Thermal /Plasma), and two-stage combustion) moving grate combustion technology is considered likely to produce the lowest GHG emissions per unit of energy output due to:

- Highest operational availability (i.e., lowest start/stop occurrences and highest normal operating hours per year) thus avoiding lost energy recovery associated with unavailability and avoiding the use of auxiliary (fossil) fuel during start-ups and shutdowns

- Highest energy recovery efficiency due to avoidance of feed pretreatment, e.g., pre-sorting and shredding, as a prerequisite for preparing the feedstock for processing.

EfW plants that recover only electrical energy from waste combustion by a steam turbine have a relatively low electrical efficiency, i.e., ~26-30% net relative to fossil fuel fired electricity generators. The co-location of other industries in the Bromelton SDA could provide a market for heating or cooling that could be supplied by the Project, thus increasing the overall energy efficiency of the Project, and concurrently reducing overall emissions intensity.

Cleanaway will continue to investigate technological and process options to further lower the emissions intensity of production and production efficiency and will integrate these into the design and procurement process if feasible prior to Project commissioning. This includes machine learning and optimised combustion and reagent (urea) control to minimise the formation of N_2O during SNCR.

6.2.3 Substitute

Cleanaway recognises that its greatest option for GHG emissions reduction through substitution is in its Scope 3 emissions during construction and operation.

Approximately 40% of the Scope 3 emissions during construction will 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. Low emissions cement and concrete, and construction steel, is increasingly available in Australia in commercial quantities for infrastructure construction and Cleanaway will contractually require its use for construction of the Project where economically feasible.

Similarly, Cleanaway will seek and procure lower emissions options for the urea and quicklime that are used during operation.

The Project will be a supplier of recyclable metals (post combustion) that were not separated prior to transport to the Project, and incinerator bottom ash aggregate (IBAA) to the market to be used as a substitute for the production of virgin materials. This will account for approximately 100,000 t CO_2-e of downstream Scope 3 emissions per year.

Cleanaway is considering the substitution of diesel with biodiesel for use during startup processes. This would reduce Scope 1 emissions by approximately 3,000 t CO_2-e/y. However, biodiesel is not currently produced in commercial quantities in Australia and supply is limited. It is possible that decarbonisation of the transport and mining industries will drive demand, production, and supply into the future, but this is not guaranteed. Boutique local supply may be possible and would be considered if economically feasible.

6.2.4 Offset

The Project will not be required to progressively reduce its emissions under the Safeguard Mechanism or offset its emissions through the purchase and surrender Australian Carbon Credit Units (ACCU) as it is covered under the electricity generation sector’s threshold.

Cleanaway will continue to scope for technically and commercially feasible carbon capture utilisation and storage (CCUS) options and will seek to invest in appropriate technology or processes if they prove feasible and cost-effective. However, industrial scale CCUS is not currently commercially feasible in Australia and is unlikely to be so for the half-life of the Project (Table 15).

Cleanaway considers that the Project contributes to the avoidance of emissions being produced in the wider Queensland economy and that this may also be considered as offsetting.

Table 15 **Assessment of risks and opportunities associated with proposed management controls**

Priority	Mitigation measure	Timeframe	Risks to successful mitigation	Opportunities from successful mitigation	Industry Standard	Annual Emissions reduction estimate (t CO_2-e)
Avoid	Avoid methane emissions due to the decomposition of organic waste in landfill	Immediate	Waste supply exceeds demand leading to methane release from anerobic decomposition Waste supply does not meet demand leading to inability to produce electricity at full capacity	Project is a key contributor to mitigation of waste and methane emissions and a provider of base load grid electricity and other services, supporting the increased contribution from variable renewable energy generation in Queensland	Emerging – Best	252,000 – 280,000 (BC – OC, GWP 100 year)
	Cleanaway avoids landfill gas emissions from its landfill sites	Immediate	High landfill gas capture rate leads to economic return for Cleanaway	Landfill gas capture supports emission reductions in QLD	Best	
Reduce	Installation of high efficiency turbines	Immediate	High capital cost leads to procurement of less efficient turbine and higher emission intensity of production	Installation of high efficiency turbine provides best return on investment through optimal electricity generation and reduced emission intensity of production	Best	TBD

	Optimise urea dosing for emissions control	Immediate	Sub optimal dosing leads to excess production of N_2O through direct decomposition or ammonia slip	Advanced process control systems can optimise NO_x destruction while keeping temperatures above the range where N_2O formation is favoured. Real-time Continuous Emissions Monitoring Systems (CEMS) allow operators to tune reagent dosing dynamically.	Best	TBD
Substitute	Cleanaway procures low emissions concrete, cement, and steel for construction	Immediate	Commercial quantities of low emissions construction material are not available at an economically viable cost	Commercial supply of low emissions construction materials stimulated by demand	Best	
	Cleanaway procures low emissions operational materials	TBD	Uncertainty regarding availability of low emissions options	Commercial supply of low emissions operational materials stimulated by demand	Emerging	
	Cleanaway provides recyclable metals and aggregate for replacement of virgin materials	Immediate	Waste separation removes majority of recyclable metals prior to combustion reducing financial return to Cleanaway	Availability of bottom ash exceeds requirement for aggregate to produce concrete Demand for low emissions concrete and recyclable construction materials	Best	

			Poor cost-effectiveness of waste separation increases availability of recyclable materials in residual waste	stimulates demand for bottom ash as aggregate		
	Cleanaway substitutes biodiesel for diesel used in operations	TBD	Supply is currently limited in Australia	Renewable energy source reducing GHG emissions and improving air quality Financial benefits due to reducing dependence on foreign oil reserves	Emerging	2,940
Offset	Feasibility assessment of CCUS technologies and processes	Ongoing	Current economic feasibility is inadequate to cost effectively sequester GHG emission from the Project	CCUS provide a bridge to renewable energy future by reducing emissions from existing infrastructure	Future	TBD
	Investment in CCUS	As practicable	Investment in ineffective CCUS technology or process may result in stranded asset and regulatory liability	Economic opportunities by creating new jobs and stimulating economic growth Reducing energy costs by using fossil fuels more effectively	Future	TBD

7. RISKS AND LIKELY MAGNITUDE OF IMPACTS ON ENVIRONMENTAL VALUES

The increasing concentration of greenhouse gases in the atmosphere, primarily due to the combustion of fossil fuels and deforestation, is leading to the warming of oceans, land, and atmosphere. This warming increases the heat energy available in the climate system leading to changed weather patterns including more frequent and intense extreme weather events.

Key climate risks for the Southeast Queensland region from increased global warming include (Department of Energy and Climate, 2024):

- increased frequency of hot days (>35 ºC) and very hot days (>40 ºC)
- changes in fire frequency and increased likeliness of more extreme fires
- variable rainfall with likelihood of a decreased average rainfall
- increased evapotranspiration rates and drying of soil and vegetation
- increased frequency and duration of drought
- less frequent but more intense tropical cyclones
- warmer and more acidic ocean
- rising sea levels and more frequent coastal and open ocean extreme events

Queensland and Australia have legally committed to achieving net zero GHG emissions by 2050 (sections 3.2.1, 3.3.1, 3.4.1). Australia is required to provide the UNFCCC with National Inventory Reports annually, biennial reports every 2 years, and National Communications every 4 years. These reports include details on total and sectoral GHG emissions, progress against reduction targets, and mitigation actions.

Cleanaway currently reports its emissions under the NGER Act (Table 3) and the Scope 1 and 2 emissions from the Project will increase its reportable emissions by 15% and 3%, respectively.

The remaining state, national and global GHG emission budgets for the 2025–2050 net-zero trajectory are presented in Table 16. Projected operational emissions for 2025–2050 are expected to account for >0.61%, >0.20%, and >0.002% of the remaining state, national and global carbon budgets, respectively.

Table 16 Drawdown of the Project's projected operational GHG emissions (Mt CO_2-e) on Queensland, Australia, and global net zero by 2050 carbon budgets

Project	Queensland		Australia		Global	
Total emissions to 2050 (Mt CO_2-e)	Carbon budget (Mt CO_2-e)	Project %	Carbon budget (Mt CO_2-e)	Project %	Carbon budget (Mt CO_2-e)	Project %
10.20	1,679.77	0.60%	7,248.62	0.14%	531,000.00	0.0019%

Cleanaway considers that the Project will contribute to Queensland addressing its waste to landfill issue and the avoidance of methane emissions from landfills, while providing base load electricity supply and underpinning the transformation in the energy sector to one dominated by variable renewable electricity generation.

8. SUMMARY

Katestone Environmental Australia Pty Ltd (Katestone) was commissioned by Cleanaway Operations Pty Ltd (Cleanaway) to conduct a Greenhouse Gas (GHG) Assessment for the construction and operation of a proposed Energy from Waste (EfW) facility in Queensland known as the Bromelton Energy and Resource Centre (BERC/ the Project). The Project will be located within the Special Industry Precinct of the Bromelton State Development Area (SDA), west of Beaudesert.

The Queensland Government's energy from waste (EfW) policy recognises that there is a role for EfW facilities in reducing waste volumes going to landfill where they create clear net benefits and do not displace waste reduction and recycling efforts. Under nominal operation, the Project is designed to incinerate 760,000 tpa of residual Municipal Solid Waste (MSW) and residual commercial and industrial (C&I) waste streams to produce 668,002 Megawatt hours per year (MWh/y) of electricity (base case, BC). Cleanaway have also considered a maximum operation case (overload case, OC) which increases the waste throughput and produced electricity to 836,000 tpa and 731,249 MWh/y respectively.

The Queensland Government has committed to achieving net zero GHG emissions by 2050 relative to the level of the State's emissions in 2005 (197.3 million tonnes of carbon dioxide equivalent emissions ($MtCO_2$-e)). Cleanaway is expected to demonstrate that the construction and operation of the facility will incorporate best practice measures for, *inter alia*, the management of GHG emissions.

This analysis has used data supplied by Cleanaway to calculate expected Scope 1, Scope 2, and Scope 3 GHG emissions during construction and operation.

Diesel combustion for transporting materials to site is estimated to be the largest source of Scope 1 emissions during the 39-month construction phase (5,961 t CO_2-e), while employee commuting, purchased capital goods, and upstream diesel combustion for transport activities account for most Scope 3 emissions at 23,215 t CO_2-e, 20,023 t CO_2-e, and 13,046 t CO_2-e respectively during construction.

The BC and OC are evaluated over two time periods that reflect legislated net zero targets by 2050: 2030 - 2050 and 2051 - 2065. The total annual BC Scope 1 emissions for each period are calculated to be 396,683 t CO_2-e/y and 323,494 t CO_2-e/y respectively. The total annual OC Scope 1 emissions for each period are calculated to be 436,042 t CO_2-e/y and 355,533 t CO_2-e/y, respectively. Combustion of waste accounts for 98% of total annual BC and OC Scope 1 emissions across both time periods.

Scope 2 emissions remain relatively constant across BC and OC at 454 - 468 t CO_2-e/y and 477 - 492 t CO_2-e/y for the periods 2030 – 2050 and 2051 - 2065, respectively.

Scope 3 emissions during operation are estimated for the BC and OC as 31,459 t CO_2-e/y and 34,160 t CO_2-e/y, respectively.

The emissions intensity of production for the BC and OC is within the range of Queensland's gas generators and less than Queensland's coal fired generators, at 0.60 t CO_2-e/MWh.

Projected total BC operational emissions for 2025–2050 are expected to account for >0.61%, >0.20%, and >0.002% of the remaining state, national and global carbon budgets to achieve net zero by 2050, respectively.

The facility will be subject to the electricity sector Safeguard Mechanism threshold and will not be required to progressively reduce its GHG emissions unless the threshold is exceeded by all electricity generation in Australia. However, Cleanaway will evaluate and incorporate best practice measures for the management of GHG emissions where practicable, as required by the GHG Guidelines, including:

- Seek options for the supply of low emission steel and concrete by tendering contractors
- Use biodiesel instead of diesel for facility startup processes, subject to review of biodiesel fuel availability and supply chain reliability

- Designing the plant for high energy recovery and electricity generation efficiency
- Explore options for offtake agreements and supply of heat to other industries in the Bromelton SDA
- Supply of recovered recyclable or reusable materials to the market after combustion, subject to approvals for IBAA reuse

Of the assessed emissions reduction scenarios:

- Combustion of diesel for the BC transport of waste by B-Double trucks (BD) to the facility accounts for 4,099 t CO_2-e/yr, and OC transport accounts for 4,499 t CO_2-e/y. Cleanaway is seeking provisional approval for A-Double trucks (AD) to transport waste to the site. This change would result in 49 t CO_2-e/y fewer BC emissions and 13 t CO_2-e/y fewer OC emissions.
- The use of biodiesel for boiler black starts would result in 11 t CO_2-e, which is 2,940 t CO_2-e fewer than if diesel were used. The current availability of biodiesel constrains this option.

While combustion of waste produces GHG emissions, the process allows for the offsetting or avoidance of emissions that might otherwise have occurred in the economy, including avoidance of methane (CH_4) generation from decomposing organic matter in landfills and from the supply of recyclable materials.

The BC would avoid ~253,000 t CO_2-e/y of fugitive CH_4 emissions under current waste streams to LFG-managed landfills. The OC is estimated to avoid a further ~10%. However, the relative value of these avoided emissions is likely to reduce over time as the fraction of organic material going to landfill reduces, the capacity to harvest legacy methane increases, and as electricity generation in the grid becomes more renewable. Avoided emissions from recycling of recovered materials are estimated to be between 121,000 and 158,000 t CO_2-e, with non-ferrous metals contributing the greatest fraction of these.

Development of the GHG mitigation design measures demonstrates that Cleanaway complies with Section 2.5.10 of the SDA Development Scheme.

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APPENDIX A

A1 WASTE FRACTIONS

Table A1 Waste fraction for Brisbane 2023 May/June forecasts and short-, medium- and long-term projections

Period	May/June and September Audit 2023		2025-2030	2030-2050	2050 +
Waste Category	Residual MSW	Residual C&I Waste	70% MSW & 30% C&I	Forecast 70% MSW & 30% C&I	Forecast 70% MSW & 30% C&I
Paper and Cardboard	17.6%	28.4%	22.7%	25.6%	29.1%
Nappies	5.3%	1.6%	4.8%	5.7%	6.9%
Wood	2.7%	15.6%	7.1%	7.8%	9.0%
Plastics & Expanded Polystyrene (EPS)	6.8%	7.5%	7.2%	7.5%	5.3%
Soft Plastics (Film)	7.2%	10.6%	8.7%	8.9%	7.3%
Ferrous Metals	1.7%	1.9%	2.0%	2.3%	2.7%
Non-Ferrous Metals	0.9%	0.5%	0.9%	1.0%	1.3%
Food Organics	26.2%	27.7%	23.2%	19.9%	15.9%
Garden Organics	12.0%	0.1%	6.3%	1.2%	0.3%
Other Putrescible	1.4%	0.0%	1.1%	1.4%	1.7%
Textiles	7.2%	3.4%	6.6%	7.4%	7.2%
Electronic Equipment, household chemicals and pharmaceuticals	4.8%	0.7%	4.1%	4.9%	6.0%
Glass	3.0%	1.7%	2.9%	3.3%	3.5%
Other - potentially combustible	0.4%	0.2%	0.4%	0.4%	0.5%
Other - inert	2.7%	0.1%	2.2%	2.6%	3.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

APPENDIX B

B1 WEIGHTED EMISSION FACTORS

Table B1 Default input values used in determining weighted emission factors

Waste type	Carbon content	Fossil origin	Default oxidation factor	Conversion factor
Food	0.38	0	1	3.664
Paper	0.46	0.01	1	3.664
Garden	0.49	0	1	3.664
Wood	0.5	0	1	3.664
Textiles	0.5	0.2	1	3.664
Sludge	0.5	0	1	3.664
Nappies	0.7	0.1	1	3.664
Rubber/leather	0.67	0.2	1	3.664
Plastic	0.72	1	1	3.664
Other	0.03	1	1	3.664

The supplied waste categories of ferrous metals, non-ferrous metals, glass, and other inert materials were classified as inert and therefore assumed to result in negligible or zero greenhouse gas emissions under combustion conditions.

Table B2 Waste composition percentages and resulting emission factors

Waste Category	2030-2025		2030-2050		2050 and Beyond	
	%	Weighted EF (t/t CO_2-e)	%	Weighted EF (t/t CO_2-e)	%	Weighted EF (t/t CO_2-e)
Paper	22.72	0.00	25.65	0.004	29.14	0.005
Nappies	4.76	0.01	5.67	0.01	6.91	0.02
Wood	7.10	-	7.78	-	8.96	-
Plastic	15.85	0.42	16.45	0.43	12.63	0.33
Food	23.19	-	19.90	-	15.88	-
Garden	7.46	-	2.56	-	1.99	-
Textiles	6.55	0.02	7.39	0.03	7.21	0.03
Other	4.46	0.00	5.33	0.01	6.52	0.01
Total	92.10	0.46	90.73	0.49	89.26	0.39