



Horsley Park Bioenergy Facility

Life Cycle Assessment

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1.0 Introduction

This Life Cycle Assessment (LCA) supports the regulatory assessment process, in particular the Environmental Impact Statement (EIS) being prepared for the State Significant Development (SSD) application by Austral Brick Co Pty Ltd (Austral Brick) to develop the Horsley Park Bioenergy Facility at 780 Wallgrove Road, Horsley Park, New South Wales.

1.1 Horsley Park Bioenergy Facility

Austral Brick propose to construct and operate a biogas facility (the Project), co-located with the existing brick manufacturing facility at Plant 2, 780 Wallgrove Road, Horsley Park, legally described as Lot 7 DP 1059698 in the Fairfield Local Government Area (LGA), with the key driver being the generation of green gas (or renewable natural gas) for use within their existing operations.

The key features of the Project include construction and operation of a bioenergy plant to treat up to approximately 150,000 tonnes per annum (tpa) of organic waste. The waste would be diverted from landfill and processed using anaerobic digestion technology. Most of the biogas produced would be converted into a 'green gas' (or renewable natural gas) for use within their operation, with the remaining being used to generate renewable heat and electricity for the parasitic load of the plant. It is estimated that at least 300 terajoules (TJ) of green gas (dependent on the type of volume of organic material received) would be delivered each year to Brickworks' manufacturing facility to be utilised behind the meter (BTM) to power the Brickworks' kilns as part of the brick manufacturing process, with the aim to decrease emissions through the displacement of fossil fuel derived natural gas with renewable natural gas (RNG).

The facility would be processing source separated organic feedstock diverted from landfill. The organic feedstock would be sourced from the commercial, industrial, and agricultural industries within the Western Sydney region, with the potential to accept separated Food Organics (FO) and/or Food Organics Garden Organics (FOGO) from residential areas within this region.

The Project would utilise proven anaerobic digestion technology. The facility's design includes mechanical separation equipment to remove contamination from the recovered organic streams, which has been designed to process up to 10% of contamination at the front end of the facility. This equipment would be housed within the reception shed, which would be enclosed and under negative pressure to meet the environmental regulatory requirements, specifically odour management. The reception building is designed to output a clean organic waste stream as the feedstock for a mesophilic biological anaerobic digestion process. The equipment would be capable of processing recovered organic feedstock packaged with paper, cardboard, plastic, and aluminium cans; however, would not be processing materials like glass and solid bulky objects such as metal fragments.

The biological process would break down the volatile organic matter in the feed sludge through a process of hydrolysis and in-vessel bio-digestion in the presence of methanogen bacteria. The methane forming bacteria would convert the biomass to methane gas, carbon dioxide and water, producing a biogas at around 55 – 65% methane. Biogas would be cleaned within the headspace of the digester through a chemical conversion of H₂S and micro-dosing of air (O₂) to give sulphate (SO₄) and water (H₂O). The biogas would then be chilled through a biogas dehumidifier and associated gas management equipment.



For the Project, green gas would be the main form of energy generated, and it is intended to be supplied to Brickworks to displace their natural gas usage. A Combined Heat and Power (CHP) system would be installed within the facility to allow heat and electricity to be used by the plant to meet its parasitic draw. An enclosed compliant high-temperature safety flare would be installed to combust excess biogas that would be unable to be processed due to any failures or shutdowns for maintenance.

The non-volatile and non-biodegradable organic solids would be converted to digested sludge (referred to as digestate) that would be fed from the digester tanks into a digester outlet tank. The outfeed sludge would be separated into the solid and liquid fractions with a mechanical separation unit. The solid digestate is proposed to be exported offsite by truck to a licenced composting facility, which would be used for its nutrient-rich content to provide a valuable composting product. The liquid fraction would either be passed through an onsite wastewater treatment plant for clean-up to meet applicable standards for disposal to sewer or be transported to a licenced composting facility.

This report presents the approach and outcomes of a high-level Life Cycle Assessment (LCA) that has been undertaken for the Horsley Park Bioenergy Plant.

1.2 ARENA Guidelines for LCA

The Secretary's Environment Assessment Requirements (SEARs) issued for the Horsley Park Bioenergy Project require 'a detailed life cycle assessment in accordance with the Australian Renewable Energy Agency guidance *Life Cycle Assessment of Bioenergy Products and Projects (ARENA, 2016)*'. The Australian Renewable Energy Agency (ARENA) was established to make renewable energy solutions more commercially competitive and to support the global transition to net zero emissions by accelerating the pace of pre-commercial innovation to the benefit of Australian consumers, businesses, and workers. In 2016, ARENA published the ARENA Life Cycle Assessment of Bioenergy Products and Projects Method and Guidance (ARENA, 2016) (hereafter referred to as 'ARENA LCA Guidelines').

SLR believes that requirements outlined for a Commercialisation LCA in the ARENA LCA Guidelines provide sufficient coverage to evaluate the life cycle impacts of the Horsley Park Bioenergy Project. This LCA also draws on relevant international standards that provide principles, a framework, and methodological requirements for conducting LCA studies, particularly the *International Standards Organization (ISO) standards ISO 14040 – Life cycle Assessment – Principles and framework* and *ISO 14044 – Life cycle assessment – Requirements and guidelines* (ISO series 14040/14044). As a result, this LCA consists of four key phases:

1. Goal and scope definition
2. Life cycle inventory (LCI)
3. Life cycle impact assessment (LCIA)
4. Interpretation



2.0 Goal and Scope Definition

2.1 Goal of the study

The goal of this LCA is to address the SEARs requirement: **a detailed life cycle assessment in accordance with the Australian Renewable Energy Agency guidance Life Cycle Assessment of Bioenergy Products and Projects (ARENA, 2016)**.

The primary audience for the study would be the NSW Department of Planning and Environment (DPE) and other relevant government agencies.

2.2 Scope of the study

The scope of the study considers and clearly defines key aspects of LCA analyses, including the product system(s) studied, the system boundaries, data required and analysis needs, impact categories to be evaluated i.e., methodology of impact assessment and type of critical review.

2.2.1 System boundary, Functional Unit and Reference System

The Horsley Park Bioenergy Project would be located at Plant 2, 780 Wallgrove Road, Horsley Park, co-located with the existing brick manufacturing facility in the Fairfield LGA, New South Wales, Australia. The plant would process approximately 150,000 tpa of a mix of solid organic waste and liquid organic waste. For the purposes of this LCA, it has been assumed that under the business as usual (BAU) or Baseline scenario, solid organic waste and liquid organic waste are currently disposed to landfill.

In order to provide reasonable coverage of the life cycle impacts of the Horsley Park Bioenergy Project, the avoided benefits of not sending waste to landfill (and the fugitive emissions associated with landfill disposal), as well as the benefits of displacing fossil fuel electricity use have been considered. Furthermore, benefits (and impacts) of applying solid digestate from the AD process to land have also been included in this LCA. However, fertiliser benefits of liquid digestate, which could be one of the potential management options, have not been included in this LCA as a conservative measure; the LCA has considered environmental burdens associated with liquid digestate disposal to sewer (noting that the project has the potential to spread liquid digestate onto land which has a beneficial affect through increasing the nutrient content of the soils).

The objective of this study is to compare the environmental impacts of the development of the Horsley Park Bioenergy Plant against the waste management Baseline as defined as landfill disposal of solid organic waste and liquid organic waste.

Following the “cradle-to-grave” approach from the ARENA LCA Guidelines, the system boundary was extended to include the impacts of waste transport (to landfill or the AD plant in the Baseline scenario or project scenario respectively), handling, processing, and disposal. The boundary, therefore, includes the following material and process flows:

- transport of the key waste streams from their indicative source of generation; solid organic waste and liquid organic waste to the Horsley Park Bioenergy Plant or to landfill (where applicable).
- upstream extraction and production of auxiliary material, fuel, and water inputs,
- combustion of biogas for renewable natural gas, electricity, and heat production,



- disposal of residues/rejects from pre-treatment in a landfill,
- use of solid digestate from AD as biofertiliser direct to agriculture,
- avoided impacts from the transport and processing of waste in a landfill and
- avoided impacts from fossil fuel derived electricity use and natural gas use.

A critical parameter in LCA is the “Functional Unit” which is defined as the amount, weight and quality of the specific product or economic function being investigated. In a comparative study, the functional unit has to be the same for all the compared scenarios otherwise inputs and outputs cannot be compared on an equivalent basis. The functional unit for this study is taken to be the total mass of waste processed at the Horsley Park Bioenergy Plant. All modelled scenarios use this same functional unit i.e., the identical quantity and composition of total waste managed, which was calculated to be 150,000 tpa and derived from the following assumptions:

1. approximately 101,500 tpa of solid organic waste delivered to the facility and
2. approximately 48,500 tpa of liquid organic waste delivered to the facility.

2.2.2 Cut-off criteria

Cut-off rules enable LCA practitioners to conduct LCA without having to model 100% of the system. Cut-off criteria as defined in the ISO 14040 refers to specification of the amount of material or energy flow, or the level of environmental significance associated with unit processes, or product system, to be excluded from a study. Within the chosen life cycle boundary there has not been any attempt to impose cut-off criteria.

2.2.3 Data quality criteria

Data quality should be addressed throughout the LCA modelling process. The input data for the LCA model consists of the chosen (filtered) information to enable model computations and calculations. All data quality goals should be determined during the goal and scope phase of the LCA and should give guidance on the data collection process. The data quality goals need to explicitly define needs for data representativeness, reliability, and completeness. During the scope phase of the LCA, the input data consists of information necessary to define the system boundary and functional unit. For the life cycle inventory analysis phase, the input data includes information necessary to clearly specify the unit processes descriptions, including both technical data and environmental interventions. For characterisation, the data chosen for the impact assessment stage is converted to equivalency factors using characterisation models chosen during the scope. Interpretation of LCA results includes the interpretation of the data quality assessment.

In this LCA, the following components of life cycle inventory data quality have been considered:

- **Flow** – relating to individual values associated with materials. Elementary flows, i.e., exchanges with the environment have been considered, e.g., total waste managed in all scenarios studied.
- **Process** – processes which describe one specific activity (a unit process) for example combustion of biogas in a gas engine or aggregate multiple activities (an aggregate process).
- **Model** – which is based on a group of linked processes.



The following data quality indicators have been considered as relevant in this LCA:

Reliability

Reliability was considered as a measure for the data sources, acquisition methods and verification. This LCA applies primary data from Austral Brick for the Horsley Park Bioenergy Plant mass and energy balances. Data based on assumptions have been used for other user defined processes where primary data was not available including the following:

- the electricity consumption of the feedstock pre-treatment equipment (de-packaging unit)
- separation efficiencies for key material categories for the de-packaging unit

Secondary data from verified external databases (through the modelling undertaken) were used for lifecycle inventory data.

Completeness

Completeness was considered as a measure for the representativeness of the sample. This is linked to the goal and scope of the LCA study, particularly the system boundary, including all flows entering, exiting and within the system boundary. By using the WRATE tool (refer to **Section 3.1.2**) which draws on data from verified databases and data from other existing facilities, the data is considered representative.

Temporal, geographical, and technological correlations

Temporal, geographical, and technological correlations measure the degree of correspondence between data and the goal and scope of the study. ISO 14044 standards define time-related coverage as the age of the data and the minimum length of time over which data should be collected. The modelling in this LCA was undertaken using the WRATE tool that utilises a background database supplied by the Ecoinvent centre, a Swiss organisation with unrivalled expertise in supplying consistent and transparent life cycle inventory data. WRATE models the environmental impacts of all phases of a waste management facility's life cycle from construction, operation, maintenance, and decommissioning, including processes associated with waste management and resource recovery. These processes include recycling, transfer stations, anaerobic digestion, compost use, etc.

2.2.4 Impact Categories

Environmental impact categories represent the different types of environmental impacts that are included in an LCA study. They include quantitative characterisation models that link inventory flows to comparable environmental impacts with indicators. These impacts can be wider than can be practically included in an LCA, as noted in the ARENA LCA Guidelines. In this LCA study, the following Lifecycle Impact Assessment (LCIA) indicators were used to assess the environmental impacts of the Horsley Park Bioenergy Plant, as applied in the WRATE software (described later in **Section 3.1.2**).

Table 1 Life Cycle Impact Categories and Indicators used in WRATE

Impact Category	Indicator	Indicator Units*
Global warming	Global warming potential - GWP 100a	kg carbon dioxide eq** (kg CO ₂ -e)



Impact Category	Indicator	Indicator Units*
Acidification	Acidification potential (AP) (average Europe total, A and B)	kg sulphur dioxide eq** (kg SO ₂ -e)
Eutrophication	Eutrophication potential (EP)	kg phosphate eq** (kg PO ₄ -e)
Freshwater aquatic ecotoxicity	Freshwater aquatic ecotoxicity potential (FAETP) infinite	kg 1,4-dichlorobenzene eq** (kg 1,4-DCB-e)
Human toxicity	Human toxicity potential (HTP) infinite	kg 1,4-dichlorobenzene eq** (kg 1,4-DCB-e)
Depletion of abiotic resources	Resources: depletion of abiotic resources	kg antimony eq** (kg Sb-e)

*Units in the results section have been changed to kilotons (kt) for presentation

**eq means equivalent (also expressed as e)

3.0 LCA Approach

SLR conducted this LCA study in accordance with the ISO standards 14040/14044 and the guidance outlined in the ARENA LCA Guidelines. This section presents the approach and methodology followed in undertaking this LCA study.

3.1 Methodology

3.1.1 Introduction

This LCA compares the environmental impacts of the proposed Horsley Park Bioenergy Plant against the “counterfactual”, i.e., current Baseline – assumed to be landfill disposal of solid organic waste and liquid organic waste. Modelling has been undertaken, to assess the following scenarios, which are characterised in more detail at **Section 3.2**:

- Scenario 1 – Baseline/Counterfactual (Baseline waste management and landfill disposal of solid organic waste and liquid organic waste)
- Scenario 2 – Horsley Park Bioenergy Plant based on an anaerobic digestion process and biogas utilisation for electricity and heat generation in a combined heat and power mode. Electricity and heat generated at the plant would be used for the parasitic load of the plant.

Additionally, a sensitivity analysis on higher landfill gas (LFG) capture rate at landfill and another sensitivity analysis using electricity grid mix as the marginal energy mix were undertaken within the Baseline scenario and Horsley Park Bioenergy Plant Scenario (refer to **Section 4.3**).

The modelling uses a life cycle assessment tool, WRATE, described in more detail below. It is also noted that the data inputs and outputs for the scenarios i.e., LCI were influenced by the inputs required by the WRATE tool, and as a result, some modifications to primary data provided were undertaken.

3.1.2 The WRATE Tool

The WRATE software is a life cycle assessment tool specifically designed to model the environmental impacts of waste and waste management processes. Its predominant use is for assessing the management of municipal and municipal type wastes (which would include commercial and industrial (C&I) waste types, hence is appropriate for the Horsley Park Bioenergy Project).



As a life cycle assessment tool, WRATE models the environmental impacts of all phases of a waste management facility's life cycle from construction, operation, maintenance, and decommissioning (where applicable). WRATE also models all elements of the waste management process from collection through to disposal.

WRATE was funded and developed by the UK Environment Agency (EA) and released to market in 2007. All users of the software pay a licence fee and must receive training in its use to ensure assessments are carried out to the required standard. SLR is a registered expert user of WRATE.

The use of the WRATE software is endorsed and encouraged by the EA and the UK Department for Environment, Food and Rural Affairs (Defra). Over many years the tool has been embedded within the waste management industry assisting with a range of projects for various organisation types:

- environmental impact calculation of options for Local Authority municipal waste management strategy development projects,
- solution testing and business case development for Local Authority and private sector,
- procurement support tool to assess the environmental impacts of bidder solutions within a local authority waste management tender process (many of these procurements received Defra funding),
- planning application support or planning variations (including successful removal of restrictive planning conditions for energy recovery facility (ERF) projects) and
- quantifying the "green" credentials of waste projects being considered by the Green Investment Bank (now Green Investment Group) and annual reporting of carbon impact for investment projects.

The software was developed to comply with the ISO standards for LCA to ensure studies using the WRATE tool can be delivered to a high technical standard. The WRATE tool utilises a background database supplied by the Ecoinvent centre.

The LCA tool helps with the identification and quantification of the following environmental impacts:

- **direct burdens** – defined as emissions from the process itself, for example carbon dioxide as a result of a consequence of combustion or aerobic degradation,
- **indirect burdens** – associated with the supply of energy and materials to the process, for example construction materials, electrical energy for motors and fans, and chemicals for pollution abatement equipment and
- **avoided burdens** – associated with the recovery of energy and materials from the waste stream resulting in the avoidance of primary energy production and mineral extraction.

The environmental impact of a particular scenario is therefore calculated as the sum of direct burdens, indirect burdens and avoided burdens.

3.2 Life Cycle Inventory Analysis

This section provides the cradle-to-grave LCI for the two scenarios in **Section 3.2.3**, i.e., Scenario 1 - the baseline/counterfactual and **Section 3.2.4**, i.e., Scenario 2 - the Horsley Park Bioenergy Plant. Primary design data were obtained from project documentation



provided to SLR, including details of waste sources and transport data. Additional data has been based on assumptions, literature, and publicly available information (where applicable).

3.2.1 Principal Assumptions within a WRATE Model

When developing a project in WRATE, a number of key assumptions must be defined. These assumptions include the tonnage of waste, the composition of the waste, the assessment year (assumed to be 2024 in this LCA Study), and the associated energy mix, which is the assumed energy mix that would be displaced by the energy generated by the biogas plant. All of these assumptions would influence the output results.

When modelling an AD plant within WRATE there are certain key parameters which must be defined (which again influence the output results). The key AD assumptions include:

- whether the plant is a high solid (dry) or a low solids (wet) AD process and
- the management route for digestate generated.

For this LCA study, the Horsley Park Bioenergy Plant was assumed to be a low solids (wet) AD process in WRATE and digestate was assumed to be applied to land as compost (compost use process in WRATE). Further details of the technical solution are presented in the Horsley Park Bioenergy Plant scoping report and concept stage report, and these data have been used to define the AD plant characteristics in WRATE. It is worth noting that WRATE software, within the limitation of the tool, was used to create a high-level representation of the AD plant and to allow comparison with the Baseline scenario of landfill disposal. Scenario 2 is not a detailed representation of the proposed facility, and therefore results should be viewed through the lens of comparative performance rather than absolute impacts of the proposed AD facility.

3.2.2 Project Information – Common to all Scenarios

In order to compare the environmental impacts of the Horsley Park Bioenergy Plant to the counterfactual scenario – Baseline waste management (i.e., landfill disposal of solid organic waste and liquid organic waste), the common technical parameters described in this section have been adopted. The year 2024 has been adopted as the assessment year.

3.2.2.1 Electricity Mix

The “Baseline” electricity mix was based on electricity generation data in NSW, by fuel type for financial year 2021-22 as obtained from the Australian Government Department of Climate Change, Energy, the Environment and Water (2022)¹. The baseline energy mix is applied for all electricity consumption from the grid within the respective scenarios.

Marginal fuel mix is calculated by considering the carbon intensive energy sources in the baseline fuel mix that are assumed to be offset by the electricity generated by the Horsley Park Bioenergy Plant. **Table 2** shows the baseline fuel mix and the marginal fuel mix adopted for this LCA. Adopting the fuel mix provided in **Table 2** is considered a reasonable assumption for the LCA given the high degree of uncertainty associated with any future forecast of energy mix in NSW.

¹ Department of Climate Change, Energy, the Environment and Water, Australian Energy Statistics, Table O Electricity generation by fuel type 2021-22 and 2022. Retrieved from <https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2021-22-and-2022>



Table 2 Baseline Fuel Mix and Marginal Fuel Mix adopted for the Horsley Park Bioenergy Plant LCA Study

Energy Source	NSW Baseline Fuel Mix*	Marginal Fuel Mix**
Coal	65.13%	92.8%
Oil	0.64%	0.9%
Gas	0.00%	0.0%
Gas CCGT	4.45%	6.3%
Nuclear	0.00%	Not Applicable
Waste	0.79%	Not Applicable
Thermal other	0.00%	Not Applicable
Renewables thermal	0.00%	Not Applicable
Solar PV	15.56%	Not Applicable
Wind	8.29%	Not Applicable
Tidal	0.00%	Not Applicable
Wave	0.00%	Not Applicable
Hydro	4.60%	Not Applicable
Geothermal	0.00%	Not Applicable
Renewable other	0.55%	Not Applicable
Total	100.0%	100.0%

*The “baseline” fuel mix is a parameter used in WRATE, which defines the typical electricity grid and its fuel source contributions and should not be confused with the “Baseline” scenario.

**The marginal fuel mix includes only the carbon intensive energy sources, which are assumed to be offset by the electricity generated from the Horsley Park Bioenergy Plant. In this LCA, the marginal fuel mix is assumed to include Coal, Oil and Gas CCGT.

As noted in **Section 3.1.1**, a sensitivity analysis was undertaken by changing the marginal fuel mix to equal the baseline electricity grid mix.

3.2.2.2 Feedstock composition

The Horsley Park Bioenergy Project is designed to process solid organic waste and liquid organic waste. As per the model inputs data and assumptions excel file², the solid organics and liquid organics each include both light and heavy contamination. And as per the scoping report³, contamination might include paper, cardboard, plastic, and aluminium cans. The Environmental Impact Statement (EIS)⁴ anticipated 3,713 tonnes of rejected materials, which is equivalent to 2.48% total feedstock. An assumed composition of solid organic waste and liquid organic waste is presented in **Table 3**.

Table 3 Feedstock Composition

Waste Category (Used in WRATE)	Solid Organic Waste (% by mass)	Liquid Organic Waste (% by mass)
Organics (Food waste)	97.52%	97.52%
Organics (Garden waste)	0.00%	0.00%

² File name: "J132-00-P-MEB-001 Brickworks Horsley Park Rev A (CHP and BMU).xlsx"

³ File name: "1. Scoping Report - 780 Wallgrove Road, Horsley Park_Proposed Bioenergy Facility.pdf"

⁴ File name: "EIS - Horsley Park Bioenergy Facility.pdf"



Waste Category (Used in WRATE)	Solid Organic Waste (% by mass)	Liquid Organic Waste (% by mass)
Paper	0.21%	0.21%
Cardboard	0.21%	0.21%
Wood	0.00%	0.00%
Textile	0.00%	0.00%
Plastic films	0.41%	0.41%
Dense Plastics	0.41%	0.41%
Other combustibles	0.00%	0.00%
Glass	0.00%	0.00%
Ferrous Metal	0.00%	0.00%
Non-Ferrous metals	1.24%	1.24%
Other non-combustibles	0.00%	0.00%
Hazardous waste	0.00%	0.00%
E-Waste	0.00%	0.00%
Fines	0.00%	0.00%
Total	100.00%	100.00%

It is assumed that the composition of the solid organic waste and liquid organic waste in **Table 3** includes around 2.48% contamination (i.e., 1.24% light contamination, like paper, cardboard, plastics, and 1.24% non-ferrous metals), which would be removed from the organic feedstock by a mechanical separation equipment at the front end of the facility.

The NSW Waste and Sustainable Materials Strategy 2041⁵ aims to mandate food and garden organics (FOGO) collection for all NSW households and selected businesses. While it is assumed that FOGO is not likely to be processed at the Horsley Park Bioenergy Plant, the food waste feedstock would likely be source-separated solid and liquid organic waste streams from the C&I sector, which would be required to satisfy typical feedstock specifications/quality requirements as outlined in the relevant supply agreements that would be established. Note: the exact source of organic feedstock waste is still not determined at this stage. As a result, the composition of feedstock waste streams adopted in this LCA study have been assumed to remain relatively consistent over the project life.

3.2.2.3 Waste Managed

The following key waste streams are proposed for processing at the Horsley Park Bioenergy Plant:

Table 4 Feedstock composition

Feedstock	Tonnage (tpa)	Total Solids (%TS)	Volatile Solids (%VS)
Solid Organic Waste	101,500	25	21
Liquid Organic Waste	48,500	20	17
Total	150,000	24	20

⁵ NSW Waste and Sustainable Materials Strategy 2041 Stage 1: 2021-2027 (NSW Government, 2021). Retrieved from https://www.dpie.nsw.gov.au/_data/assets/pdf_file/0006/385683/NSW-Waste-and-Sustainable-Materials-Strategy-2041.pdf



SLR notes that the WRATE tool only allows modelling of food and garden wastes only for the low solids (wet) AD process, and that material stream characteristics (such as total solids) are fixed. However, with respect to AD detailed modelling, key parameters that influence results will include % TS, %VS and nutrient content.

3.2.3 Scenario 1 – Baseline/Counterfactual

The Baseline scenario was developed to assess the environmental impacts of the current BAU management of the waste streams, i.e., landfill disposal of solid organic waste and liquid organic waste. **Figure 1** shows a scenario Map from WRATE showing the processes adopted for the baseline scenario.

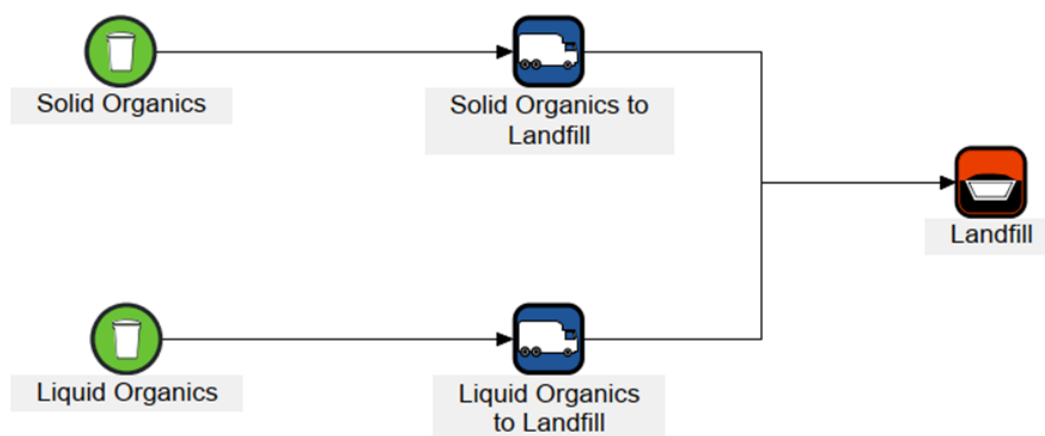


Figure 1 Process Flow Diagram showing key processes for Scenario 1 - Baseline/Counterfactual

3.2.3.1 Landfill assumptions

As noted in **Section 3.2.2.2**, the exact sources of organic waste streams are still not determined at this stage. As a result, in this LCA study, it has been assumed that under the Baseline scenario both solid organic waste and liquid organic waste would be disposed of at an appropriate landfill for the Fairfield Local Government Area. The nearest putrescible landfill was considered in our assumption. Distances are based on SLR assumption – from a central location, as exact source of feedstock is not known at this stage.

Since no details of a specific landfill has been provided to SLR, in this LCA study, an average capture rate of 37% for methane emissions from landfill in New South Wales has been assumed based on Carbon Credits (Carbon Farming Initiative—Alternative Waste Treatment) Methodology Determination 2015.⁶ It is worth noting that this assumption has been subjected to sensitivity testing. As noted in **Section 3.1.1**, a sensitivity analysis based on a landfill gas capture rate of 70% was undertaken.

⁶ Carbon Credits (Carbon Farming Initiative—Alternative Waste Treatment) Methodology Determination 2015, Australian Government, <https://www.legislation.gov.au/Details/F2015L00060>



3.2.3.2 Other technical assumptions

A summary of other technical characteristics and input data used for the baseline scenario is provided in **Table 5**.

Table 5 Scenario 1 – Baseline/Counterfactual Characteristics

Material Stream	Process Description	Quantity (tpa)	Transport Distance (km/trip)	Reference/Comment
Solid Organic Waste	Transport from source to Lucas Heights landfill	101,500	30	Distance based on SLR assumption – from a central location (exact source of solid organic waste not known at this stage)
Liquid Organic Waste	Transport from source to Lucas Heights landfill	48,500	30	Distance based on SLR assumption – from a central location (exact source of liquid organic waste not known at this stage)

3.2.4 Scenario 2 – Horsley Park Bioenergy Plant

This scenario evaluates the environmental impacts of processing a mix of solid organic waste and liquid organic waste at the proposed Horsley Park Bioenergy Plant. **Figure 2** shows a scenario map from WRATE showing the processes adopted for Scenario 2 – Horsley Park Bioenergy Plant. Both solid organic waste and liquid organic waste delivered to the facility would undergo a pre-treatment process using a de-packaging unit to remove impurities like paper, cardboard, plastic, and aluminium cans. The total amount of rejects was not yet provided to SLR, however SLR assumed typical separation efficiencies for key material categories for the de-packaging unit (presented in **Table 7**) based on experience and knowledge of material separation equipment.

Based on the assumptions of the separation efficiency, the amount of solid organic waste and liquid organic waste (sent to the AD process) and reject material (sent to landfill) were determined from a mass balance.

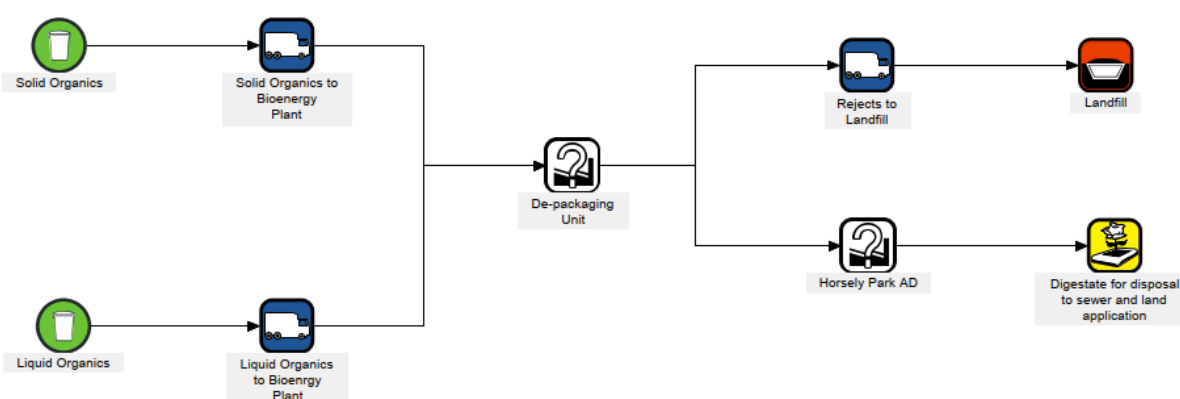


Figure 2 Process Flow Diagram showing key processes used in WRATE for Scenario 2 - Horsley Park Bioenergy Plant

Icons presented in the process flow diagram in **Figure 2** are from the WRATE scenario map. Note: WRATE icons with “?” symbol identify processes which are “User Defined”. It is noted that the generation of electricity, and heat is included within the WRATE modelling process



but is not specifically shown on the WRATE scenario map for simplicity. This includes electricity and heat usage in the AD process.

3.2.4.1 Pre-treatment process assumptions

As noted in **Section 3.2.4** above, a de-packaging unit would be installed in the pre-treatment hall to remove impurities from solid organic waste and liquid organic waste. This unit is typically a mechanical system that performs size separation of waste material and includes a screw compactor and hydraulic system to convey material. In order to consider the environmental impacts of the organic feedstock pre-treatment process, this process was incorporated in the LCA modelling. However, most of the processes utilised within WRATE are WRATE standard (also referred to as “default”) processes. The process utilised for de-packing unit is a ‘User Defined Process’ (UDP). A UDP is where a WRATE standard process is duplicated, and changes are made to the background allocation table to better represent the process or treatment technology.

The WRATE default processes for pre-treatment assume a comprehensive pre-treatment process involving a considerable mass reduction due to moisture loss and several recyclable material types recovered from the residual waste. As a conservative assessment, it is assumed that the solid organic waste and liquid organic waste for the project would undergo simple pre-treatment at the de-packing unit to remove the likely key impurities; mainly paper, cardboard, plastic, and aluminium cans contaminants with no material loss associated with bio-drying. To account for this, a UDP has been developed for the de-packing unit. The electricity consumption for the de-packing unit was based on the power consumption for a SMIMO120 equipment (which has a similar capacity to the proposed de-packing unit). The de-packing unit UDP was then based on duplicating a WRATE standard Transfer Station process and modifying the data in the background allocation table, particularly to account for the change in electricity consumption by prorating it to the functional unit (throughput) of the UDP as shown in the table below. The environmental impacts of electricity consumption are calculated based on the baseline electricity mix, as described in **Section 3.2.2.1**.

For WRATE modelling purposes, it was assumed that the de-packing unit, as an additional piece of equipment to the main AD process, was powered by electricity from the local power grid. Based on the information provided by the client, the de-packing unit will be powered by the electricity generated from the AD plant. However, a conservative approach was taken which covers a potential unlikely scenario where the plant is not generating power, and the de-packing unit needs to be operated to process incoming waste.

Table 6 De-packaging unit UDP characteristics

Parameter	Value	Units
Electricity consumption of the de-packaging unit based on similar unit*	3,030,612**	MJ/year
Expected annual capacity of de-packaging unit	150,000	Tonnes/year
Functional unit for the UDP	72,000	Tonnes/year
Electricity consumption of the de-packaging unit (Prorated to UDP functional unit)	1,454,694***	MJ/year

*Based on a similar capacity de-packaging unit – Smicon SMIM0120

** 3,030,612 MJ is equivalent to 841,837 kWh

*** 1,454,694 MJ is equivalent to 404,082 kWh

The assumed separation efficiencies of the key material categories are shown in **Table 7**.



Table 7 Assumed separation efficiencies for the de-packaging unit

Material category	Separation efficiency
Putrescible and Garden Waste	0%
Paper	100%
Cardboard	100%
Wood	100%
Textile	100%
Plastic films	100%
Dense Plastics	100%
Other combustibles	Not Applicable
Glass	0%
Ferrous Metal	0%
Non-Ferrous metals	100%
Other non-combustibles	100%
Hazardous waste	Not Applicable
E-Waste	Not Applicable
Fines <10mm	0%

3.2.4.2 AD process assumptions

The AD process is modelled using a combination of a default WRATE AD process, particularly the '*AD Small low solid BIOGEN GREENFINCH process*' for solid organic waste and liquid organic waste.

The *AD Small low solid BIOGEN GREENFINCH process* in WRATE is only capable of modelling the impacts of source-separated food waste and garden organics (with limits on mass fractions allowable). As a result, only food waste feedstock was modelled using this WRATE default process.

The *AD Small low solid BIOGEN GREENFINCH process* models electricity generation from anaerobic digestion of organic material. Avoided burdens from the use of this electricity would be accounted for based on the marginal energy mix as described in **Section 3.2.2.1**. It is noted that the high-level modelling in WRATE differs from the proposed usage of biogas. As per the scoping report, the project is intended to use biogas within a CHP to generate both electricity and heat, while also cleaning up the majority of the biogas to produce renewable natural gas to be used directly in brick kilns. The high-level WRATE AD model assumes all the biogas is used in the CHP engine to generate electricity and heat.

Using the *AD Small low solid BIOGEN GREENFINCH default WRATE process*, it is assumed that solid digestate generated would be applied to land and liquid digestate would be disposed to sewer. The proposed management approach for solid digestate is land application for beneficial reuse, which is consistent with the project intentions. While the project proposed utilisation pathway for liquid digestate could be either treatment and disposal to sewer or transported to a licenced composting facility for land application, the WRATE default process in this LCA study represents a 'worst case' scenario for liquid digestate management (i.e., disposal to sewer), which SLR considers as a conservative approach to results reporting.

Austral Brick is expected to apply for a resource recovery order and exemption under the NSW resource recovery framework, allowing application of digestate to land for beneficial reuse. This will result in positive environmental outcome, particularly as a result of the benefits of using an organic fertiliser and thus the avoidance of chemical fertiliser production and use.



Hence, SLR believes that the WRATE modelling of digestate adopted (both solid and liquid) is acceptable, albeit conservative given all project digestate (both liquid and solid) could be applied to land.

The estimated residual waste tonnages generated from the AD plant which is calculated as per the separation efficiencies provided in **Table 7** is significantly lower than the default tonnages calculated by WRATE default AD process. To account for this, a UDP has been developed within the AD process to reduce the residual waste to estimated tonnages for better accuracy of the model.

Rejects from the Horsley Park Bioenergy Plant would be disposed of at an appropriate licenced landfill which is assumed to be the same landfill site as noted under the Baseline scenario in **Section 3.2.3**. Although all rejects are destined to landfill within the WRATE software, further processing of the rejects to capture non-ferrous metals could result in increased environmental benefits.

A summary of other technical characteristics and input data used for the Horsley Park Bioenergy Plant scenario is provided in **Table 8**.

Table 8 Scenario 2 – Horsley Park Bioenergy Plant characteristics

Material Stream	Process Description	Quantity (tpa)	Transport Distance (km/trip)	Reference/Comment
Solid organic waste	Transport from source to the Horsley Park Bioenergy Plant	101,500	10	Distance based on SLR assumption – from a central location (exact source of solid organic waste not known at this stage)
Liquid organic waste	Transport from source to the Horsley Park Bioenergy Plant	48,500	10	Distance based on SLR assumption – from a central location (exact source of liquid organic waste not known at this stage)
Rejects from Horsley Park Bioenergy Plant	Transport from the Horsley Park Bioenergy Plant to Lucas Heights landfill	3,713	40	Based on distance from the proposed Horsley Park Bioenergy Project location to Lucas Heights landfill

3.3 Data quality assessment

It is understood that the results of a LCA study can be affected by several uncertainties, particularly due to methodological choices, initial assumptions, system boundaries and quality of the available data. The WRATE AD model applied in this LCA study is based on representative data for an anaerobic digestion plant treating source separated biowaste for energy generation and digestate production – a process which is well established and well understood.

4.0 Modelling Results

4.1 Introduction

Results of the LCA modelling are presented and discussed below. In interpreting the result, it is worth remembering that the functional unit for comparison is 150,000 tpa total waste



managed, and that the environmental impact for each scenario comprises the following contributions:

- **Direct Burdens** – defined as emissions from the process itself,
- **Indirect Burdens** – associated with the supply of energy and materials to the process, for example construction materials, electrical energy from the grid for motors and fans, and chemicals for pollution abatement equipment and
- **Avoided Burdens** – associated with the recovery of energy and materials from the waste stream resulting in the avoidance of primary energy production and mineral extraction.

Since each scenario is based on the same functional unit, it is possible to directly determine the net benefit of a scenario against the Baseline/counterfactual scenario.

4.2 Results – Comparison of Scenario 1 and Scenario 2

The results presented in this section show a comparison of the Baseline scenario vs the Horsley Park Bioenergy Plant for all the impact categories assessed. Avoided burdens are shown as negative values and burdens are shown as positive values in the figures below.

4.2.1 Global warming potential (GWP) impacts

Figure 3 shows results of the WRATE analysis for GWP for the two scenarios assessed in this LCA study: Baseline vs Horsley Park Bioenergy Plant for the assessment year 2024.

The GWP results are presented as CO₂ equivalent (CO₂-eq), which accounts for the emissions of various greenhouse gases (GHGs), including carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). CO₂ equivalent is a unit of measurement that is used to standardise the climate effects of the various greenhouse gases.

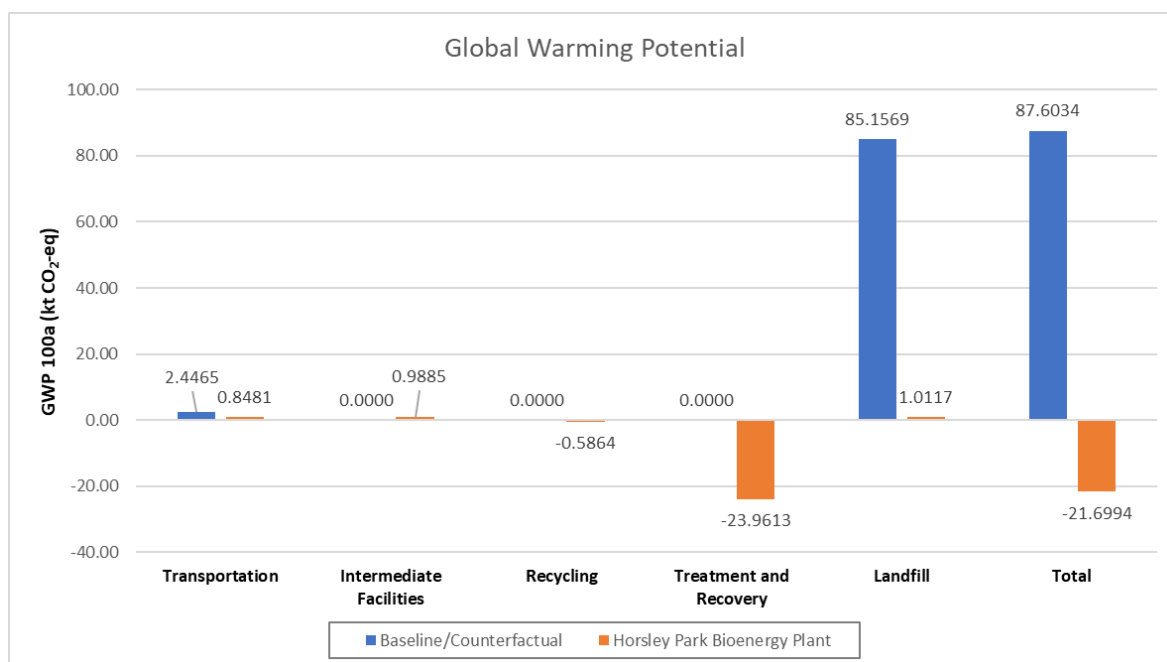


Figure 3 Comparison of GWP of Baseline vs Horsley Park Bioenergy Plant



Based on the results from WRATE analysis, it is noted that treatment and recovery stage, i.e., anaerobic digestion of waste at the Horsley Park Bioenergy Plant, would result in the most significant reduction of carbon impacts (23.96 kt CO₂-e avoided per year). Treatment and recovery stage include avoided fossil energy use (grid electricity usage). Carbon impacts from transport considerations of organic waste and residues, from intermediate facilities (i.e., de-packaging unit) and from recycling stages are less significant both for the Baseline and the Horsley Park Bioenergy Plant.

Landfill disposal of organic waste would result in an overall carbon burden in both the Baseline (85.16 kt CO₂-e per year) and the Horsley Park Bioenergy Plant (1.01 kt CO₂-e per year) scenarios, with the latter being the reject disposal. This is typically due to the GWP of fugitive LFG emissions, particularly methane. While LFG capture rate assumed in this LCA is relatively low (37%), fugitive LFG emissions would have an impact on carbon burdens for each tonne of waste disposed of in landfill.

Overall, the results from WRATE analysis indicate that development of the Horsley Park Bioenergy Plant⁷ for treatment of solid organic waste and liquid organic waste would result in a significant reduction in carbon impacts (overall avoided carbon burden of 21.70 kt CO₂-e per year) compared to the Baseline scenario (overall carbon burden of 87.60 kt CO₂-e per year).

4.2.2 Acidification potential (AP) impacts

Figure 4 shows results of the WRATE analysis for the AP for the two scenarios assessed in this LCA study for the assessment year 2024.

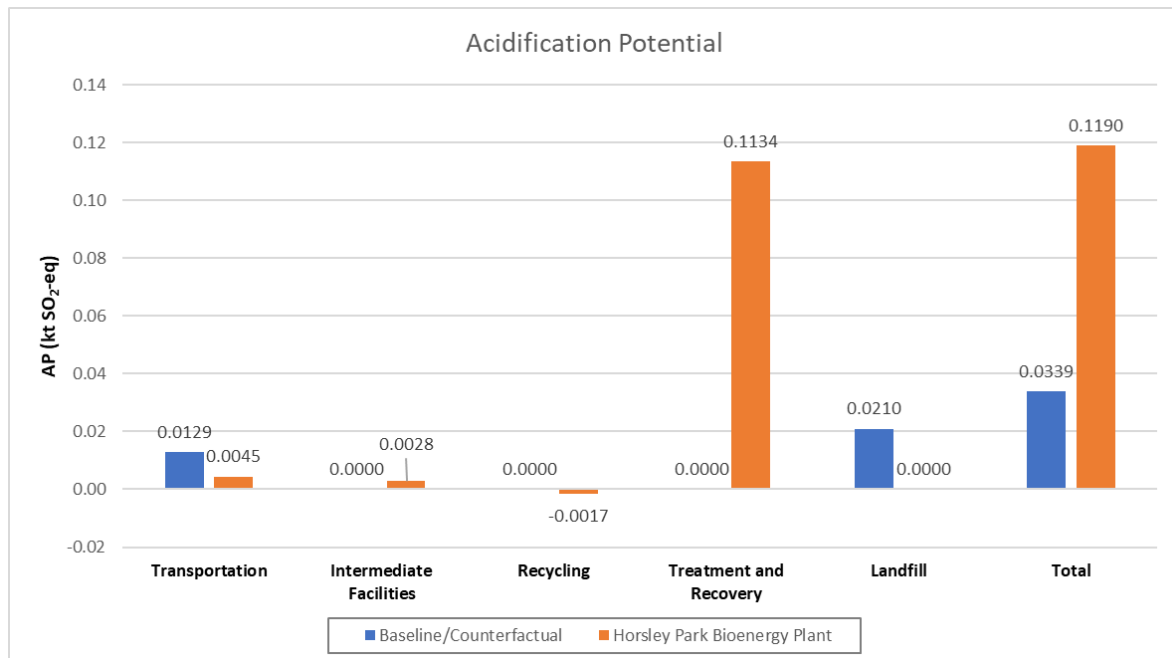


Figure 4 Comparison of AP of Baseline vs Horsley Park Bioenergy Plant

The results from WRATE analysis presented in Figure 4 indicate that the establishment of the Horsley Park Bioenergy Plant would result in environmental burdens associated with acidification potential and treatment and recovery stage would contribute the most to the AP

⁷ Development of the Horsley Park Bioenergy Plant is based on the construction and operation of the biogas plant and its associated infrastructure including the pre-treatment hall.



(0.11 kt SO₂-e per year) impact. This is due to the emissions of ammonia, nitrogen oxides and sulphur oxides associated with the AD process. Some of the nitrogen oxides are associated with the mobile plant and equipment fuel usage, in addition to the process emissions from the plant.

Under the Baseline scenario, transport of organic waste would result in a burden of 0.013 kt SO₂-e per year, however, impacts from the transport of organic waste and residues under the Horsley Park Bioenergy Plant scenario are lower (0.005 kt SO₂-e per year). Landfill disposal of organic waste under the Baseline scenario would result in a burden of 0.021 kt SO₂-e per year. Impacts from the intermediate facilities and from recycling stages are less significant for both the Baseline and the Horsley Park Bioenergy Plant scenarios.

Principal causes of AP burdens include acidifying contaminants such as nitrogen oxide (NO_x) and sulphur oxide (SO_x) emissions to the environment. Under the Baseline scenario, landfill disposal of organic waste would result in release of these contaminants to the environment; however, by establishing the Horsley Park Bioenergy Plant to process the organic waste, the quantity of acidifying contaminants released to the environment would also increase.

Overall, the results from this LCA study indicate that development of the Horsley Park Bioenergy Plant would result in an increased burden in acidification potential impacts (overall AP burden of 0.12 kt SO₂-e per year) compared to the Baseline scenario (overall AP burden of 0.03 kt SO₂-e per year).

4.2.3 Eutrophication potential (EP) impacts

Figure 5 shows results of the WRATE analysis for the EP for the two scenarios assessed in this LCA study for the assessment year 2024.

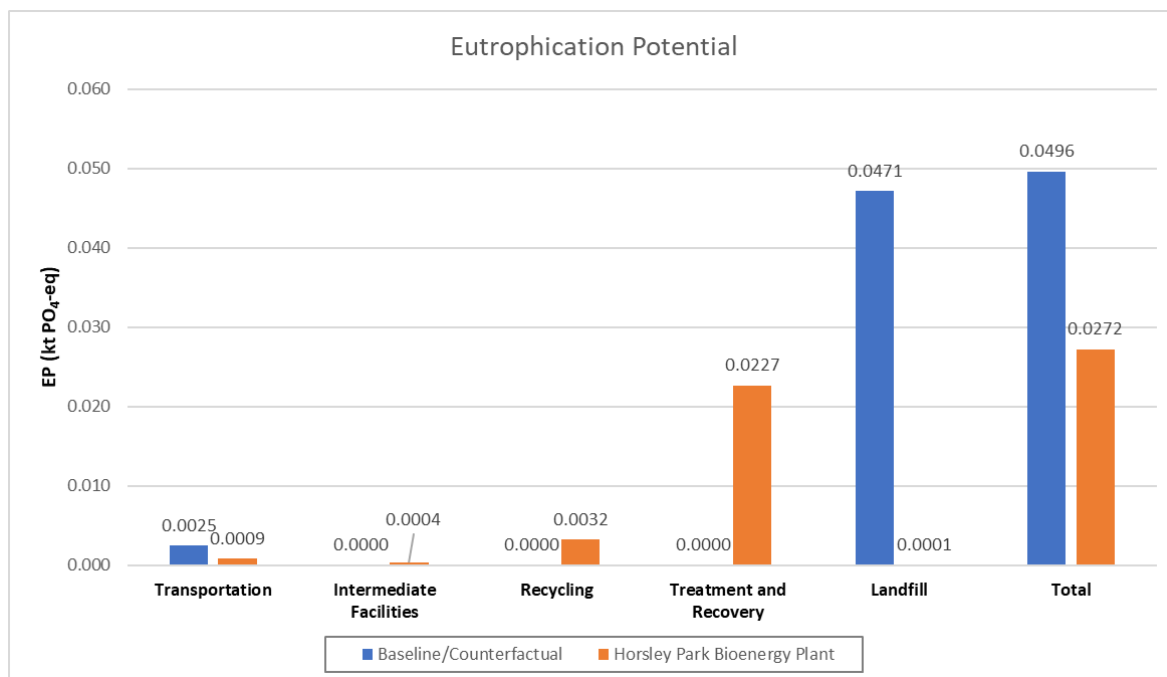


Figure 5 Comparison of EP of Baseline vs Horsley Park Bioenergy Plant

The results from WRATE analysis presented in Figure 5 indicate that landfill disposal of organic waste under the Baseline scenario would result in the most significant burden with respect to EP (0.05 kt PO₄-e per year) impact. However, results from this LCA study also indicate that the development of the Horsley Park Bioenergy Plant would also result in



environmental burdens associated with EP, and treatment and recovery stage would contribute the most to the EP (0.02 kt PO₄-e per year) impact.

The impact from the recycling of solid and liquid digestate under the Horsley Park Bioenergy Plant scenario would result in a burden of 0.003 kt PO₄-e per year. Under the Baseline scenario, transport of organic waste would result in a burden of 0.0025 kt PO₄-e per year; however, impacts from the transport of organic waste and residues under the Horsley Park Bioenergy Plant scenario are relatively lower (0.0009 kt PO₄-e per year). Impacts from the intermediate facilities are less significant for both the Baseline and the Horsley Park Bioenergy Plant.

EP is an indicator of the enrichment of the ecosystem with nutritional elements, due to the emission particularly of nitrogen or phosphorus containing compounds. Treatment and recovery of waste at the Horsley Park Bioenergy Plant would reduce emissions of these compounds, particularly from reducing direct gaseous emissions through exhaust treatment systems from the biogas engine generator. Furthermore, reducing the amount of waste applied to land and to landfill through leachate flows or runoff would contribute towards this indicator.

Overall, the results from this LCA study indicate that development of the Horsley Park Bioenergy Plant waste would result in a reduction in EP impact (overall EP burden of 0.03 kt PO₄-e per year) compared to the Baseline scenario (overall EP burden of 0.05 kt PO₄-e per year).

4.2.4 Freshwater aquatic ecotoxicity potential (FAETP)

Figure 6 shows results of the WRATE analysis of the FAETP for the two scenarios assessed in this LCA study for the assessment year 2024.

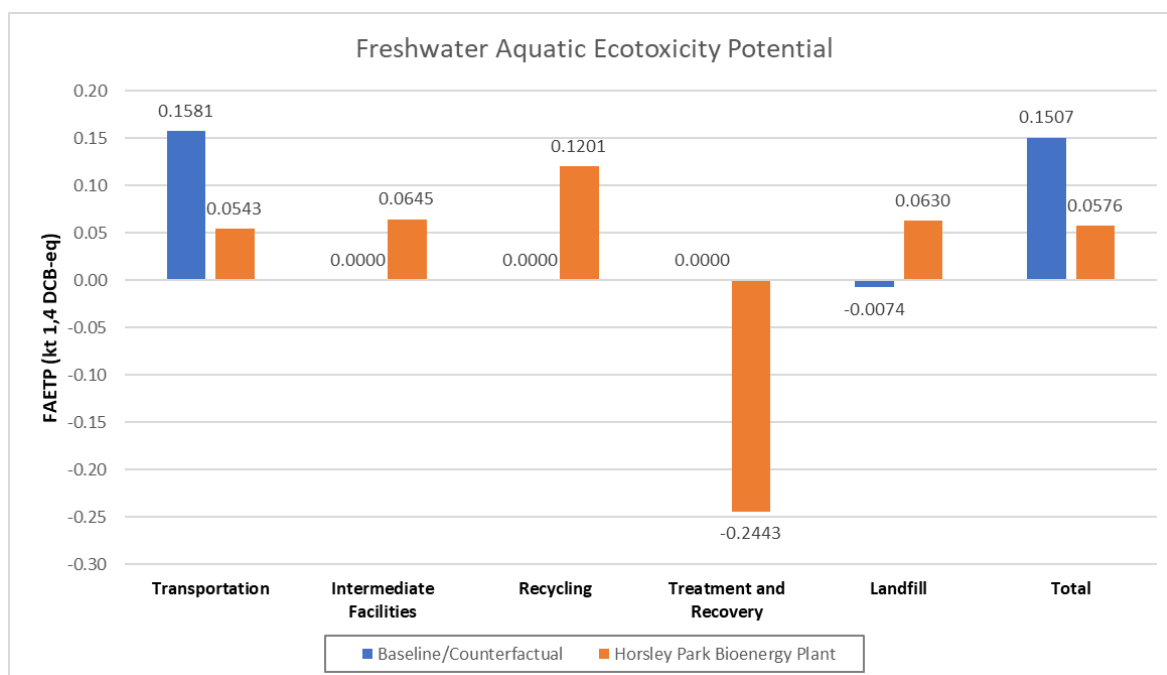


Figure 6 Comparison of FAETP of Baseline vs Horsley Park Bioenergy Plant

Based on the results from WRATE analysis as indicated in Figure 6, it is noted that treatment and recovery, i.e., anaerobic digestion of waste at the Horsley Park Bioenergy Plant, would



result in a significant reduction of impacts with respect to FAETP (0.24 kt 1,4-DCB-e per year) impact.

The results also indicate that recycling stage (i.e., application of solid and liquid digestate) would result in the most significant burden respect to FAETP (0.12 kt 1,4-DCB-e per year) impact. This is likely attributed to the fact that in the WRATE analysis, liquid digestate was assumed to be disposed of to sewer; however, SLR understands that the expected utilisation pathway for the liquid digestate from the Horsley Park Bioenergy Plant could either be land application or disposal to sewer. WRATE modelling of liquid digestate to sewer in this LCA study represents a 'worst case' scenario for liquid digestate management. This is considered an appropriate but necessarily conservative approach due to the limitations of the WRATE tool.

Under the Baseline scenario, transport of organic waste would result in a burden of 0.16 kt 1,4-DCB-e per year, however, impacts from the transport of organic waste and residues under the Horsley Park Bioenergy Plant scenario are relatively lower (0.05 kt 1,4-DCB-e per year). The impact from the intermediate facilities under the Horsley Park Bioenergy Plant scenario would result in a burden of 0.06 kt 1,4-DCB-e per year and landfill disposal of rejects would also result in a burden of 0.06 kt 1,4-DCB-e per year. However, this is a somewhat hypothetical result as the organic waste (the source of contamination) represents a smaller quantity (compared to what has been modelled) and the fact that strict biosecurity controls, including a purpose-built de-packaging unit and the application of nutrient management plans will ensure that water concentrations remain within safe limits. It is also noted that though all rejects are destined to landfill within the WRATE software, further processing of the rejects to capture potential recovered materials, namely non-ferrous metals, could result in increased environmental benefits.

Overall, the results from WRATE analysis indicate that development of the Horsley Park Bioenergy Plant would result in a reduction with respect to freshwater aquatic ecotoxicity potential impact (overall burden of 0.06 kt 1,4-DCB-e per year) compared to the Baseline scenario (overall avoided burden of 0.15 kt 1,4-DCB-e per year).

4.2.5 Human toxicity potential (HTP)

Figure 7 shows results of WRATE analysis for the HTP for the two scenarios assessed in this LCA study for the assessment year 2024.



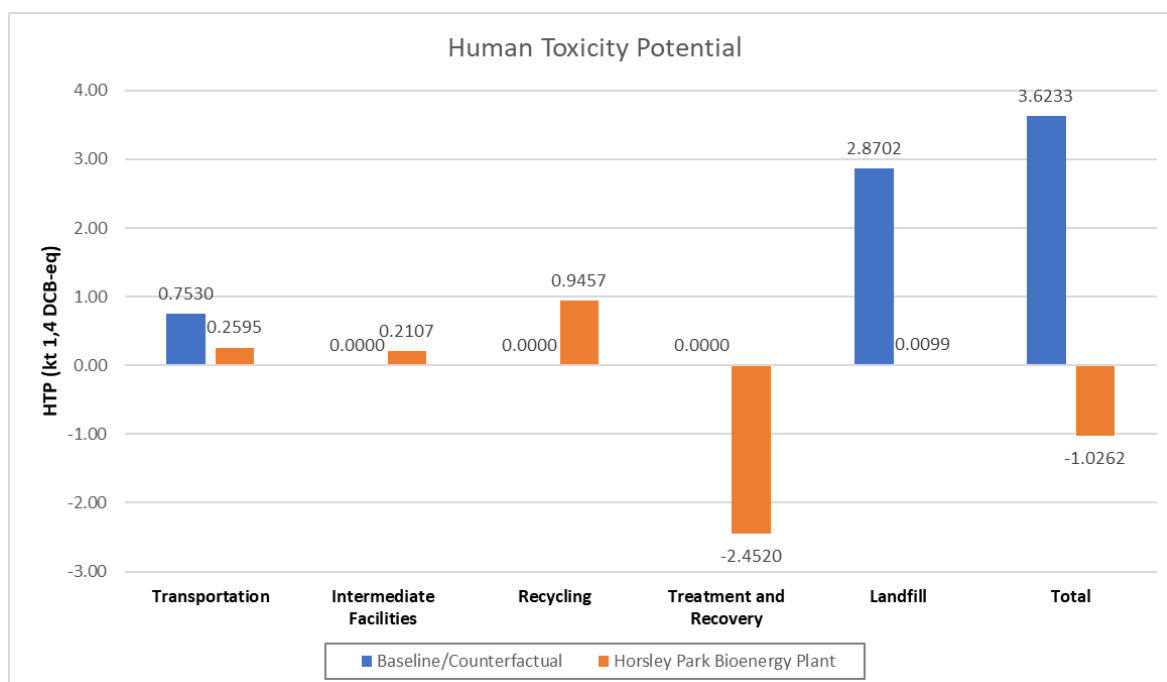


Figure 7 Comparison of HTP of Baseline vs Horsley Park Bioenergy Plant

Based on the results from WRATE analysis as indicated in **Figure 7**, it is noted that treatment and recovery stage would result in an avoided burden of 2.45 kt 1,4-DCB-e per year. It is also noted that recycling i.e., direct land application of solid digestate would result in the most significant burden with respect to HTP (0.946 kt 1,4-DCB-e per year) impact. This trend is common to most AD projects whereby digestate is applied to land and is presumably because the model assumes an accumulation of heavy metals and other potentially toxic elements in the soil and crops. This is a somewhat hypothetical result as the potential accumulations of heavy metal will be limited for the project case.

Transportation of organic waste to the Horsley Park Bioenergy Plant and residue to the landfill would also result in burden impacts (0.26 kt 1,4-DCB-e per year), followed by intermediate facilities (0.21 kt 1,4-DCB-e per year). Landfill disposal of waste would result in HTP burden in both the Baseline scenario (2.87 kt 1,4-DCB-e per year) and the Horsley Park Bioenergy Plant scenario (0.01 kt 1,4-DCB-e per year).

Overall, the results from WRATE analysis indicate that with respect to HTP, development of the Horsley Park Bioenergy Plant would result in a significant reduction in HTP impacts (overall avoided burden of 1.03 kt 1,4-DCB-e per year) compared to the Baseline scenario (overall burden of 3.62 kt 1,4-DCB-e per year).

4.2.6 Resources: depletion of abiotic resources

Figure 8 shows results of the WRATE analysis for the depletion of abiotic resources for the two scenarios assessed in this LCA study for the assessment year 2024.



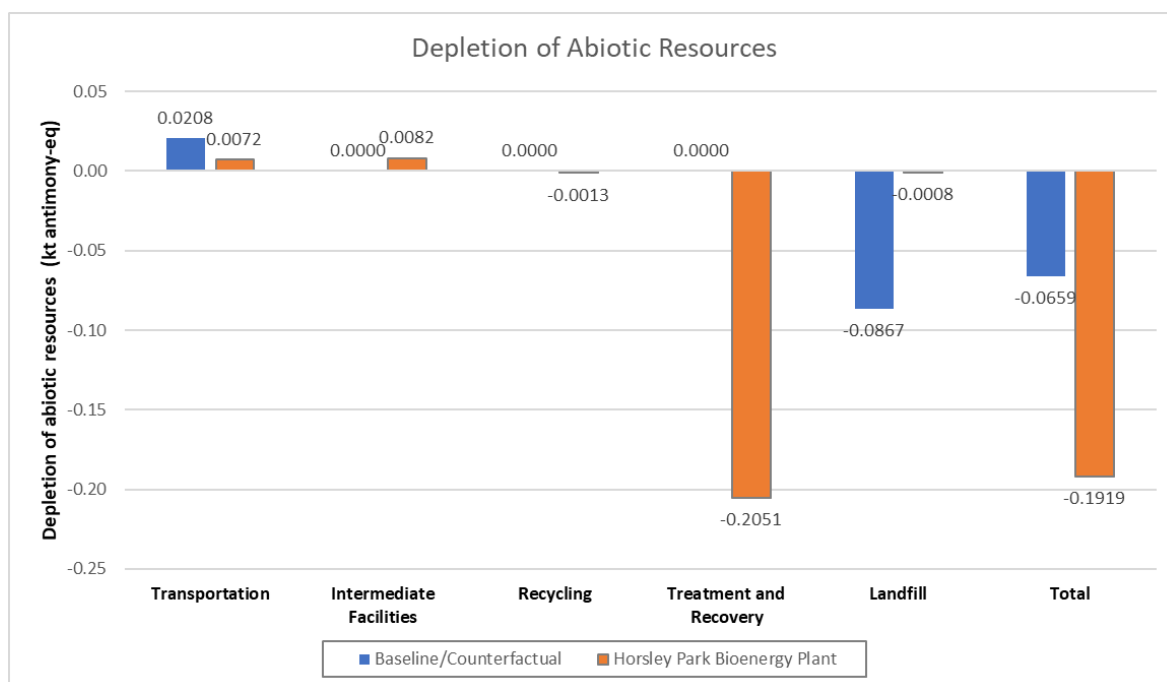


Figure 8 Comparison of Resources: depletion of abiotic resources of Baseline vs Horsley Park Bioenergy Plant

Based on the results from WRATE analysis as indicated in **Figure 8**, it is noted that treatment and recovery stage at the Horsley Park Bioenergy Plant would result in the most significant avoided burdens associated with depletion of abiotic resources (0.21 kt Sb-e per year) impact. This is expected, as the development of the Horsley Park Bioenergy Plant supports material and energy recovery, hence reduces the environmental impacts associated with the use of primary raw materials, including fossil and non-fossil resources. This is demonstrated through the use of waste-derived fuel during anaerobic digestion and replacement of grid-sourced electricity with power from the biogas plant hence avoiding the use of resource-intensive fossil energy sources (natural gas, oil and coal).

It is also noted from results from WRATE analysis that landfill disposal would also result in avoided burdens (e.g., 0.001 kt Sb-e per year for the Horsley Park Bioenergy Plant). This is likely attributed to the assumption that the landfill would capture landfill gas and generate electricity, which would reduce the environmental impacts associated with the use of primary raw materials, including fossil and non-fossil resources during grid electricity generation.

Burdens associated with abiotic resource depletion impacts from transport considerations of waste and residues, from intermediate facilities, and from recycling stages are less significant under both scenarios.

Overall, the results from WRATE analysis indicate that development of the Horsley Park Bioenergy Plant would result in a significant reduction in environmental impacts associated with depletion of abiotic resources (overall avoided burden of 0.19 Sb-e per year) compared to the Baseline scenario (overall avoided burden of 0.066 kt Sb-e per year).



4.3 Sensitivity Results

4.3.1 Landfill Gas Recovery

Sensitivity analysis was undertaken on assumed landfill gas capture efficiency for the landfill processes within both Baseline/Counterfactual Scenario and Horsley Park Bioenergy Plant scenarios.

To address the uncertainties around actual landfill gas capture rates reported at landfill site, a comparison was undertaken in this LCA to assess the environmental impacts for the different LFG capture rates: Baseline (LFG capture rate of 37%) and Alternative Baseline (higher LFG capture rate of 70%).

A higher LFG capture rate (70%) would result in overall reduction in environmental burdens for four (4) out of the six (6) impact categories assessed for the Horsley Park Bioenergy Plant scenario. The detailed result from the LCA for this sensitivity analysis for each impact category is presented **Appendix A**.

4.3.2 Marginal Energy Mix

The electricity grid mix was utilised as the baseline energy mix for energy consumption in processes. The carbon intensive energy sources were used as the marginal energy mix; the premise being that non-renewable sources would be reduced or “turned down” as energy from the Horsley Park Bioenergy Plant becomes baseload energy (i.e., where renewable energy is available, and its use would be prioritised over combustion of fossil fuels). However, as suggested by the peer review process, a second sensitivity analysis was undertaken by changing the marginal fuel mix to equal the baseline electricity grid mix for both Baseline/Counterfactual scenario and Horsley Park Bioenergy Plant scenario.

The results of using electricity grid mix as the marginal energy mix indicates a reduction in environmental burdens for five (5) out of the six (6) impact categories assessed for the Horsley Park Bioenergy Plant scenario. However, when the electricity grid mix is applied to the marginal energy mix, the overall balance of the results between scenarios remains unaffected. The detailed results from the LCA for this sensitivity analysis for each impact category are presented **Appendix B**.

4.4 Summary of Results

Table 9 shows a summary of the total LCIA burdens from the WRATE analysis of the two principal scenarios evaluated (150,000 tpa of waste input).

Table 9 Summary of total LCIA burdens (150,000 tpa of waste input)

Scenario	Global Warming Potential kt CO ₂ -e	Acidification Potential kt SO ₂ -e	Eutrophication Potential kt PO ₄ -e	Freshwater Aquatic Ecotoxicity Potential kt 1,4-DCB-e	Human Toxicity Potential kt 1,4-DCB-e	Resources depletion kt Sb-e
Baseline	87.60	0.03	0.05	0.15	3.62	-0.07
Horsley Park Bioenergy Plant	-21.70	0.12	0.03	0.06	-1.03	-0.19



The results indicate that the Horsley Park Bioenergy Plant would result in a reduction in environmental burdens for five (5) out of the six (6) impact categories assessed. Significant avoided burdens would be achieved from the GWP impact category.

5.0 Life Cycle Interpretation

Section 4.0 presents results from the WRATE analysis of the principal scenarios assessed (150,000 tpa of waste input). The results indicate the following:

- Transport of waste and intermediate facilities (i.e., de-packaging unit) stages would result in the least impacts for most of the six environmental impact categories assessed in this LCA study. The low average distances adopted for transport of waste and residues and the vehicle payloads would contribute to the low impacts or avoided burdens associated with transport. Furthermore, as the pre-treatment process is likely to be powered by the AD parasitic load for the majority of the time, the impacts associated with the intermediate facilities are likely to be lower in practice.
- For the Horsley Park Bioenergy Plant scenario, recycling stage i.e., application of solid and liquid digestate, would result in burdens for the EP, FAETP and HTP categories; however, this is partly due to the fact that benefits from the recycling of liquid digestate (i.e., land application of liquid digestate as fertiliser) have not been included in the high-level WRATE modelling. During the operation of the Horsley Park Bioenergy Plant, the application of digestate to land will be conducted in accordance with nutrient management plans to ensure that soil concentrations remain within safe limits.
- Treatment and recovery stage, i.e., processing of organic waste at the Horsley Park Bioenergy Plant and utilisation of energy recovered from biogas as electricity, would result in avoided burdens for the GWP, FAETP, HTP and Depletion of resources impact categories; however, it is also noted that the Horsley Park Bioenergy Plant would result in burdens for the AP and EP impact categories.
- Impacts from landfill disposal of waste would be significant in most of the impact categories assessed. The Horsley Park Bioenergy Plant would result in a reduction of waste volumes sent to landfill, reducing landfill impacts (as shown by the comparison against the Baseline scenario).

Overall, the results from WRATE analysis indicate that development of the Horsley Park Bioenergy Plant would result in a significant reduction in environmental impacts for five (5) out of the six (6) impact categories assessed. The Baseline scenario would seem to perform better than the Horsley Park Bioenergy Plant scenario for the AP impact category only.

6.0 Study Limitations

This study has been undertaken based on design data provided by Austral Brick. While design development can result in potential changes to the proposed operating conditions, the results of this LCA may not always reflect the actual operating conditions of the Horsley Park Bioenergy Plant. WRATE software, within the limitation of the tool, was used to create a representation of the AD plant and to compare with the Baseline scenario of landfill disposal for the purposes of a high level LCA comparison study.

It is noted that the project is intended to use CHP to generate electricity and heat, and clean up the majority of the biogas to produce renewable natural gas to be used in brick kilns. However, the high-level WRATE AD model assumes the all biogas is used in CHP engine to generate electricity and heat.



Moreover, in this LCA study using WRATE analysis, liquid digestate was assumed to be disposed to sewer; however, SLR understands that the proposed utilisation pathway for the liquid digestate from the Horsley Park Bioenergy Plant could be potentially land application, which would in turn result in additional avoided burdens associated with avoided production of chemical fertilisers.

As a result, the LCA can be updated using actual operating data following commissioning and annual operating data once the Horsley Park Bioenergy Plant becomes operational.

As noted in the ARENA LCA Guidelines, the scope and quality of the data used for the inventory modelling and analysis are typical limiting factors for the environmental impact assessments.

7.0 Critical Review

The results of the LCA would be communicated to third parties, particularly DPE. According to ISO 14044, if the results of the LCA are to be shared or communicated with any third party other than the commissioner of the LCA study, then a third-party report shall be prepared, and a critical review of the report would be required.

The critical review of the LCA study would need to be conducted by a LCA practitioner. Based on a request from Austral Brick, SLR commissioned Frith Resource Management as the LCA practitioner to undertake the peer review of the LCA report and associated files. The peer review was completed by Paul Frith as lead author and Sarah Lucas as reviewer from Frith Resource Management.

According to the critical review, the LCA study has been carried out to industry standard, in-line with ISO14044:2006, and in a scientifically rigorous and objectively justifiable manner. The two key recommendations received were to undertake a sensitivity analysis on marginal energy mix and to include fossil fuel energy use results. This feedback is addressed in **Section 4.3.2** and **Appendix C** of the report.

The peer view report by Frith Resource Management is presented in **Appendix D**.



8.0 Conclusions

This report presents the LCA for two principal scenarios assessing the current and proposed management of 150,000 tpa of waste. Modelling has been carried out using the UK Environment Agency's life cycle assessment tool WRATE. The modelled scenarios are as follows:

- Scenario 1 – Baseline/Counterfactual (baseline waste management of landfill disposal of solid organic waste and liquid organic waste)
- Scenario 2 – Horsley Park Bioenergy Plant based on an anaerobic digestion process and biogas utilisation for electricity and heat generation in a combined heat and power mode. Electricity and heat generated at the plant would be used for the parasitic load of the plant.

The results of the WRATE modelling demonstrate that approval of the planning application and therefore the processing of 150,000 tpa of waste at the Horsley Park Bioenergy Plant would deliver overall environmental benefits for five out of six impact categories assessed when compared against the current management method (Baseline scenario) which involves landfill disposal of solid organic waste and liquid organic waste.

The Baseline scenario would seem to perform better than the Horsley Park Bioenergy Plant scenario for the Acidification Potential impact category; however, it is noted that the LCA study did not include benefits/impacts from utilisation of liquid digestate as a fertiliser.

On this basis, it is concluded that the proposed Horsley Park Bioenergy Plant would deliver environmental benefits based on the six environmental impact categories assessed.





Appendix A Sensitivity Testing - Landfill Gas Recovery Assumption

Horsley Park Bioenergy Facility

Life Cycle Assessment

The Austral Brick Co Pty Ltd

SLR Project No.: 630.30619.00000

6 November 2024

The results from the LCA for sensitivity analysis on higher LFG capture rate (70%; compared to 37% for the baseline) for each impact category are presented in the following sections.

Sensitivity results - Global warming potential

Figure 9 presents the sensitivity results for WRATE analysis of the GWP impact category for different LFG capture rates: Baseline (37% LFG capture rate) and Alternative Baseline (70% LFG capture rate).

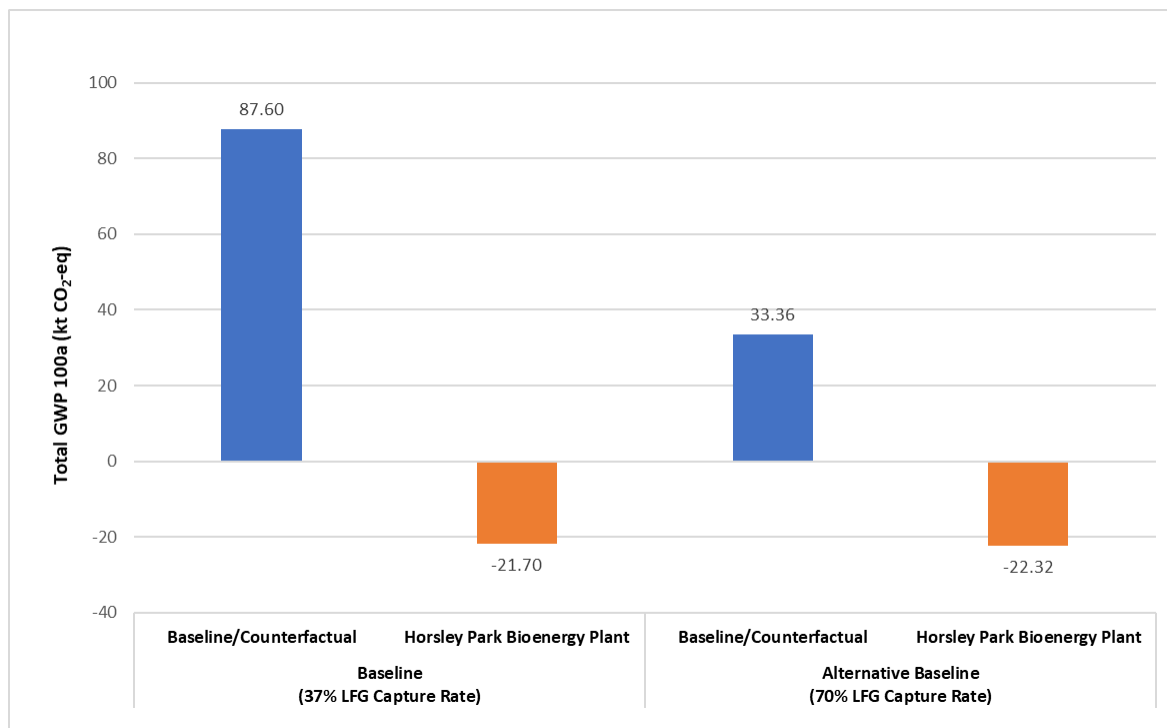


Figure 9 Sensitivity results for GWP

It is noted from **Figure 9** that an increase in LFG capture rate to 70% would still result in overall avoided carbon burdens for the Horsley Park Bioenergy Plant Scenario compared to the Baseline scenario as would be expected from the avoided direct environmental release of LFG emissions.



Sensitivity results – Acidification potential

Figure 10 presents the sensitivity results for the AP impact category for different LFG capture rates: Baseline (37% LFG capture rate) and Alternative Baseline (70% LFG capture rate).

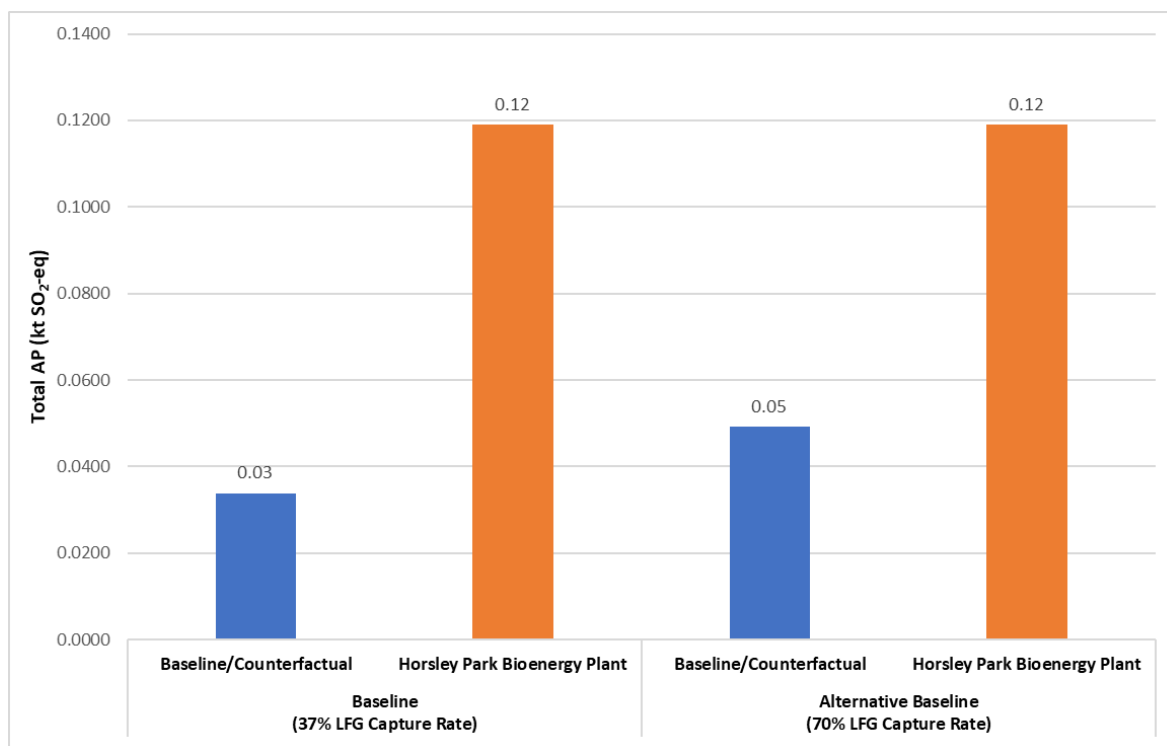


Figure 10 Sensitivity results for AP

Figure 10 shows that the Horsley Park Bioenergy Plant would still result in burden with respect to acidification potential even if an LFG capture rate of 70% is assumed. According to the results from WRATE analysis, LFG capture rate seems to have no significant impact to AP.



Sensitivity results – Eutrophication potential

Figure 11 presents the sensitivity results for the EP impact category for different LFG capture rates: Baseline (37% LFG capture rate) and Alternative Baseline (70% LFG capture rate).

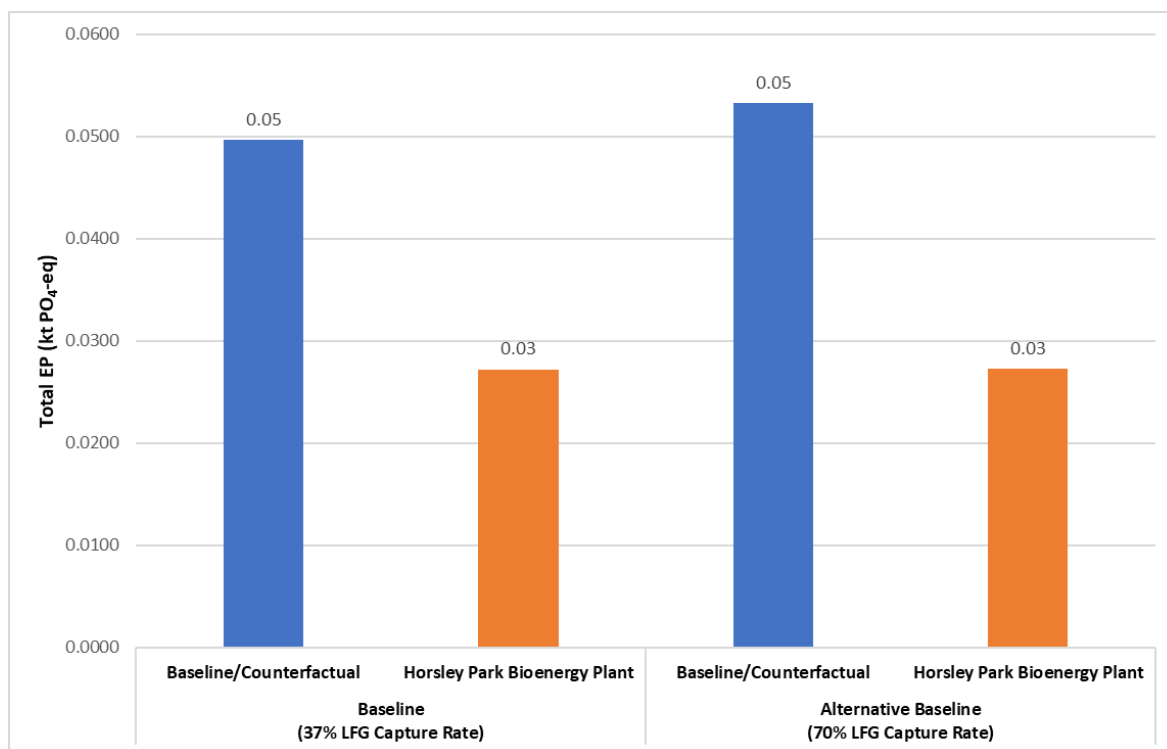


Figure 11 Sensitivity results for EP

Figure 11 shows that the Horsley Park Bioenergy Plant would still result in burden with respect to eutrophication potential even if an LFG capture rate of 70% is assumed. According to the results from WRATE analysis, LFG capture rate seems to have no significant impact to EP.



Sensitivity results – Freshwater aquatic ecotoxicity potential

Figure 12 presents the sensitivity results for the FAETP impact category for different LFG capture rates: Baseline (37% LFG capture rate) and Alternative Baseline (70% LFG capture rate).

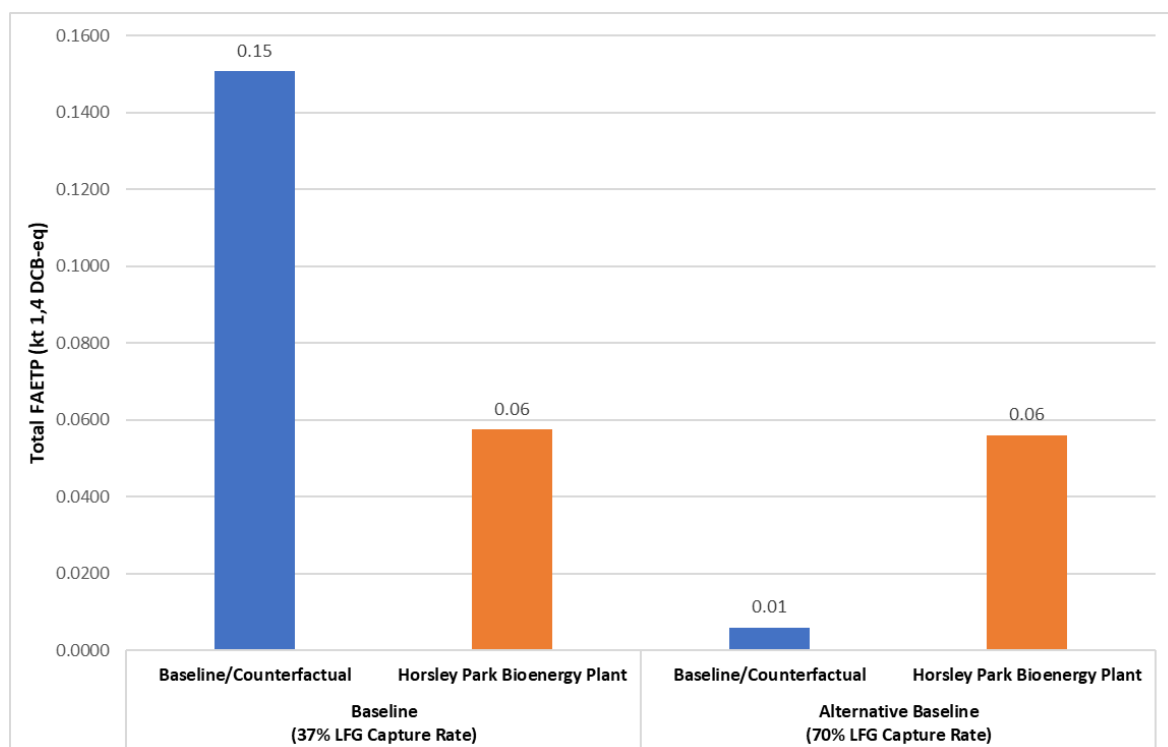


Figure 12 Sensitivity results for FAETP

Figure 12 shows that the Horsley Park Bioenergy Plant would result in burden with respect to freshwater aquatic ecotoxicity potential even if an LFG capture rate of 70% is assumed, with the Baseline scenario of landfill disposal impacts reduced for FAETP with achievement of higher LFG capture rates.

In the sensitivity scenario (i.e., higher LFG capture rate scenario), the FAETP results indicate that the Baseline scenario of landfill disposal impacts is significantly reduced helping the Baseline scenario to perform better than the Horsley Park Bioenergy Plant scenario within the sensitivity test.



Sensitivity results – Human toxicity potential

Figure 13 presents the sensitivity results for the HTP impact category for different LFG capture rates: Baseline (37% LFG capture rate) and Alternative Baseline (70% LFG capture rate).

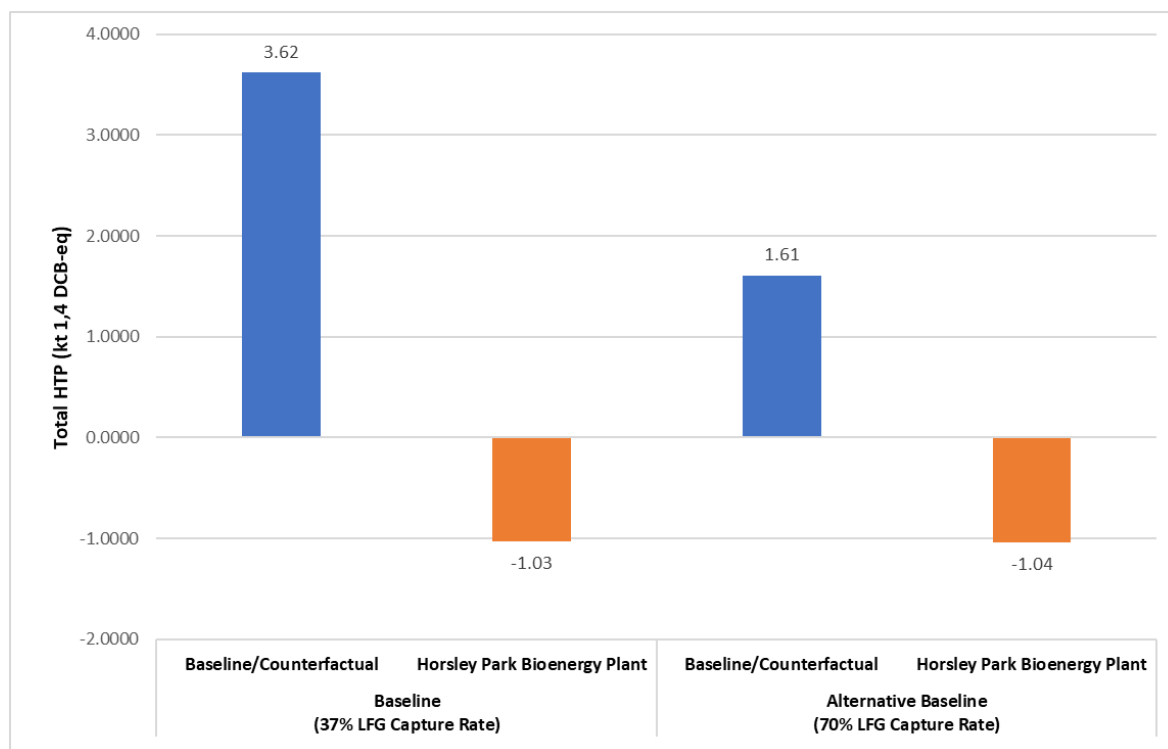


Figure 13 Sensitivity results for HTP

Figure 13 shows that the Horsley Park Bioenergy Plant would still result in overall avoided burdens with respect to human toxicity potential even if an LFG capture rate of 70% is assumed.

Although the Baseline scenario of landfill disposal impacts is reduced in the sensitivity (i.e., higher LFG capture rate) scenario, the Horsley Park Bioenergy Plant scenario continues to perform better than the Baseline scenario within the sensitivity test.



Sensitivity results – Depletion of abiotic resources

Figure 14 presents the sensitivity results for the Resources: depletion of abiotic resources impact category for different LFG capture rates: Baseline (37% LFG capture rate) and Alternative Baseline (70% LFG capture rate).

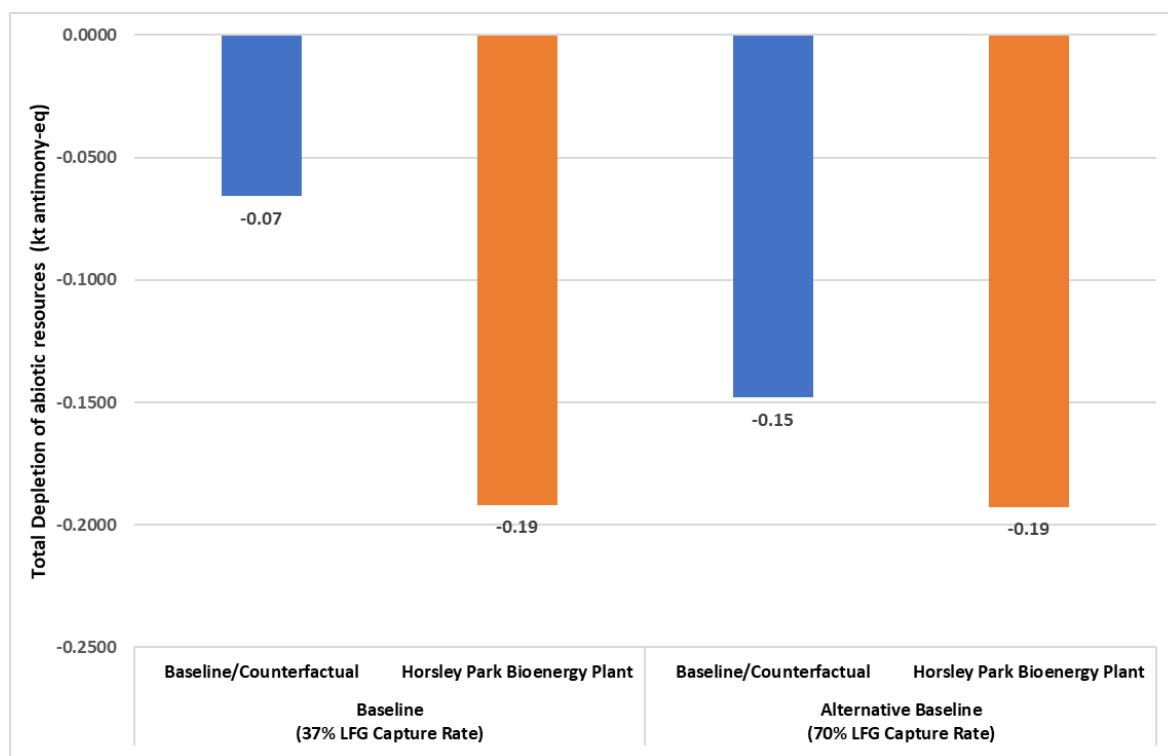


Figure 14 Sensitivity results for depletion of abiotic resources

Figure 14 shows that the Horsley Park Bioenergy Plant would still result in significant overall avoided burdens with respect to depletion of abiotic resources even if an LFG capture rate of 70% is assumed, albeit the differential between the Baseline scenario and Horsely Park scenario are reduced within the sensitivity test of higher LFG capture.

Overall, the Horsley Park Bioenergy Plant scenario continues to perform better than the Baseline scenario of landfill disposal within the sensitivity test.





Appendix B Sensitivity Testing - Marginal Energy Mix Assumption

Horsley Park Bioenergy Facility

Life Cycle Assessment

The Austral Brick Co Pty Ltd

SLR Project No.: 630.30619.00000

6 November 2024

The results from the LCA for sensitivity analysis on marginal energy mix (electricity grid mix; compared to non-renewable energy sources for the baseline) for each impact category are presented in the following sections.

Sensitivity results - Global warming potential

Figure 15 presents the sensitivity results for WRATE analysis of the GWP impact category for different marginal energy mixes: Baseline (non-renewable energy as the marginal energy mix) and Alternative Baseline (electricity grid as the marginal energy mix).

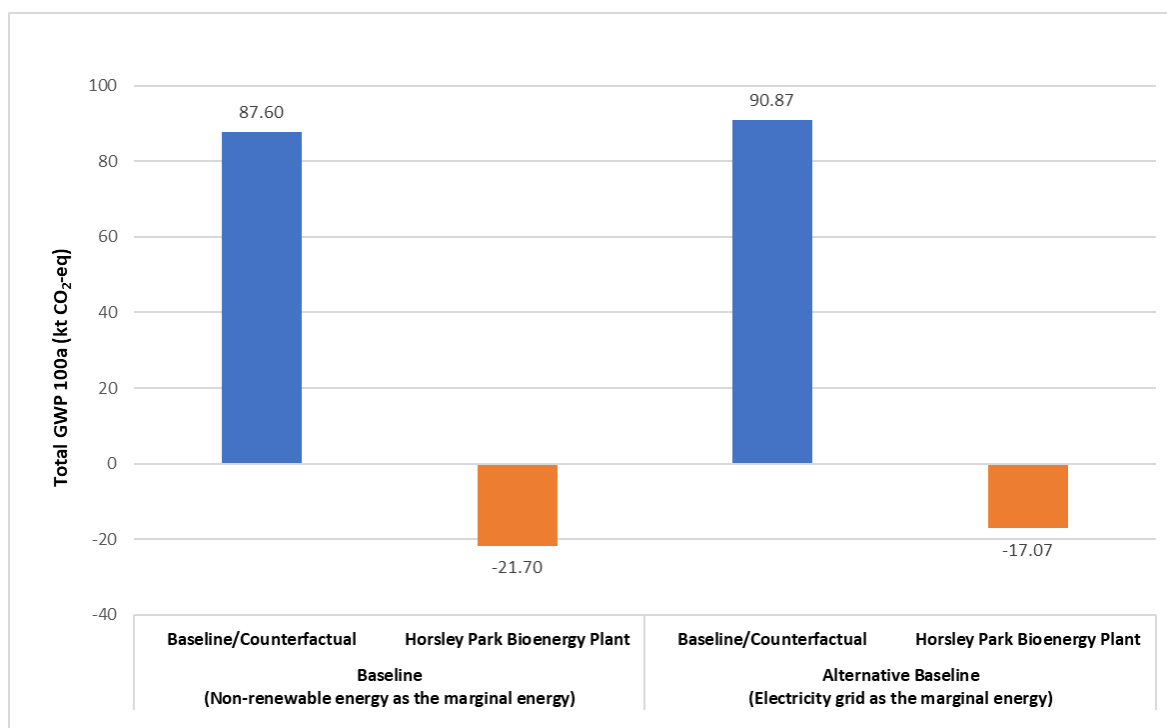


Figure 15 Sensitivity results for GWP

It is noted from **Figure 15** that using electricity grid mix as the marginal fuel mix would still result in overall avoided carbon burden for the Horsley Park Bioenergy Plant scenario compared to the Baseline scenario. According to the results from WRATE analysis, marginal energy mix seems to have no significant impact to GWP.



Sensitivity results – Acidification potential

Figure 16 presents the sensitivity results for the AP impact category for different marginal energy mixes: Baseline (non-renewable energy as the marginal energy mix) and Alternative Baseline (electricity grid as the marginal energy mix).

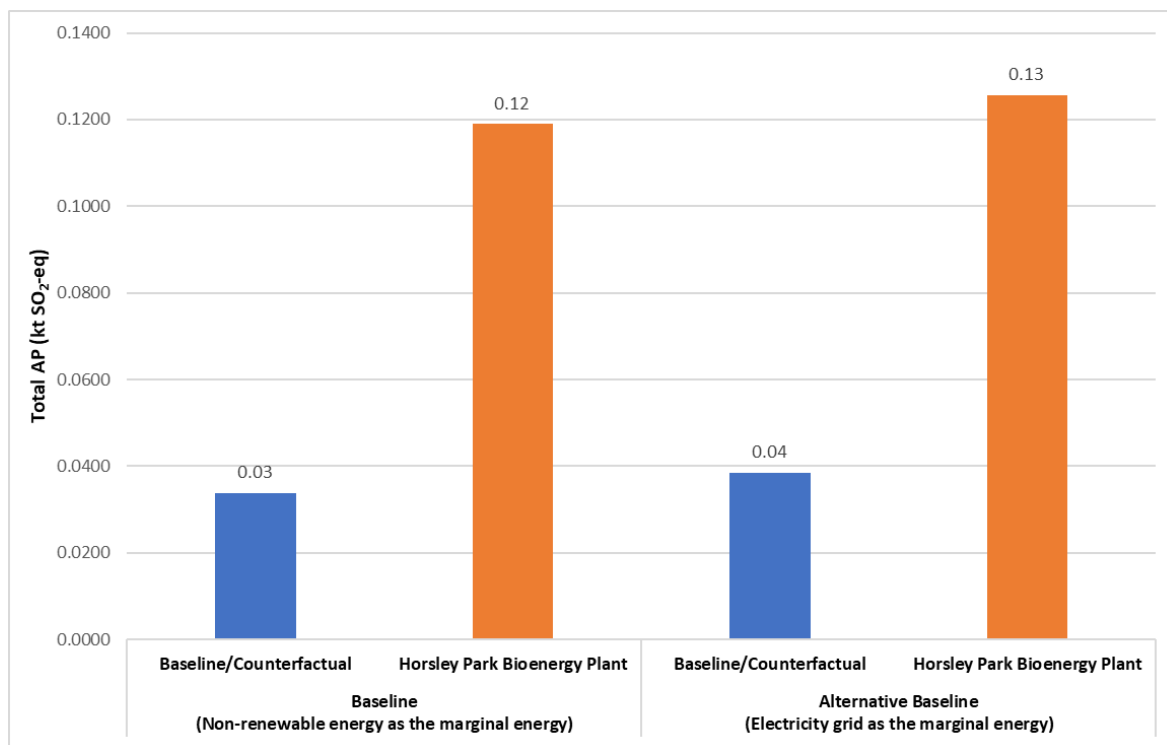


Figure 16 Sensitivity results for AP

Figure 16 shows that the Horsley Park Bioenergy Plant would still result in burden with respect to acidification potential even if electricity grid mix is used as the marginal energy mix. According to the results from WRATE analysis, marginal energy mix seems to have no significant impact to AP.



Sensitivity results – Eutrophication potential

Figure 17 presents the sensitivity results for the EP impact category for different marginal energy mixes: Baseline (non-renewable energy as the marginal energy mix) and Alternative Baseline (electricity grid as the marginal energy mix).

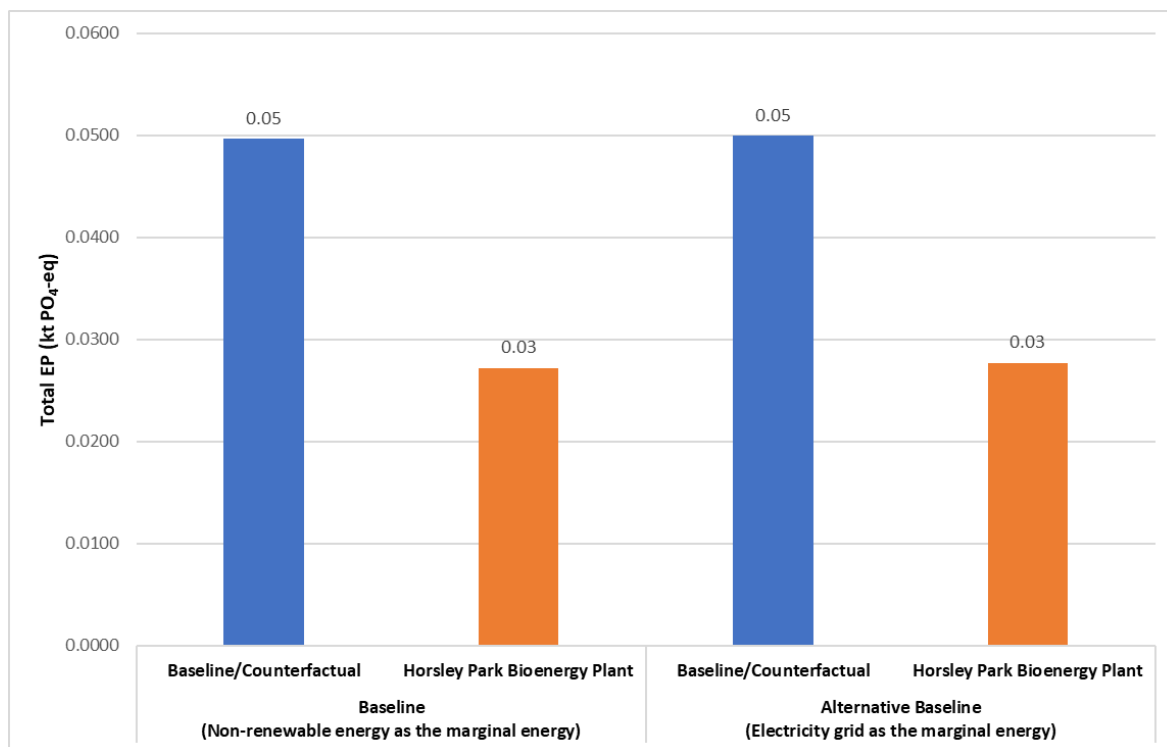


Figure 17 Sensitivity results for EP

Figure 17 shows that the Horsley Park Bioenergy Plant would still result in burden with respect to eutrophication potential even if electricity grid mix is used as the marginal energy mix. According to the results from WRATE analysis, marginal energy mix seems to have no significant impact to EP.



Sensitivity results – Freshwater aquatic ecotoxicity potential

Figure 18 presents the sensitivity results for the FAETP impact category for different marginal energy mixes: Baseline (non-renewable energy as the marginal energy mix) and Alternative Baseline (electricity grid as the marginal energy mix).

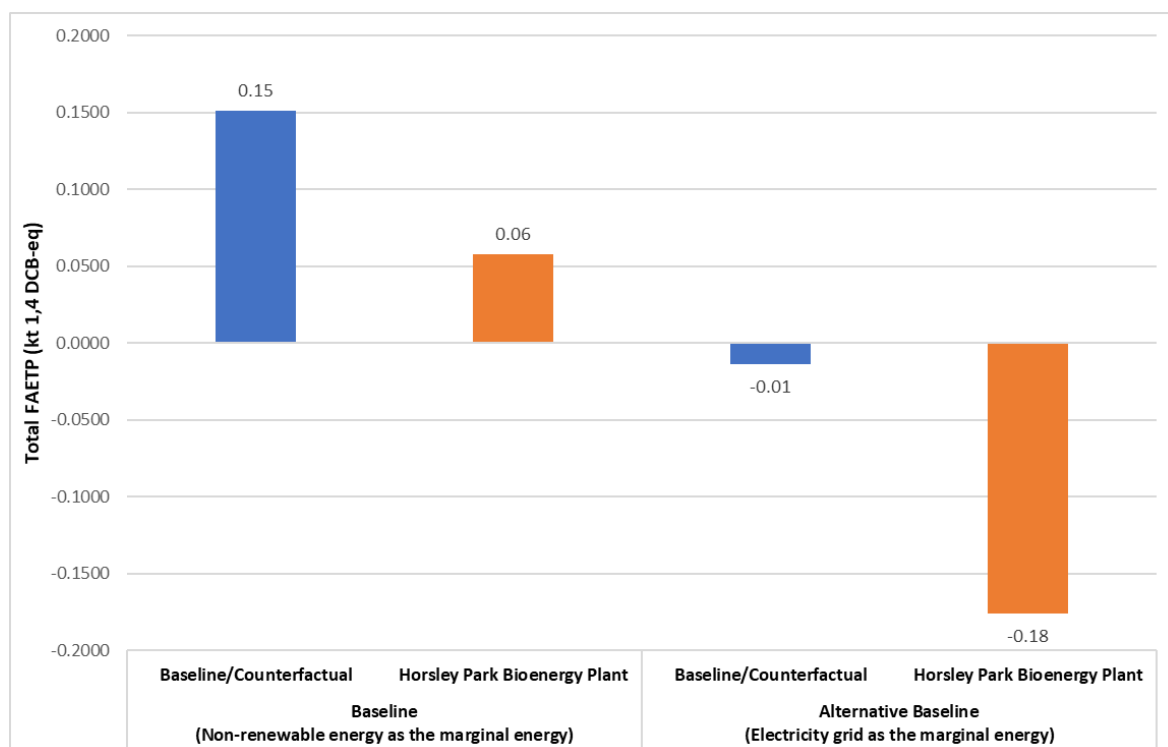


Figure 18 Sensitivity results for FAETP

Figure 18 shows that the Horsley Park Bioenergy Plant would result in avoided burden with respect to freshwater aquatic ecotoxicity potential when electricity grid mix is used as the marginal energy mix.

In the sensitivity scenario (i.e., electricity grid as the marginal energy mix), the FAETP results indicate that the Baseline scenario of landfill disposal impacts is also reduced (and becomes an avoided burden); however, the difference between the two scenarios is increased within the sensitivity test, thus helping the Horsley Park Bioenergy Plant scenario to perform even better than the Baseline scenario of landfill disposal.



Sensitivity results – Human toxicity potential

Figure 19 presents the sensitivity results for the HTP impact category for different marginal energy mixes: Baseline (non-renewable energy as the marginal energy mix) and Alternative Baseline (electricity grid as the marginal energy mix).

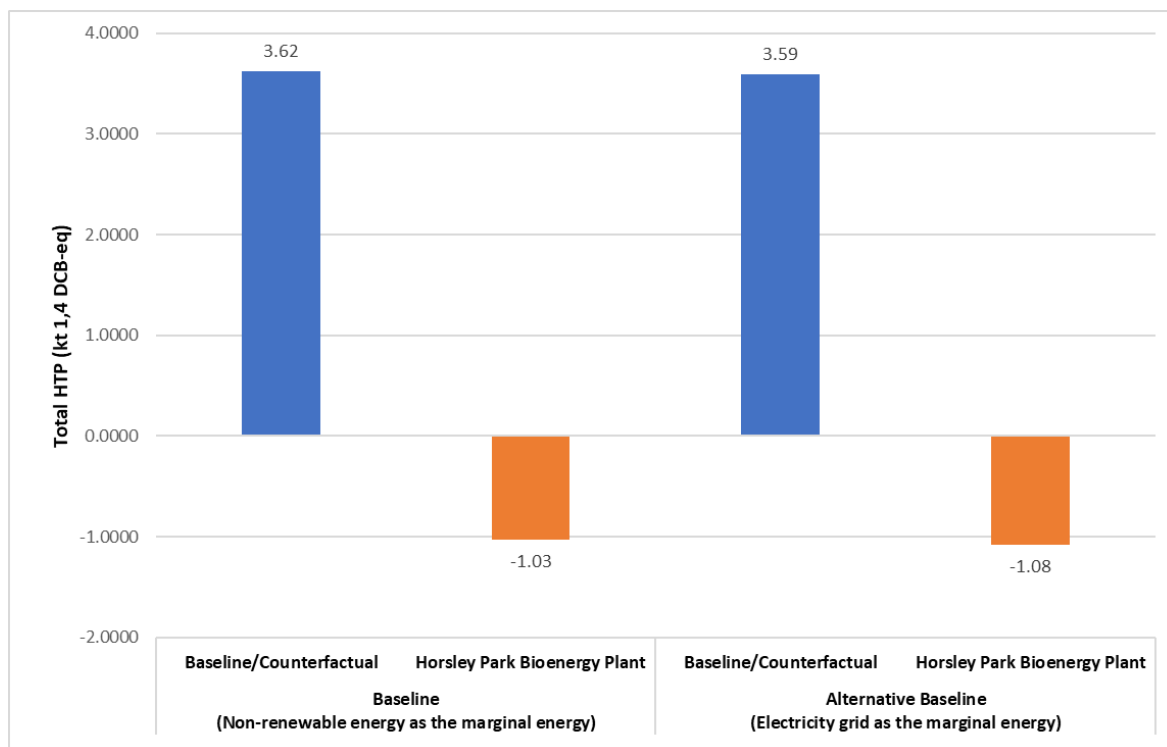


Figure 19 Sensitivity results for HTP

Figure 19 shows that the Horsley Park Bioenergy Plant would still result in overall avoided burdens with respect to human toxicity potential even if electricity grid mix is used as the marginal energy mix. According to the results from WRATE analysis, marginal energy mix seems to have no significant impact to HTP.



Sensitivity results – Depletion of abiotic resources

Figure 20 presents the sensitivity results for the Resources: depletion of abiotic resources impact category for different marginal energy mixes: Baseline (non-renewable energy as the marginal energy mix) and Alternative Baseline (electricity grid as the marginal energy mix).

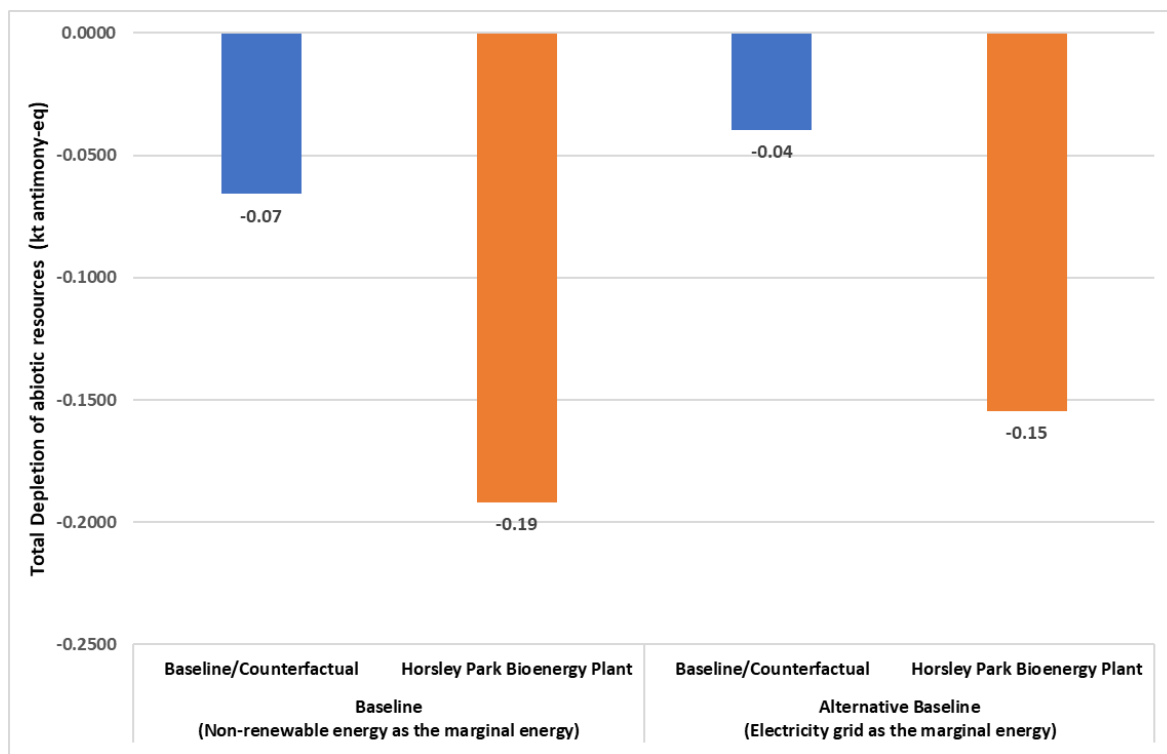


Figure 20 Sensitivity results for depletion of abiotic resources

Figure 20 shows that the Horsley Park Bioenergy Plant would still result in significant overall avoided burdens with respect to depletion of abiotic resources even if electricity grid mix is used as the marginal energy mix, although the differential impacts between the Baseline scenario of landfill disposal and Horsely Park scenario are slightly reduced within the sensitivity test.

Overall, the Horsley Park Bioenergy Plant scenario continues to perform better than the Baseline scenario of landfill disposal within the sensitivity test.





Appendix C Fossil Fuel Energy Use

Horsley Park Bioenergy Facility

Life Cycle Assessment

The Austral Brick Co Pty Ltd

SLR Project No.: 630.30619.00000

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The fossil fuel energy used for each scenario was calculated based on total net calorific value (MJ) of fossil fuel energy (coal / oil / gas) used to obtain the delivered energy resource. It was expected that fossil fuel would be used during transportation, intermediate facilities (i.e., de-packaging unit) and treatment and recovery stages (i.e., Horsley Park AD process). In order to calculate the fossil fuel energy used during transportation stage, a net calorific value (NCV) of 36 MJ/l was used.⁸

The results of the fossil fuel energy used are as follows:

- Under the baseline scenario of landfill diversion, approximately 14,974,368 MJ of fossil fuel is expected to be used, while approximately 16,023,027 MJ of fossil fuel is expected to be used for the Horsley Park Bioenergy Plant scenario. However, as discussed in **Section 4.2.1**, this fossil fuel usage would in effect be offset during the treatment and recovery stage of the Horsley Park Bioenergy Plant.
- According to the findings from WRATE analysis, landfill gas capture rate has no impact to the fossil fuel energy use results, as expected.
- The results also indicated that the fossil fuel energy use results remain the same, even if electricity grid mix is used as the marginal energy mix, as expected.

⁸ a NCV of 36 MJ/l diesel fuel from https://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html.





Appendix D Peer Review Report

Horsley Park Bioenergy Facility

Life Cycle Assessment

The Austral Brick Co Pty Ltd

SLR Project No.: 630.30619.00000

6 November 2024

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**Horsley Park Bioenergy Plant - LIFE
CYCLE ASSESSMENT - PEER REVIEW**

28th October 2024

Acknowledgements:

Frith Resource Management would like to thank the essential contributions and responses from the LCA study authors at SLR, namely Bithi Roy.

Disclaimer:

Frith Resource Management Ltd (FRM) is an independent waste and resource management consultancy providing advice in accordance with the project brief. FRM has taken all reasonable care and diligence in the preparation of this report to ensure that all facts and analysis presented are as accurate as possible within the scope of the project. However no guarantee is provided in respect of the information presented, and FRM is not responsible for decisions or actions taken on the basis of the content of this report.

For and behalf Frith Resource Management

Frith, Paul,
FCIWM

Lucas, Sarah
Senior Consultant

Lead Author

Frith Resource Management

Reviewer

Frith Resource Management

File name: 281024 SLR004 Review Report v0.2i ED

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1 Introduction

Frith Resource Management Ltd (FRM) were tasked with providing an expert peer review for a life-cycle analysis study carried out by SLR Consulting for Austral Brick Co Pty Ltd (Austral Brick) to develop Horsley Park Bioenergy Facility.

FRM has delivered WRATE assessments for a range of treatment processes and waste collection arrangements to support due diligence assessments, procurements and options appraisals. Clients include local authorities, consultancies and waste management contractors. Our capability statement for carbon modelling is attached for reference (Appendix A). Example WRATE projects have included:

- Assessment for a prospective EfW in Glasgow
- Assessment for Hay Hall gasification development and the Port Clarence EfW
- Review of WRATE analysis on a pyrolysis process treating waste plastics
- Review of anaerobic digestion (AD) process developed for Agrivert (UK)
- Assessment of different food and garden waste collection and treatment systems for central Government (Defra) in the UK
- Carbon evaluation of tenders for residual household waste treatment (various Councils)

The Life Cycle Assessment (LCA) peer reviewed within this report supports the regulatory assessment process, in particular the Environmental Impact Statement (EIS) for the project application by Austral Brick to develop the Horsley Park Bioenergy Facility at 780 Wallgrove Road, Horsley Park, New South Wales, in accordance with the Australian Renewable Energy Agency guidance Life Cycle Assessment of Bioenergy Products and Projects (ARENA, 2016). For a detailed understanding of this project and the study itself, the reader is referred to the Horsley Park Bioenergy, Life Cycle Assessment Report prepared by SLR Consulting.

1.1 Review Process and Workflow

In the first instance, all the information and assumptions used to construct the original WRATE model, along with the actual WRATE model (as a .lca file) were requested from SLR Consulting. The information received comprised of a spreadsheet (file name: SLR_LCA_Mass Balance - WRATE Input Data & Results_BR 8.xlsx) containing relevant calculations and inputs for the WRATE model, .lca file for the model itself (and the sensitivity analysis model), and the current draft of the Life Cycle Assessment Report prepared for Austral Brick (file name: 630.30619.00000-R01-v3.0-20240923.pdf). As specified in the proposal and correspondence with SLR Consulting, this verification and review was carried out in accordance with ISO 14044:2006 (see overleaf for an extract for the document).

The information received was carefully reviewed, the references and calculations were checked accordingly and traced back to original sources for verification. The .lca file was also explored in detail, testing out various parts of the model and checking input data, modifications of background allocation

tables and ensuring the outputs were being generated correctly. The assumptions highlighted in the main report and the spreadsheet were carefully examined to ensure they were scientifically rigorous, justifiable, and suitable for the Horsley Park Bioenergy Facility.

ISO14044:2006: *“The critical review process shall ensure that the methods used to carry out the LCA are consistent with this International Standard, the methods used to carry out the LCA are scientifically and technically valid, the data used are appropriate and reasonable in relation to the goal of the study, the interpretations reflect the limitations identified and the goal of the study, and the study report is transparent and consistent.”*

2 Detailed Reviewer Feedback

The methods used to carry out the LCA are consistent with ISO14044:2006, whereby the goal and scope are outlined and defined clearly. Moreover, the System boundary, Functional Unit and Reference System are also defined clearly. The inventory used and the processes used are described clearly, and where required, the modifications made to parts of the model have been outlined clearly and accompanied with calculations and supporting references. Similarly, the impact categories and data quality criteria are included within the report as well. In accordance with ISO14044:2006, benefits of the Horsley Park Bioenergy Facility are specified and highlighted by deriving various impact assessments, and not a single overall score or number. The Method and guidance for undertaking lifecycle assessment (LCA) of bioenergy products and projects (ARENA) LCA method was also referred to in the undertaking of this review.

2.1 Assumptions and Methodology

The model is described as a high-level Life Cycle Assessment at various points within the SLR report, and assumptions provided around the management route of the digestate generated, indicative composition of the input wastes, and the energy mix (baseline and marginal) are largely sufficiently justified and referenced and where further supporting evidence was required or further sensitivity analysis warranted in our view, these have been provided.

There was an additional sensitivity analysis requested for the marginal energy mix from the SLR model. The assumption was that all electricity generated from the AD process would displace fossil fuel derived electricity (only), and not the actual carbon intensity of the New South Wales electricity grid (which also includes a significant element of solar derived electricity for example). This assumption was queried, and the reasoning was “because the premise being that non-renewable sources would be turned down as energy from AD becomes baseload energy” [email dated 24/10/24]. This is a reasonable rationale, however there may be other influences on the composition of the electricity grid which affect the assumption. Therefore, SLR also provided a sensitivity analysis model (model 8b) in response to our query, where the baseline electricity mix was also applied to the Marginal Energy mix (and therefore more consistent with the carbon intensity of the New South Wales electricity). This showed lower performance by both the AD plant (for example by c.4.5kt of CO₂ equivalent) and the landfill (by c.3kt of CO₂ equivalent), but it does not affect the overall balance of the results or the conclusions.

Where background allocation tables for various WRATE processes have been modified, these have been either based on client data, and/or appropriately referenced literature. Furthermore, checking these data within the .lca WRATE file indicate that these modifications have been made correctly.

Horsley Park Bioenergy Facility workflows provided (from feedstock delivery to the AD process), step-wise process efficiencies and average transport distances are based on client data, and have been justified appropriately in the report.

Digestate use from the AD plant is largely assumed to be sent to sewer, with a relatively small amount assumed applied for use on land. This is consistent with the AD model from the WRATE tool, and likely

to reflect a conservative assumption as there may be further environmental and economic benefits from applying the liquid fraction to land as well in practice.

The energy recovery from the biogas generated by the AD plant is reported as “all biogas is used in CHP engine to generate electricity” in the SLR report and model, whereas the actual plant may clean up some biogas for use in the brick making process, with some of the remainder being used for electricity generation (as appropriate). The AD process selected in WRATE generates both heat and electricity through the process, and so the text in section 6.0, 2nd paragraph, should be altered to reflect this. The overall assumption, and the way it is modelled is appropriate for a high-level study.

Power consumption for the Depackaging unit to be placed in the Horsley Park Bioenergy Facility was not reported / available to SLR. Instead the power consumption of a different commercially available unit with similar capacity (SMIMO120) is provided. We sought supporting evidence of the MIMIMO120 plant which was satisfactorily provided by SLR. The separation efficiency of the Depackaging unit is unlikely (in practice) to be 100% effective, as shown in the SLR model, however for such relatively low contamination and with residues sent to landfill, we consider this assumption appropriate for an LCA at this level.

2.2 WRATE .lca Model

The main changes from defaults in the WRATE model are summarised below:

- Depackaging unit – energy consumption in the background allocation tables is changed
- AD plant – changes to the management of reject from the facility (due to the addition of the pre-treatment at the Depackaging unit)¹
- Energy mixes justified, referenced appropriately [see previous comment in section 2.1 of this report] and input into the model correctly
- Landfill gas recovery efficiencies changed to the 37% efficiency (using the Flexible landfill model) and a sensitivity analysis applying 70% gas recovery efficiency. Both are reasonable assumptions showing the potential range of recovery.

2.2.1 Business As Usual (BAU)

Data inputs into the model have been carried out correctly. There have been some broad assumptions concerning the feedstock composition, for example, for the composition of the contamination within the feedstock. This is based on the Environmental Impact Statement (2.48% total contamination) and that this will be half ‘light contamination’ (e.g. paper, card, plastics) and half ‘heavy contamination’ in this case; non ferrous metal. However, as such a relatively small component of the waste, variations in the composition of this element of the feedstock will only have very minor impacts on the model and in both cases it is sent to landfill, so this is not considered to have any significant impacts within the model downstream. The liquid and solid organic waste inputs waste composition have been assumed to be identical. Whilst this may not be the case in ‘real life’, and in the context of limitations within WRATE for

¹ This included a reduction in the amount of reject from the AD process (as it was rejected at the Depackaging Unit)

what feedstocks can be modelled in anaerobic digestion, this assumption we believe is justifiable. This is particularly when the AD model within WRATE operates on biogenic carbon available (which is based on the mass of volatile solids within a particular feedstock, i.e. complex changes in biochemical make-up of various feedstocks are not taken into account).

The landfill used for final disposal is a 'modern' landfill (WRATE ID No. 11255). This is a flexible landfill model with a modifiable efficiency of landfill gas recovery, as noted previously both 37% recovery of landfill gas and an enhanced efficiency of 70% was also applied as a sensitivity analysis. Other key design features (e.g. clay cap + HDPE liner) are also appropriately modelled.

2.2.2 Horsley Park Bioenergy Facility

Waste arisings modelled are identical to the Business As Usual (BAU) case. The transport of food waste is also identical, although it should be noted that some relatively low capacity vehicle types have been selected (e.g. a compartmentalised refuse collection vehicle with a max payload capacity of 5.5 tonnes), an improved environmental performance would be achieved (by c. 400tCO₂ eq.) using larger capacity vehicles, but as stated the same assumption is shown for both scenarios and therefore it does not affect the comparison between the two options, and may be viewed as a conservative assumption.

The inputs into the model are entered correctly and in-line with the supplied data, reports and references. The standard wet AD process [Biogen / Greenfinch WRATE ID: 11036] is largely kept the same as the WRATE default for food waste. As noted in section 2.1 this AD process is based on a plant that also exhibits some heat recovery, and whilst the Horsley Park Bioenergy Facility proposes to utilise gas onsite, and it is not proposed to export heat off site for recovery by others (as is the case for the AD plant in WRATE). It is nonetheless the most appropriate default AD process for use within the WRATE software for the feedstock proposed. The rejects (from the Depackaging unit) are sent to landfill with a distance modified to match expected destinations.

The landfill is identical to the one used in the BAU case.

For production of compost, WRATE Process ID 12298 for Compost Use-Other/AD Cake has been used, this is appropriate, and the bulk of digestate (liquid) is sent to sewer, which would be considered a conservative assumption.

For the Depackaging unit, electricity consumption from a similar unit has been supplied. One concern regarding the Depackaging unit and its modelling within WRATE is noted. It is questionable whether the capital burdens of screw-feed and hydraulic units are worthy of addition within the WRATE model. Whilst capital burdens may only be c. 10% of the total impact of this element of the model (which in itself is a very small component of the overall model), and as a high-level model, this is considered only a minor point of note.

2.2.3 Alternate Scenario for Landfill Gas recovery

The sensitivity analysis model with 70% landfill gas recovery, was modelled correctly, using an appropriate assumption.

2.2.4 Alternate Scenario for a marginal energy mix to match grid mix

The sensitivity analysis model for a closer reflection to the current carbon intensity of the electricity grid for electricity generated (the marginal energy mix), was modelled correctly and using appropriate assumptions.

2.2.5 ARENA LCA Guidance

The ARENA guidance specifies that, the following should be reported: Climate Change; Fossil Fuel Resource Depletion, and; Fossil Fuel Energy Use should be reported. The SLR LCA reports Climate Change; Resource Depletion; Acidification; Eutrophication; Human Toxicity; and Freshwater Aquatic Ecotoxicity. It is recommended that (as an appendix) the 'Fossil Fuel Energy Use' is added as a reported outcome. This is based on the total net calorific value (MJ) of coal / oil / gas used to obtain the delivered energy resource. This could be derived from the 'Advanced' tab and 'Allocation' for the vehicles (factored for the mileage and split of road types) + energy use in facilities (e.g. Depackaging unit), moderated by the mix of fossil energy in the grid, as appropriate, and reported as MJ.

2.3 Results and Implications

It is noted that the results quoted within the main report and data supplied were checked, tested and are reproducible using the latest version of the WRATE model. The results, data and assumptions were presented and discussed within the report appropriately and in a scientifically rigorous manner, noting the minor comments raised in the report.

2.3.1 Observations and Sensitivities

There were no major omissions or errors noted in the review of the modelling, report or assumptions; however some minor aspects could be improved, subject to the views of the client. These are as follows:

2.3.1.1 Reference to AD Energy Recovery

It is noted that the SLR report refers to the AD energy recovery is electricity only, whereas the model actually recovers both heat and electricity, this should be made clear in the report.

2.3.1.2 Reporting Fossil Fuel Energy Use

It is recommended that (as an appendix) the 'Fossil Fuel Energy Use' is added as a reported outcome.

Other comments of note (but not requiring changes include:

2.3.1.3 Application of Liquid Digestate

Within the main report it is noted that the application of the liquid digestate is sent for disposal to a sewer, whereas in practice there may be better applications (for example spreading to suitable agricultural land), the approach is considered as a conservative estimate, and so no changes recommended.

2.3.1.4 Choice of sensitivity analysis

The efficiency of the landfill gas energy recovery [SLR sensitivity] and the marginal energy mix [FRM sensitivity] were both appropriate, and the respective changes entered correctly.

3 Concluding Remarks

A WRATE LCA model for the proposed facility has been reviewed. The main report, input data, background data, and associated references have been reviewed and detailed feedback has been provided. As part of the feedback, one area of further sensitivity analysis (marginal energy mix) has been proposed and conducted, where appropriate, and detailed checks on the .lca file have been carried out.

The impact of changing vehicle types and marginal energy mix has been studied and results and commentary included within sections 2.1 and 2.2.2.

Three areas of variance (how the Depackaging unit is modelled, how energy is recovered from the AD and assumptions around the feedstock), all could be refined further, however as a high level model reasonable assumptions have been applied in each case.

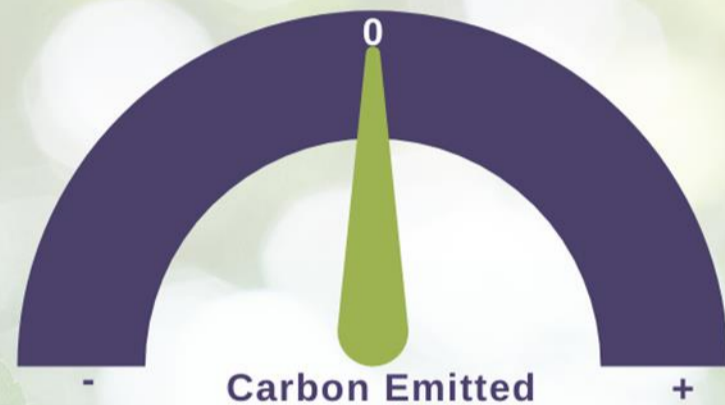
It is recommended that 'fossil fuel energy use' results should be added as an appendix within the final form of the SLR report to align with the ARENA guidance.

In summary, it is established that the WRATE LCA study reviewed within this report has been carried out to industry standard, in-line with ISO14044:2006, and in a scientifically rigorous and objectively justifiable manner.

MANAGING CARBON & ACHIEVING NET-ZERO

Carbon Assessment

- We **assess** and explore options for **minimising the carbon impacts** of Council services.
- We apply **specialist** models (e.g. Kerbside Analysis Tool (KAT) for collection modelling, Waste and Resources Assessment Tool for the Environment (WRATE) for environmental impacts of waste management activities) to provide **detailed, bespoke and accurate accounting of carbon emissions**.
- We also offer **Scope 1, 2 and 3** (e.g. transportation-related) carbon assessments. We utilise appropriate emission factors to **calculate the resulting footprint** and present findings graphically and clearly.



Cutting-Edge Research

- Our team possesses a **strong track-record** in state-of-the-art **academic** and applied **research**.
- We were commissioned by the **International Solid Waste Association (ISWA)** for research into sustainable & alternative waste collection vehicles and fuels.
- We supported **Department for Environment, Food and Rural Affairs (Defra)** in an evaluation of the carbon impact of waste treatment processes.
- We have made **valuable contributions** to provide an **evidence base for Government policy** and **advancement of waste management research** which has been **published** in peer-reviewed academic journals and, **cited globally** by our peers working in this field. An example is provided **here**.

*“Frith RM combined their **excellent technical knowledge** and **thoroughly professional approach** with a friendly down to earth manner. First draft documents were **very high quality**, responses to queries were **swift** and the final product was **comprehensive** yet easy to understand. That is quite an achievement for such a specialist area of work”.*

Norfolk County Council – Carbon Assessment for Residual Waste Procurement



FRM was incorporated in 2008 and specialises in waste and resource management consultancy. We give advice, modelling support and expertise through our team of Chartered Engineers, Environmentalists, Logisticians and Waste Managers who support or lead on waste and environmental projects.

ISO9001 & ISO14001 certified for Quality & Environmental Management



