Greenhouse Gas and Energy Impact Assessment

C-Loop

Toongabbie Biogas Project

January 2024

Disclaimer

The data presented in this GHG Emissions Report is based on information provided by various sources, including client data, internal records, third-party data, and industry databases. While we have made efforts to verify the accuracy of the data relied on, we do not control the quality of third-party data and cannot assume responsibility for any inaccuracies or discrepancies.
The data provided in this report is limited to the boundaries of C-Loop's Toongabbie biogas Project and the GHG Emissions Report represents emissions data for a specific future reporting period. Changes in operations, technology, or data collection methods may impact emissions in future periods. This report has not undergone external verification or audit.
This report is confidential and is provided solely for the purposes that have been set out in the project proposal. This report is strictly limited to the matters stated in it and subject to the various assumptions, qualifications, and limitations in it and does not apply by implication to other matters. EnergyLink Services makes no representation that the scope, assumptions, qualifications, and exclusions set out in this report will be suitable or sufficient for other purposes nor that the content of the report covers all matters that you may regard as material for your purposes.
This report must be read as a whole, and any subsequent report must be read in conjunction with this report.
The report supersedes all previous draft or interim reports, whether written or presented orally, before the date of this report. This report has not and will not be updated for events or transactions occurring after the date of the report or any other matters which might have a material effect on its contents, or which come to light after the date of the report. EnergyLink Services is not obliged to inform you of any such event, transaction, or matter nor to update the report for anything that occurs or of which EnergyLink Services becomes aware after the date of this report.
Unless expressly agreed otherwise in writing, EnergyLink Services does not accept a duty of care or any other legal responsibility whatsoever in relation to this report, or any related enquiries, advice, or other work, nor does EnergyLink Services make any representation in connection with this report, to any person other than C-Loop. Any other person who receives a draft or a copy of this report (or any part of it) or discusses it (or any part of it) or any related matter with EnergyLink Services, does so on the basis that he or she acknowledges and accepts that he or she may not rely on this report nor on any related information or advice given by EnergyLink Services for any purpose whatsoever.

COMMERCIAL AND CONFIDENTIAL

Version Control Record

Project Number – J0542					
Document File Name	Date Issued	Version	Approved by	Peer Reviewer	Completed by
20231219 GHG and Energy Impact Assessment, C-Loop, Toongabbie vF.0 (Draft for comment)	20 Dec 2023	vF.0	Mark Wallace	Mark Wallace	Claire Pollock
20240119 GHG and Energy Impact Assessment, C-Loop, Toongabbie vF.1	19 Jan 2024	vF.1	Mark Wallace	Mark Wallace	Claire Pollock

Table of Contents

List of Tables

1 Introduction

EnergyLink Services have been engaged by C-Loop to provide a Greenhouse Gas (GHG) and Energy Impact Assessment for a its proposed Bioenergy and Micro-algae Facility (Biorefiner) to be located near Toongabbie in Victoria Australia, referred to as the Toongabbie Project. C-Loop proposes to develop its Toongabbie Project on farmland adjacent to Hendersons road in Toongabbie, VIC 3856. The site access will be from Grahams lane, off Cairnbrook road, south of the development site.

1.1 Objectives

The objectives of this report are the following:

- Quantify the Toongabbie Project's GHG emissions and energy use; and
- Outline the systems in place to minimise GHG emissions.

1.2 Scope and Boundary

The scope of the GHG and Energy Impact Assessment includes:

- Calculation of energy consumption for the Toongabbie Project
- Estimate potential energy generation for the Toongabbie Project
- Calculation of GHG emissions for the Toongabbie Project
- Identifying energy and GHG management best available practices.

The scope of the project applies to the following boundary:

- Scope 1 emissions for the combustion of biogas within the CHP;
- Scope 1 fugitive emissions relating to biogas and Micro-algae raceway pond;
- Scope 2 emissions relating to any purchased electricity;
- Energy consumption relating to biogas combustion, solar energy consumption and the self-consumption of generated electricity; and
- Energy production relating to the CHP and solar systems.

2 GHG Emissions Inventory Framework

The primary purpose of this report is to convey the energy and Scope 1 and 2 GHG emissions that are relevant to the Toongabbie Project. GHG emissions scopes are defined as per the below:

- Scope 1 – Direct emissions - emissions related to activities occurring within the boundary various, which are under the operational control of a reporting entity.
- Scope 2 – Indirect emissions - emissions related to secondary energy imported to a facility, such as electricity, which are under the operational control of another entity.
- Scope 3 – Indirect emissions - related to activities *upstream* and *downstream* of the activities under a reporting entities operational control, which are caused/required by the activities of the reporting entity but occur at sources controlled by other entities. (excluded from the scope of this report)

More information on GHG emissions and the different scopes is provided in Appendix A. The international Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (the Value Chain Standard)[1] presents the three Scopes pictorially as shown in Figure 1.

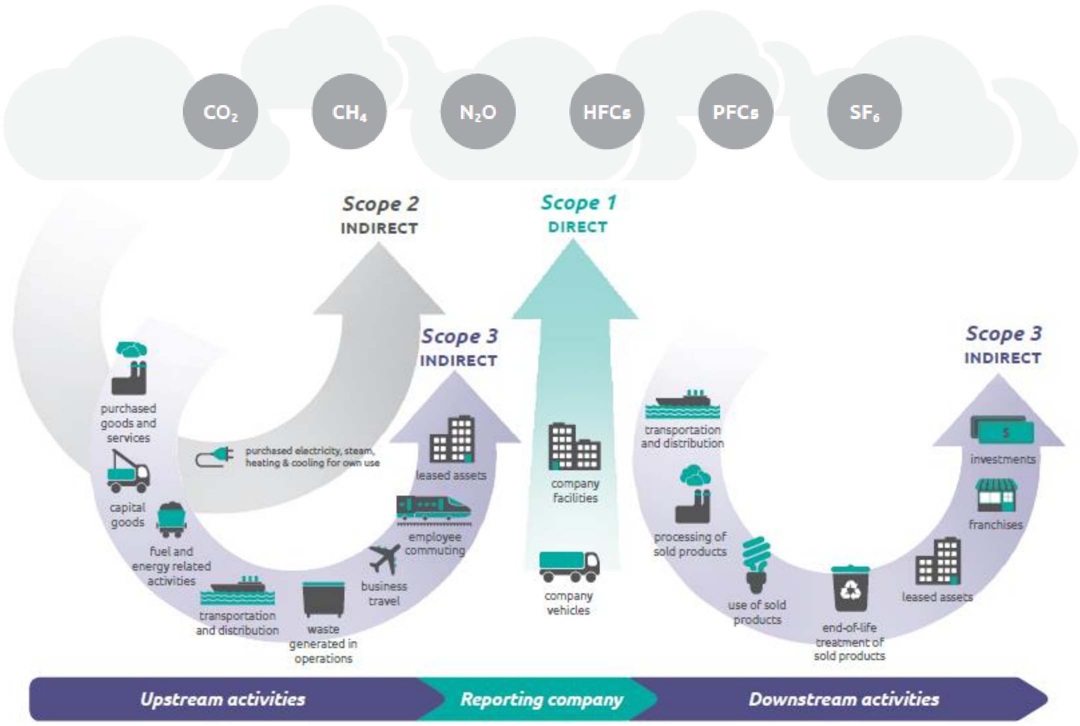


Figure 1: Overview of GHG Protocol Scopes and emissions across the value chain

2.1 Reporting principles

Under the NGER legislation emission estimates need to be complied in accordance with several common principles, relating to relevance, completeness, consistency, transparency, and accuracy of data.

[1] *World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) (2011) Corporate Value Chain (Scope 3) Accounting and Reporting Standard, retrieved from:* *https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf*

2.1.1 Completeness

Material GHG emission sources within the emission boundary have been accounted for. Where GHG emissions sources have not been estimated, their exclusion has been documented (refer to section 1.2).

2.1.2 Consistency

Methods applied are consistent with the NGER legislation and the methods applied for emissions inventories for similar facilities. Any modifications to the inventory, including alterations in accounting methods, boundaries, or calculation approaches, have been documented, and transparently justified to enable a comparison of GHG emissions performance over time and identify trends and performance over time.

2.1.3 Transparency

Emission estimates have been prepared with explicit identification of reference data, justification of any exclusions, disclosure of assumptions, and references to methodologies and data sources to enhance transparency in the GHG inventory. Estimates and the preparation methodology have been peer reviewed and are presented in a format to enable consistent continuation of reporting.

2.1.4 Accuracy

The accuracy of data used to estimate the emission inventory has not been calculated. The assumptions made in the course of processing Activity Data and the selection of factors have been documented within this report.

3 Proposed Operation

3.1 Overview

Each year the Toongabbie Project will process around 10,000 tonnes of poultry litter and 5,000 tonnes of food waste to generate:

- ~ 14,500 MWh of baseload renewable electricity (Bioenergy and Solar PV);
- ~12,000MWh of baseload renewable heat;
- 40 tonnes of high protein Micro-algae in Phase one and then increasing to 160 tonnes once Phase 2 construction is complete;
- 8,666 tonnes of high-grade organic solid fertiliser; and,
- ~14,500 Large Generation Certificates (LGC)

The Toongabbie Project will produce over 3,800,000 Nm3 of biogas (60-65% methane) per year which will be converted into approximately 10,611 MWh of electricity via a 1.26 MW combined heat and power (CHP) generator. Additionally, a two staged solar system shall produce approximately 1,170 MWh/annum on completion of phase 1 and 3,890 MWh/annum once phase 2 is complete. The electricity generated by the CHP and solar systems will substantially offset the power required for the Toongabbie site operations with the remainder being exported to the grid. The purpose of the project is to develop a baseload renewable energy system and optimise the use of byproducts produced by the system.

The proponent intends on producing micro-algae to take advantage of the heat, nutrients and CO_2 produced from the Anaerobic Digestion (AD) process. This micro-algae will be a high protein, high value product cultivated and processed with a low emissions footprint.

3.2 Process

3.2.1 Feedstocks

The project involves the use of spent bedding material (poultry litter) as a primary feedstock. This waste material is currently used as a seasonal soil improver throughout the district. The proximity of the project from the existing farm reduces the logistics footprint involved with the disposal of the bedding material. There is a substantial reduction in the carbon footprint associated with this outcome, distribution of the material in the district regularly involves b-doubles undertaking round trips to and from the farming site in excess of 100km. This reduction in supply chain GHG emissions is outside the reporting boundary of this report. The region is experiencing greater impact from the establishment of broiler farms in the area and this project provides a year round solution for the management of agricultural waste.

3.2.2 Wet Feeding Process

The project requires the extraction of groundwater in combination with the recycling of leachate to condition feedstock to a 12% solids concentration to commence hydrolysis. Groundwater extraction will occur onsite using the projects own bore. The project will also optimise the catchment of surface water from site and water recovered from the micro-algae harvesting and drying process will be used to aid the mixing and conditioning of feedstock material in winter months when cultivation rates slow down.

3.2.3 Hydrolyser and CSTRs

A hydrolyser which will be 18m in height and have a working volume of 1.3ML will be used for the mixing and standardisation of feedstock. The hydrolyser converts bulk feedstock into soluble compounds aiding the formation of volatile acids (VAs) and volatile fatty acids (VFAs). Two 4.2ML Uni fermenters will operate in parallel with continuous mixing occurring in each fermenter. Feedstock will have a residence time of circa 30 days in each fermenter before being transferred into a single Post Digester. The Uni fermenters and Post digester operate in series, meaning that a defined volume of feedstock is transferred into the Post digester from each Uni fermenter and a portion of the digestate is waste, sent out to of the system to maintain hydraulic stability of the process. Biogas will be captured within the headspace between the liquid level and roof of the Uni fermenters whilst the Post digester will contain a flexible HDPE membrane cover to capture biogas. The flow of biogas to the gas treatment process will occur using the head pressure of each tank with a blower from each vessel in place to maintain the flow rate to the gas treatment process should pressure in the headspace drop.

3.2.4 Digestate Processing and Fertiliser Production

Digestate will be wasted from all fermenters into a dewatering/filtration process to separate insoluble and soluble fractions of digestate. The facility will produce approximately 140kL of digestate daily with approximately 50% of this volume being recirculated back to the hydrolyser to aid with the formation of VFAs and VAs.

Approximately 9,000tonnes per annum of high-grade organic solid fertiliser @ 50%solids will be produced after dewatering using a mechanical screw and filter press.

3.2.5 Micro-algae Raceway Ponds

The project has two phases of development. Phase 1 involves the establishment of 1.3ha of micro-algae raceway ponds under a semi-transparent solar roof. A total of 16 raceway ponds will be constructed at ground level with underfloor heating.

Under Phase 2, a further 2.3ha of raceway ponds will be constructed. These ponds will be longer and wider than the Phase 1 ponds but will also utilise renewable heat and power for all cultivation, harvesting and processing requirements. The two phases will produce the following outputs:

- Phase 1 - will output 40 tonnes per annum of high protein micro-Micro-algae at 80% solids concentration
- Phase 2 – the cultivation area will be more than double phase 1 which will result in the total production of biomass increasing to 160 tonnes per annum.

3.3 Gas

3.3.1 Biogas

The biogas will be approximately 60-65% methane and 35-37% carbon dioxide. For the purposes of this GHG impact assessment, the remaining 3% of the biogas is assumed to have zero GWP (nitrogen and hydrogen sulphide).

An estimated 3,874,000 Nm^3 of biogas will be produced by the system annually, consisting of 2,518,050 Nm^3 of methane and 1,239,730 Nm^3 of carbon dioxide. While there is a flare that will be used for the combustion of any excess biogas or as backup during unscheduled maintenance, all biogas produced and captured is intended to be combusted on site by the CHP generators.

For the purposes of estimating fugitive emissions, it is assumed that the method of biogas collection is 98%[2] efficient. This accounts for the leakage of methane into the atmosphere through seals and valves of storage and process equipment. Hence, 52,145 Nm^3 of methane is estimated to be released into the atmosphere annually, equating to 1,043 tCO_2e/annum.

It is noted that all carbon dioxide within the biogas can be considered biogenic carbon dioxide as it has come from organic sources and therefore there are no emissions related to fugitive carbon dioxide for the Toongabbie Project. The same outcome applies to the combustion of biogas (methane) which then releases biogenic carbon dioxide.

3.3.2 Wastewater

For the purposes of this GHG impact assessment, it is assumed that there will be negligible fugitive emissions from wastewater. All process wastewater has already been used for the purposes of biogas production and shall be reused within the system.

Their may be a beneficial reuse scheme utilised whilst the micro-algae cultivation area expands from Phase 1 to Phase 2. This will result in local land application of leachate under a Health and Environmental Management Plan with a land capability assessment already completed to substantiate the maximum application rate which can be applied to land seasonally.

3.3.3 Micro-algae

The Micro-algae to be cultivated at the Toongabbie Project is Limnospira maxima (Arthrospira maxima), better known as Spirulina, which is a denitrifying bacterium. The total nitrogen content within the liquid digestate is all ammoniacal nitrogen. Due to the microalgae species and nitrogen feedstock used, the fugitive nitrous oxide emissions of the micro-algae raceways have been deemed negligible[3] and reported as nil.

The liquid digestate will be produced from the Anaerobic Digestion process at a targeted ammoniacal nitrogen concentration of 4,000mg/L and microdosed into raceway ponds post filtration to achieve a 50x dilution. Each pond in Phase 1 will contain a culture volume of 159kL and 15% of the culture will be harvested daily. For Phase 1, only 364kL of volume will be removed daily from the ponds and concentrated from 99.5% moisture down to only 8% moisture post drying. At each stage of the daily harvesting and biomass concentrating process, the recovered water will be recycled back to 16 ponds and there will be adjustments to the rate of harvesting between seasons.

Micro-algae uptake of CO_2 occurs at a theoretical rate of 1.83kg of CO_2 per 1kg of biomass produced. This is a far more efficient absorption rate than any other plant-based material and the process benefits from having a cultivation process that occurs all year round. Micro-algae will utilise the CO_2 recovered from flue gas from the CHP engines onsite as the primary source of carbon and a reserve of bicarbonate will be micro-dosed when CO_2 is unavailable.

[2] *Factor from Carbon Credits (Carbon Farming Initiative – Alternative Waste Treatment) Methodology Determination 2015*
[3] *Based on an experimental study stating that Arthrospira platenis (a similar species of Arthrospira) produced undetectable amounts of N2O emissions when fed with an ammonia nitrogen feedstock.*
'N2O emissions during microalgae outdoor cultivation in 50 L column photobioreactors' (2017) available at: *https://www.sciencedirect.com/science/article/abs/pii/S2211926417300917*

3.4 Heat Recovery

The project will utilise heat recovery from the CHP engines onsite for the heating of micro-algae raceway ponds and low heat drying of harvested spirulina. The heat recovered is a byproduct from the combustion of biogas and enhances the overall efficiency of a stand-alone electricity generator from ~40% efficiency to >80% efficiency through the capture of waste heat. This outcome enables the site to maintain the necessary temperature profile of micro-algae ponds for optimal growth and also avoids the need to redistribute biogas for the drying of micro-algae biomass.

3.5 Electricity

3.5.1 Electricity Demand

It is estimated that the Toongabbie Project will consume approximately 2,867 MWh per annum. This load includes:

- Gas Treatment & Processing (27%)
- Hydrolyser, CSTRs & Digestate Processing (50%)
- Micro-algae related equipment (6%)
- Other equipment (17%)

These assets make up the parasitic load of the project and this load will be met by the power generated onsite. It is noted that some electricity may be purchased from the grid during shutdown periods, however, for the purposes of this GHG impact assessment these amounts are considered negligible.

The micro-algae cultivation and harvesting process is a relatively low energy use as less than 400kL of the stored pond volume will be harvested daily in Phase 1, with this value increasing to 1,200kL in Phase 2. The harvesting process involves concentrating, dehydrating, shaping and then drying of the micro-algae. None of these processes are high energy intensive processes by design, as a high velocity flow creates sheer to the biomass and high, rapid heat exposure can cause high value proteins to denature.

3.5.2 Electricity Production

The Toongabbie Project will produce an estimated 3,874,000 Nm^3 of biogas annually, including 2,518,050 Nm^3 of methane. It is estimated that 41% of this methane will be converted into electricity by the CHP generators producing 10,610,783 kWh per annum. The remaining methane will be converted into heat to be used at the site for heating the anaerobic digestion tanks, micro-algae raceways and for micro-algae processing. For the purpose of this report, it is assumed that the CHP generators will combust the methane at 100% efficiency and therefore there are no fugitive methane emissions released at the CHP generators.

The Toongabbie Project will also generate electricity from solar arrays. The solar system shall be implemented in two stages, with the first stage being 900 kWp and the combined Phases 1 & 2 being 3,000 kWp. These solar systems are estimated to generate 1,170 MWh/annum and 3,888 MWh/annum, respectively and a primarily to be used to support parasitic loads onsite.

The energy production from the CHP generators and solar arrays will total an estimated 14,499 MWh per annum once the Phase 2 solar system is complete. Due to this, the Toongabbie Project shall be a net exporter of electricity to the grid with approximately 11,631 MWh to be exported to the local Ausnet connection per annum.

3.6 Water

3.6.1 Water Use

While a high portion of the water required by the Toongabbie Project is recirculated by the system, there are losses in both the drying process of the solid fertiliser and Micro-algae product, evaporation from the Micro-algae raceways and in the fertiliser and Micro-algae products themselves. Therefore, it is estimated that the Micro-algae process may require approximately 67 kL/day of additional water, sourced from a bore constructed onsite, totaling 24,500 kL per annum. The AD requires approximately 60-80kL of water daily in addition to recycled digestate. Overall, the hydraulic capacity of the AD process is 15.6ML and the micro-algae ponds in Phase 1 will store 2.54ML of culture at 0.5g/L. Phase 2 will increase the volumetric capacity of the culture under cultivation to ~7ML.

4 GHG Assessment Methodology

4.1 GHG Emissions and Energy Assessment

The assessment framework is based in NGERs reporting methodology and the National Greenhouse Accounts (NGA) Factors (2023)[4] that incorporate the principles of the Greenhouse Gas Protocol[5].

The project's energy flows were calculated from the quantities and energy contents as outlined in Table 1. The energy types in this table have been separated into consumption and production. Furthermore, the consumption of solar energy for the purposes of generating electricity from solar arrays has been included as a consumed energy to align with the NGERs reporting methodology.

Table 1: Summary of Fuel Quantities and Energy Content

Energy Type	Quantity	Units	Energy Content	Units	Energy GJ/yr	Consumed / Produced
Fuel consumption						
Biogas captured for combustion in CHP (methane only)	2,518,050	m3	0.0370	GJ/m3	93,168	Consumed
Electricity - self-consumption	2,867,440	kWh	0.0036	GJ/kWh	10,323	Consumed
Electricity - purchased from grid	-	kWh	0.0036	GJ/kWh	-	Consumed
Solar Energy – stage 1 solar	4,211	GJ	1	GJ/GJ	4,211	Consumed
Solar Energy – stage 2 solar	9,787	GJ	1	GJ/GJ	9,787	Consumed
Energy production						
Electricity - generated (CHP)	10,610,783	kWh	0.0036	GJ/kWh	38,199	Produced
Electricity – solar stage 1	1,169,660	kWh	0.0036	GJ/kWh	4,211	Produced
Electricity – solar stage 2	2,718,540	kWh	0.0036	GJ/kWh	9,787	Produced

The project's emissions were calculated from the energy and emission factors as outlined in Table 2. Only the relevant fuels from Table 1 are included in Table 2. It is noted that biogenic carbon dioxide has a GWP of 0 as it is not derived from a source of fossil fuel. In addition to the emission associated with the energy consumed and produced at the site, the project's total emissions also consider the inefficiencies of an anaerobic digestion plant to capture all methane generated.

[4] *Australian Government Department of Climate Change, Energy, the Environment and Water (2023), Australian National Greenhouse Accounts Factors For individuals and organisations estimating greenhouse gas emissions, retrieved from: https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-account-factors-2023.pdf*

[5] *World Business Council for Sustainable Development / World Resources Institute, The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard, Revised edition, retrieved from: https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/Resources/A-corporate-reporting-and-accounting-standard-revised-edition*

Table 2: Summary of Emission Factors and Emissions for relevant Fuel Types

Fuel	Quantity	Units	Emissions Factor	Units	Emissions (tCO2e/yr)	Emission Scope
Biogas captured for combustion in CHP (methane only)	93,168	GJ	6.43	$kgCO_2e/GJ$	599	1
Electricity - self-consumption	2,867,440	kWh	-	kgCO2e/kWh	-	
Electricity - purchased from grid	-	kWh	0.79	kgCO2e/kWh	-	2
Fugitive - Methane (biogas)	51,389	Nm3	0.02	tCO2e/m3 methane	976	1
Fugitive - Carbon Dioxide (biogas)	25,301	Nm3	-	-	-	
Total Project Emissions					1,575	1 & 2

Key emissions and energy values from Table 1 and Table 2 are summarised in Table 3 to give the project's overall emissions and energy footprint.

Table 3: GHG Emissions, Energy Production and Energy Consumption

	Scope 1 Emissions (tCO_2e)	Scope 2 Emissions (tCO_2e)	Total emissions (tCO_2e)	Energy Consumed (GJ)	Energy Produced (GJ)
Facility Stage 1	1,575	-	1,575	107,701	42,410
Facility Stage 2	1,575	-	1,575	113,277	47,986

It is noted that the project is projected to consume more than 100,000GJ of energy per annum. This is the energy consumption 'trigger' threshold for NGERs reporting. As such, upon the start of operations annual reporting of activities to the Clean Energy Regulator will be required.

Further detail related to this section is contained in Appendix B.

5 Best Available Energy and Greenhouse Gas Management

5.1 Energy Saving / Recovery Systems

5.1.1 Biogas Capture

Biogas recovery in the Uni fermenters will occur within the headspace of the Uni fermenters with the fixed roof and liquid levels used to maintain head pressure and biogas flow rates. The post digester will adopt a membrane based roof material because the rate of biogas formation is expected to be slower and varied as residence time is extended. Heat from the CHP's will maintain a set diurnal temperature for the fermenters.

The captured biogas is then all planned to be combusted in the CHP engines for the production of energy. The facility is also planning on installing a flare to combust methane rather than vent it in a scenario that the CHP engines are not operational.

5.1.2 CHP Generators

Heat will be recovered via the engine cooling system and also an economiser will be fitted to the exhaust stack. The expected heat recovery is circa 12,000MWh of heat per annum which has a primary application in maintaining fermenter and raceway pond temperature profiles and a secondary application of drying harvested micro-algae biomass. The CHPs will incorporate flue gas capture for the application of carbon dioxide into the raceway ponds. This recovery process may incorporate an intermediate process to remove sulphur dioxide prior to gas sparging in ponds.

5.1.3 Digestate Water Recovery

The project will utilise a mechanical screw and filter press to recover leachate. Leachate containing highly concentrated ammoniacal nitrogen is a key enabler required for the cultivation of low-cost, low emissions micro-algae. The alternative source of nitrogen required for cultivation is urea which has a significant carbon profile associated with its manufacture.

5.2 Renewable Energy

The facility will generate renewable electricity using the CHP engines powered by biogas and the solar PV arrays. The generate electricity will be used to power the facility, avoiding the importing of fossil fuel derived grid electricity, as well as export renewable energy to the grid to increase the quantity of renewable available in the local electrical network.

6 Conclusions

This GHG emissions and energy assessment conducted for C-Loop's Toongabbie project has quantified the facilities Scope 1 and 2 GHG emissions and the energy that will be both generated and consumed by the facility. It has also identified that the project has undertaken the necessary steps to optimise energy efficiency and resource recovery, not only for its own facility but also for the region, resulting in the creation of a local circular economy. Steps taken include the following:

- Recovering waste streams from the local economy.
- Generating and capturing biogas from the collected waste streams to generate renewable electricity to power its facility, export renewable electricity to the grid and produce renewable heat energy for its processes and micro-algae raceway ponds. This results in the following emissions savings:
    - Scope 2 emissions from the consumption of grid electricity;
    - Scope 1 emission from the combustion of LPG to provide heat for the facility; and
    - Scope 1 emissions from the venting of methane in biogas.
- Installation of solar PV arrays to avoid scope 2 emission from importing grid electricity.
- Optimising water consumption by recycling water within the project boundary.
- Recovery of leachate as a source of nitrogen for the production of micro-algae to avoid the use of other nitrogen sources such as urea which have high embodied carbon and GHG emissions from use.
- Recovery of carbon dioxide to grow micro-algae.

The assessment has quantified the following GHG emissions, energy generation and energy consumption for the project:

- The facility will require 2,867MWh of electricity to operate.
- 14,499 MWh of renewable electricity will be generated from the facility.
    - 10,611 MWh will be generated from the site's 1.26 MWe CHP engines that will be fuelled from the biogas generated in the site's Ads.
    - 3,888 MWh will be generated from the site's 3 MWp solar PV arrays.
- 11,632 MWh of renewable electricity will be exported into the local electricity network, displacing fossil fuel derived electricity.
    - As little as 7,743 MWh will be baseload electricity generated from the biogas powered CHP engines.
- The project will consume 113,277GJ of energy which will trigger the NGER reporting threshold of 100,000GJ of energy per annum.
- 10,000 tonnes of poultry litter and 5,000 tonnes of food waste will be used as a nutrient input for micro-algae growth. The final product produced will be a high-protein, low emissions food source.
- The project will emit as little as 1,575 tCO_2e per annum of Scope 1 GHG emissions.

Appendix A: GHG Data

The United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol (the Kyoto Protocol) identified six anthropogenic greenhouse gas (GHG) emissions (UN, 1998). These include:

- Carbon Dioxide (CO_2);
- Nitrous Oxide (N_2O);
- Methane (CH_4);
- Perflurocarbons (PFCs);
- Hydroflurocarbons (HFCs); and
- Sulphur Hexafluoride (SF_6).

For the purposes of this greenhouse gas (GHG) assessment, the GHG emissions considered only CO_2, N_2O and CH_4 emissions. All GHG emission quantities are provided in tonnes of carbon dioxide equivalent (tCO_2e).

The CO_2e of a particular GHG emission is calculated based on its Global Warming Potential (GWP). The GWP reflects the relative global warming impact that one metric tonne of a particular GHG emission source has relative to one metric tonne of carbon dioxide (tCO_2). The GWPs for gases relevant to this study have been taken from the National Greenhouse and Energy Reporting Regulations (the NGER Regulations) and are provided in Table 4.

Table 4: Global Warming Potentials

GHG	Chemical Formula	GWP
Carbon Dioxide	CO_2	1
Methane	CH_4	28
Nitrous Oxide	N_2O	265

Operational Boundary (GHG Emissions Scopes)

Defining an operational boundary assists with the determination of GHG Emissions associated with a facility. Identifying the operational boundary also assists with determining and categorising GHG emissions sources as *direct* and *indirect* GHG emissions through the identification of three Scope level of GHG emissions (Scope 1, Scope 2 and Scope 3) (ISO, 2006). These Scope levels are defined in Table 5.

Table 5: Carbon Emissions Scope Details

Scope	Details
Scope 1	Direct GHG emissions which occur from sources that are owned or controlled by an organisation. Examples of Scope 1 emissions include the emissions from on-site fuel combustion for electricity generation purposes, or emissions associated with diesel combustion from transport activities.
Scope 2	Indirect GHG emissions are emitted from the generation of purchased electricity, heat or steam consumed by an organisation (i.e. the emissions do not physically occur within the boundary of the facility).
Scope 3	Indirect GHG emissions are generated in the wider economy as a result of an organisation's activities, however these emissions physically occur elsewhere. For example, the emissions from waste disposed at a third party's operated landfill facility.

Appendix B: GHG Data

B.1. Electricity Usage

Table 6: Electricity Generation

Electricity Generation	Phase 1 Annual Output (kWh)	Phase 2 Annual Output (kWh)
CHP	10,610,783	10,610,783
Solar Farm	1,169,660	3,888,200
Total	**11,780,443**	**14,498,983**

Table 7: Electricity Demand

Electricity Usage / Demand Estimates	Annual (kWh)
Gas Treatment & Processing	779,640
Hydrolyser, CSTRs & Digestate Processing	1,427,150
Micro-algae related equipment	163,520
Other equipment	497,130
Total	**2,867,440**

Table 8: Electricity Exported

Electricity Exported	Solar Phase 1 Annual (kWh)	Solar Phase 2 Annual (kWh)
Electricity Generated	11,780,443	14,498,983
Total Facility Electricity Demand	2,867,440	2,867,440
Exported to grid	8,913,003	11,631,543

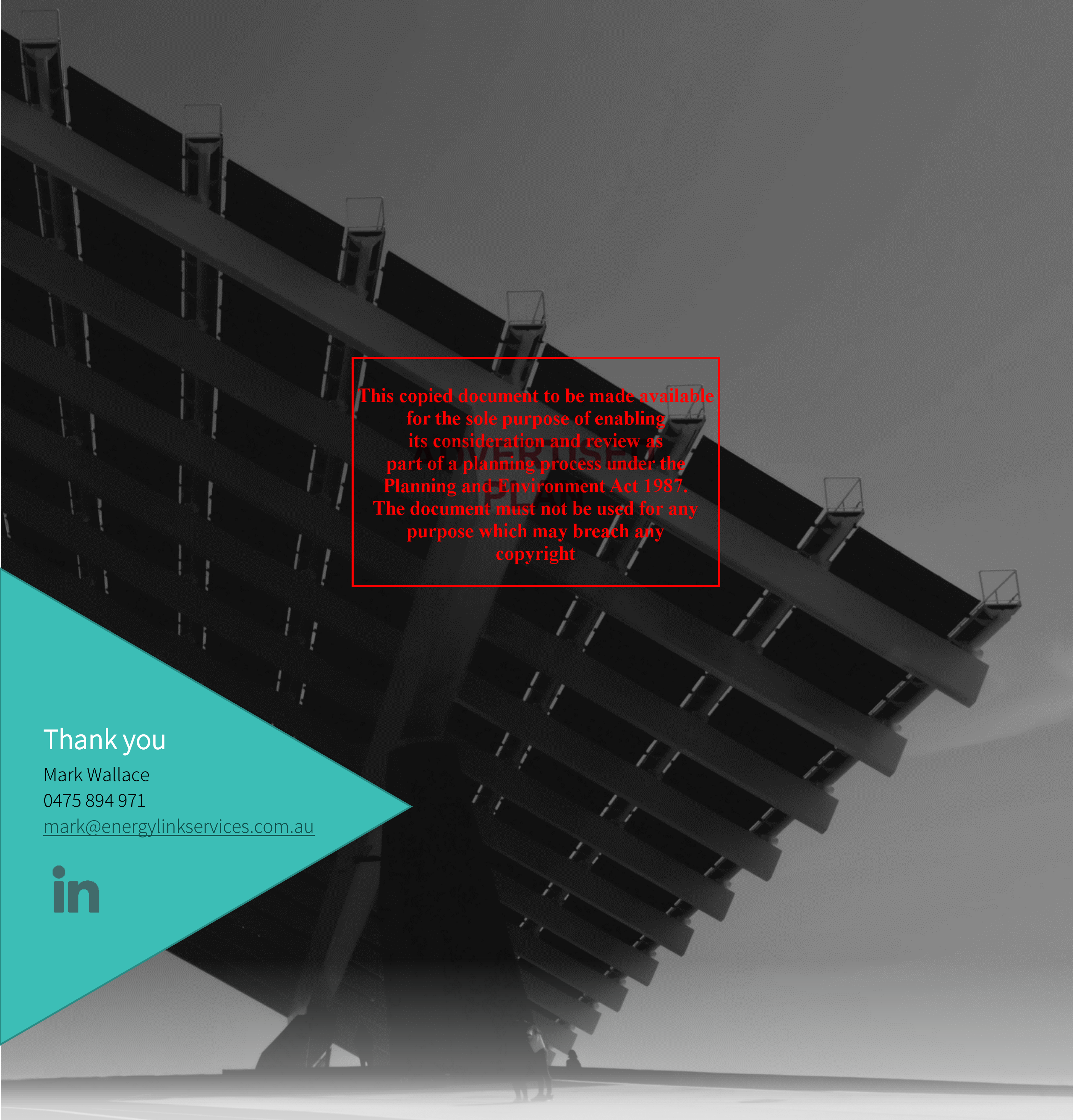
B.2. Gas Usage

Table 9: Biogas and Fugitive Emissions

	Annual Volume (Nm^3)	Fugitive Emissions	Units	Emissions Factor	Units	Fugitive Emissions (tCO_2-e/yr)
Methane (biogas)	2,518,050	51,389	Nm3/year	0.02	tCO2e/m3 methane	976
Carbon Dioxide (biogas)	1,239,730	25,301	Nm3/year			-

The fugitive emissions in Table 9 have been estimated from the following assumptions:

- *Biogas is 65% methane and 31% carbon dioxide*
- *GWPs are 0 for biogenic carbon dioxide, 28 of methane and 265 for nitrous oxide*
- *Fugitive methane emissions are estimated using an assumed efficiency of collection of 98% (AWT Method Biogas collection efficiency)*



Thank you

Mark Wallace
0475 894 971
mark@energylinkservices.com.au