Albemarle Kemerton Plant

Report

Greenhouse Gas Management Plan

Document No. 606541-4500-DV00-RPT-0026

Albemarle Project No. 7421

Revision History

Rev	Date	Description	Prepared	Reviewed	Approved	
					Project Manager	Owner
0	1/11/18	Issued for Use	T Millachip	C Paxton	A Bradbury	V Phan
1	29/11/18	Reissued for Use	T Millachip	C Brandwood	P Kelsall	C Brandwood

*Item	Page	Section	Comments
Various		5.2.3	Section Added following EPA review

** Use after Rev. 0*

ALBEMARLE®

Albemarle Lithium Pty Ltd

Albemarle Kemerton Plant Greenhouse Gas Management Plan

November 2018

GHD

Executive summary

This Greenhouse Gas Management Plan (GHG MP) has been developed for the construction and operation of Albemarle Lithium Pty Ltd's (Albemarle) lithium hydroxide facility at Kemerton, WA. This management plan has been prepared to satisfy the conditions of the environmental approval issued by the WA Environmental Protection Authority (EPA) and Environment Minister for the construction and operation of the facility.

The GHG MP includes a greenhouse gas inventory and assessment (section 2). The assessment estimated that peak GHG emissions arising from the construction phase are approximately 20,600 t CO_2-e and comprise entirely of scope 1 emissions from the combustion of diesel for stationary purposes and the loss of carbon sink due to vegetation removal. GHG emissions from the construction phase are only 3% of the emissions arising from the peak annual operation of the facility.

GHG emissions from the peak annual operation of the facility are estimated to be 661,940 t CO_2-e. Peak operations were assumed to occur once five process trains are operating. Operational GHG emissions are largely attributed to the consumption of grid electricity (scope 2 emissions) and the combustion of natural gas for steam generation and kiln firing (scope 1 emissions).

GHG emissions from the facility are estimated to contribute 0.8% to WA's annual emissions and 0.1% of Australia's annual emissions and are not considered significant (section 3). The GHG emissions intensity was estimated to be 6.6 t CO_2-e per tonne of lithium hydroxide produced. A lack of publicly available GHG emissions data from similar plants operating globally restricted the ability to benchmark the emissions intensity of the Albemarle Kemerton Plant.

The operational GHG emissions and energy consumption of the facility exceed the corporate and facility thresholds under the National Greenhouse and Energy Reporting (NGER) Scheme and hence Albemarle will be required to report annually to the Clean Energy Regulator (CER) once train 1 is operational (section 5). It is estimated that Scope 1 emissions will also exceed the Safeguard Mechanism threshold prior to the second train being operational.

GHG minimisation measures have been identified for the construction and operation of the facility and include measures related to the selection of fuel and energy sources, plant process and technology that maximise energy efficiency and reduce emissions (section 4).

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.3 and the assumptions and qualifications contained throughout the Report.

Table of contents

Table index

1. Introduction

1.1 Background

Albemarle Lithium Pty Ltd (Albemarle) is proposing to establish a Lithium Hydroxide Product manufacturing plant (the Project), in Kemerton Strategic Industrial Area near Bunbury in Western Australia. The Project has been assessed by the Western Australian Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986*.

The Project includes the construction and operation of a Lithium Hydroxide Product manufacturing plant (the 'facility') and associated infrastructure including administration facilities, workshop, supply warehouse / store, fuel and reagent storage, amenities, laboratory, control centre, water management infrastructure and a service corridor.

Once operational the facility will produce up to 100,000 tonne per annum (tpa) of lithium hydroxide monohydrate (Lithium Hydroxide Product) from five 20,000 tpa process trains and produce up to 1,100,000 tpa of tailings. The construction of the process trains will be staged over the next five years with construction of the first trains commencing in 2019. The facility will process spodumene ore concentrate supplied from the Talison mine in Greenbushes, WA.

1.2 Scope of work

This Greenhouse Gas Management Plan (GHG MP) has been prepared to satisfy Condition 9 of Ministerial Statement 1085 for the construction and operation of the facility as outlined below.

9. Greenhouse Gas Reporting

9-1 The proponent shall manage the implementation of the proposal to meet the following environmental objective:

1. *avoid, where possible, and minimise greenhouse gas emissions as far as practicable.*

9-2 Prior to commencement of construction of the lithium processing plant, the proponent shall prepare a Greenhouse Gas Management Plan to meet the objective required by condition 9-1.

9-3 The Greenhouse Gas Management Plan shall address the following matters:

1. *benchmarking against applicable standards at the time of construction of the lithium processing plant;*
2. *design of the proposal to minimise greenhouse gas emissions as far as practicable;*
3. *monitoring and public reporting; and*
4. *opportunities for continuous improvement and minimising net emissions in the future within the existing design of the Proposal.*

9-4 The proponent may review and revise the Greenhouse Gas Management Plan.

9-5 The proponent shall review and revise the Greenhouse Gas Management Plan as and when directed by the CEO.

9-6 The proponent shall continue to implement the version of the Greenhouse Gas Management Plan most recently approved by the CEO until the CEO has confirmed by notice in writing that the plan meets the objective specified in condition 9-1.

This GHG management plan:

- establishes a GHG inventory for the facility (section 2) to estimate the likely GHG emissions attributed to the construction and operation of the facility per annum
- benchmarks estimated emissions against applicable standards (section 3)
- identifies GHG minimisation and opportunities for continuous improvement (section 4) and
- specifies monitoring and public reporting requirements (section 5).

1.3 Limitations

This report has been prepared by GHD for Albemarle and may only be used and relied on by Albemarle for the purpose agreed between GHD and Albemarle as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Albemarle arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 2.5 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Albemarle and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Abbreviations

Acronym	Term
CER	Clean Energy Regulator
CH_4	Methane
CO_2	Carbon dioxide
DEFRA	UK Government Department for Environment, Food and Rural Affairs
EF	Emission factors
EMS	Environmental Management System
EPA	Environmental Protection Authority
GHG	Greenhouse gas
GHG MP	Greenhouse Gas Management Plan
GWh	Gigawatt hour
GWP	Global warming potential
ha	hectares
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation

Acronym	Term
LPG	Liquefied Petroleum Gas
Mt	Million tonnes
MVR	Mechanical vapour recompression
NGER / NGERS	National Greenhouse and Energy Reporting / Scheme
N_2O	Nitrous oxide
sqm	Square metres
TAGG	Transport Authorities Greenhouse Group
t CO_2-e	Tonnes of carbon dioxide equivalent
tpa	Tonnes per annum
WA	Western Australia

2. GHG inventory

2.1 Methodology

This assessment has been undertaken in accordance with the principles of ISO 14064-2 and the general principles for estimating emissions in the National Greenhouse and Energy Reporting (NGER) (Measurement) Determination 2008. Relevant sections of the following documents were used for the purposes of defining appropriate methods for quantification of emissions from individual sources:

- NGER (Measurement) Determination 2008 (as amended) and NGER Act 2007, Commonwealth Department of Environment and Energy; and
- National Greenhouse Accounts Factors, Commonwealth Department of Environment and Energy, July 2018.

These guidelines are considered representative of good practice GHG accounting in Australia and are applicable to the Project.

The GHG condition did not mandate a specific standard, protocol, or methodology for the greenhouse gas assessment. The WA EPA 'Environmental Factor Guideline: Air Quality' also does not indicate how the greenhouse gas assessment is to be done – it sets out general guidelines to meet the primary objective which is "*To maintain air quality and minimise emissions so that environmental values are protected*".

2.2 Greenhouse gases and global warming potentials

The greenhouse gases considered in this assessment and the corresponding global warming potential (GWP) for each GHG are listed in Table 1. GWP is a metric used to quantify and communicate the relative contributions of different substances to climate change over a given time horizon. GWP accounts for the radiative efficiencies of various gases and their lifetimes in the atmosphere, allowing for the impacts of individual gases on global climate change to be compared relative to those for the reference gas carbon dioxide. The GWPs from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment report and section 2.02 of the National Greenhouse and Energy Reporting (NGER) Regulations 2008 were used in this assessment.

Table 1 Greenhouse gases and 100 year global warming potentials

Greenhouse gas	Global warming potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298

2.3 Assessment Boundary

2.3.1 Emissions boundary

The following GHG emissions have been considered:

- Scope 1 emissions from direct energy use during construction and operation
- Scope 1 emissions from loss of carbon due to the removal of vegetation
- Scope 2 emissions from indirect energy use from the import of electricity

The following emission sources were included in the assessment boundary:

- Fuel consumption during construction activities (including electricity generation, use of mobile plant and equipment)
- Energy (fuel/ electricity) consumption during operation of the facility including:
  - Grid electricity use
  - Fuel (natural gas) used for stationary purposes including steam generation, and kiln operation
  - Fuel (diesel) used for stationary purposes including front end loaders, forklift trucks, etc. around the site
- Consumption of raw carbonate materials (i.e. calcium carbonate) in the form of limestone sand consumed in the calcining process per annum

Specific exclusions are listed in section 2.4.

2.3.2 Emission scopes

Emissions have been separated into Scope 1 and 2 in accordance with the NGER (Measurement) Determination. These scopes are defined as follows:

- Scope 1 emissions are GHG emissions created directly by a person or business from sources that are owned or controlled by that person or business.
- Scope 2 emissions are GHG emissions created as a result of the generation of electricity, heating, cooling or steam that is purchased and consumed by a person or business. These are indirect emissions as they arise from sources that are not owned or controlled by the person or business who consumes the electricity.
- Scope 3 emissions, i.e. GHG emissions that are generated in the wider economy as a consequence of a person's or business's activities, are not required to be estimated for this Project (such as upstream emissions attributable to the extraction and processing of spodumene ore or the extraction, production and transport of fuels consumed in the course of the construction and operation of the facility).

2.4 Exclusions

Specific exclusions from this GHG assessment include:

- Scope 3 emissions including:
  - Transmission and distribution emissions of electricity imported to site
  - Embodied emissions of construction materials
  - Embodied emissions of spodumene ore and reagents used at the facility
  - Emissions from extraction and transport of fuels
  - Transport of materials. All transport will be by contractors, including spodumene ore and reagents to the facility, and products and tailings from the facility
- Emissions associated with personnel travelling to and from the facility, during construction or operational stages
- Emissions associated with the disposal of waste streams
- Emissions associated with wastewater handling. Wastewater will be held in an on-site storage tank for a short period prior to pumping to the Kemerton Wastewater Treatment Plant. Residence times in the holding tank will be insufficient to generate methane or nitrous oxide emissions.

- Emissions which are likely to be negligible compared with the other emissions from the Project were excluded from the assessment, including:
  - Emissions associated with the decommissioning and rehabilitation of the Project site at the end of its life
  - Emissions associated with combustion of fuels used in minor quantities such as LPG and oils and greases.
  - Emissions associated with the leakage of hydrofluorocarbons. The Project may use negligible quantities of hydrofluorocarbons for refrigeration and air conditioning during construction and operation.
  - Emissions from the storage or use of sulphur hexafluoride. Sulfur hexafluoride may be used as an electrical insulator within the switchgear. It will be used in small quantities (kilograms) and will be carefully controlled, inventoried and only handled by licenced operators. Hence, emissions from leakage of sulphur hexafluoride are expected to be negligible.
  - Emissions associated with transport purposes for plant operations and maintenance vehicles
- Emissions from the generation, storage, or use of perfluorocarbons – these substances are unlikely to be stored, generated, or used at the facility

2.5 Assumptions

Assumptions used in estimating GHG emissions for the construction and operation of the facility are listed in Table 2. The assessment was based on emission factors available at the time of the assessment and future changes in emission factors were not considered. Emissions factors used in preparation of this inventory are also described in the table below.

Data used for the GHG assessment was provided by Albemarle. The inventory is based on an assessment period of one year, being, for operations the year of peak production when five process trains are operating. For construction, it was assumed that emissions would peak in the initial construction period.

Table 2 Greenhouse gas assessment assumptions by source

Parameter	Assumptions
Construction	
Diesel combustion – transport purposes	No emissions from transport diesel have been estimated for the construction phase. It was assumed that 100% of the diesel consumed for construction was for stationary energy purposes as these are likely to contribute the majority of diesel consumption.
Diesel combustion – stationary energy purposes	Estimated diesel use for the initial stage of the construction phase was 2,500 kL. This includes diesel consumed in construction mobile plant and equipment and generators used for supplying electricity to construction operations. Emission factors (EF) were from the NGER (Measurement) Determination.
Grid electricity	Albemarle are currently reviewing options to use grid electricity during construction. For the purpose of this GHG plan, it has been assumed that no grid electricity will be used during construction, with all electricity generated by diesel-fired mobile generators.
Lost carbon sink due to land clearing	The Transport Authorities Greenhouse Group (TAGG) GHG Assessment Workbook for Road Projects was used to estimate the quantity of lost carbon sink associated with land clearing. The use of this method is inherently

Parameter	Assumptions
	conservative in that it assumes all carbon pools are removed, and all carbon removed is converted to carbon dioxide and released to the atmosphere (TAGG 2013). The estimate was prepared using vegetation survey information from the Environmental Referral (Albemarle Lithium 2017b). The coverage of individual vegetation classes in the survey area was used, with a clearing area of 88 ha of grassland and woodland vegetation types. It was assumed that diesel consumption associated with vegetation clearing is captured in the diesel consumed for stationary energy purposes above.
Operations	
Diesel combustion – stationary purposes	Estimated diesel consumed for stationary purposes at the facility was 2,962 kL/a (source: Albemarle). EF were from the NGER (Measurement) Determination.
Grid electricity	Estimated electricity sourced from the grid used during production was 503 GWh/a (source: Albemarle) EF were from the NGER (Measurement) Determination.
Natural gas combustion – kiln firing and boilers	Estimated natural gas consumption for the firing of the roast kilns was 92,418 tpa (source: Albemarle). An energy density value of 53.6 GJ/t (International Gas Union 2012) was applied to the estimate to determine the energy consumed from this emission source, equating to 4,953,605 GJ/annum. EF were from the NGER (Measurement) Determination.
Use of carbonates	Estimated calcium carbonate consumption in the form of limestone sand was 118,260 tpa (source: Albemarle). The NGER (Measurement) Determination, section 4.22, requires the fraction of the raw carbonate material consumed in the industrial process during the year. If the information is not available the fraction is assumed to have the value ‘1’ for the purposes of estimating emissions using Method 1. The value ‘1’ has been applied to the estimate of emissions from this source.

2.6 Results

2.6.1 Construction emissions

The estimated peak annual GHG emissions related to construction are approximately 20,600 t CO_2-e. A summary of the estimated scope 1 GHG emissions as a result of peak construction activities is presented in Table 3. There are no scope 2 emissions anticipated.

Construction emissions are estimated as approximately 3% of peak operational emissions. Construction emissions will be of limited duration for each train.

Table 3 Construction GHG emissions

Activity	GHG Emissions (t CO_2-e)
Diesel combustion – plant and equipment and electricity generation	6,774
Vegetation clearing - Loss of carbon sink	13,843
Total annual GHG emissions	**20,617**

2.6.2 Operational emissions

The estimated peak annual GHG emissions for the operational phase of the facility is approximately 661,940 t CO_2-e. A summary of the estimated peak annual GHG emissions from operation of the facility is in Table 4.

Table 4 Operational GHG emissions

Activity	Scope 1 GHG Emissions (t CO_2-e)	Scope 2 GHG Emissions (t CO_2-e)
Diesel combustion – stationary	8,026	0
Natural gas – Kiln firing and boilers	255,259	0
Use of carbonates	46,831	0
Consumption of grid electricity	0	351,824
Total per scope	*310,116*	*351,824*
Total annual GHG emissions	**661,940**	

2.6.3 Emissions intensity

At peak production of 100,000 tpa of lithium hydroxide product, the emissions intensity is estimated to be 6.6 t CO_2-e per tonne of lithium hydroxide produced.

3. Benchmarking

3.1 Literature review

The WA EPA 'Environmental Factor Guideline: Air Quality' indicates that an analysis of greenhouse gas intensity should be undertaken (i.e. quantity of CO_2-e generated per tonne of product produced) with comparison against published benchmarked practice for equivalent plant, equipment and operations.

3.1.1 Australian plant

The only Australian lithium plant (approved under development) is the Tianqi Lithium Australia Hydroxide Process Plant (Tianqi), located in Kwinana, WA. Tianqi could be considered as having equivalent plant, equipment and operations to the Albemarle plant:

- Similar capacity 24,000 tpa lithium hydroxide plant, compared with 20,000 tpa for each process train for Albemarle
- Similar lithium mineral conversion process
- Similar source material – spodumene ore concentrate (from the same Talison Greenbushes mine)
- Natural gas is used for the acid roast kiln and steam generation

The 2016 Works Approval for the first stage of the Tianqi operations indicates that specific detail regarding the process is the subject of an exemption from publication claim on the basis of commercial-in-confidence (WA Department of Environment Regulation, Works Approval W5977/2016/1, Tianqi Lithium Australia Pty Ltd, Lithium Hydroxide Processing Plant). No details of fuel/ electricity use or GHG emissions are included.

The Tianqi plant is currently doubling its capacity (WA Department of Water and Environment Regulation, Works Approval W5977/2016/1, Tianqi Lithium Australia Pty Ltd, Lithium Hydroxide Processing Plant, Amendment Notice 1). Again no details of fuel/ electricity use or GHG emissions are included in the documentation.

Tianqi has not published any projected GHG emissions data on its website.

All facilities with scope 1 emissions above the reporting threshold of 100,000 t CO_2-e per annum has the facility GHG benchmark published by the Clean Energy Regulator under the NGER Safeguard Mechanism. No GHG benchmark has been published for the Tianqi plant.

Published benchmarks for other mineral processing plants are not available in Australia for comparison. When available, these will be published by the Minister for Environment in 'Schedule 1 Benchmark Emissions-Intensity Index' of the *NGER (Safeguard Mechanism) Rule 2015*. Even if benchmarks were available for other types of mineral processing, it may not be possible to compare across different industries as benchmarks are expressed as t CO_2-e/ tonne specific product.

Therefore, there are no published GHG benchmarks available for equivalent Australian plants.

3.1.2 International plants

International Mineral Conversion Plants (either lithium hydroxide or lithium carbonate) are located in China, with one additional small plant located in Minas Gerias, Brazil (Hatch 2017). Published English-language data on GHG emissions from these sources was not available.

A number of projects are also under development worldwide. Feasibility studies contain some information, but not complete information to enable a comparison. For example:

- The proposed 24,500 tpa lithium hydroxide plant for Nemaska Lithium, Shawinigian plant, Canada, indicates 430 GWh/a electricity but does not specify natural gas use quantities, so total GHG cannot be determined
- The proposed 14,000 tpa lithium hydroxide plant for Sayona Mining Limited in Quebec, Canada, gives a preliminary estimate of 66 GWh/a electricity, 500 TJ/a gas and 10,000 tpa calcium carbonate. This equates to an approximate emissions intensity of 5.5 tCO2-e/ tonne product. However, it is unclear whether the process and assumptions are comparable. The emissions intensity was not published, but estimated by GHD based on the preliminary information.
- Feasibility and concept studies for a number of lithium hydroxide and lithium carbonate producers were examined1, however, there is insufficient data available on estimated fuel/ electricity use and carbonate consumption to estimate comparative GHG emissions.

Lithium hydroxide can be produced from brines via solar evaporation. However, this process cannot be considered equivalent plant, equipment and operations. Emissions are much lower from this process.

Therefore, there are no published benchmarks available for equivalent international plants.

3.1.3 Benchmarking summary

A literature review found no publicly available comparable information on the greenhouse gas emissions from the operation of lithium hydroxide plants around the world. This is because the production of lithium hydroxide by mineral conversion plants is a relatively new technology with a limited number of plants operating globally. Therefore, it was not possible to benchmark the greenhouse gas emissions performance of the Albemarle facility against equivalent operating plants.

3.2 State and national GHG emissions

Since data for comparable plants are not available, estimated peak emissions have been benchmarked against state and national GHG emission totals. The quantity of emissions estimated to occur during operations are approximately 661,940 tCO_2-e.

Australia's national greenhouse gas emissions, by sector, for the year to March 2018 are presented in Table 5 below. Total annual emissions are 536.7 Mt CO_2-e. Annual emissions from the Project, at peak capacity, would account for approximately 0.1% of Australia's annual emissions.

The most recently published state-based emissions inventory is for 2016. Western Australia's greenhouse gas emissions, by sector, for the 2016 year are also presented in Table 5. Total annual emissions are 82.2 Mt CO_2-e. Annual emissions from the Project would account for approximately 0.8% of WA's annual emissions.

[1] Publically available reports/ company announcements/ web sites for the following lithium mineral conversion plants were reviewed:

- NeoMetals Ltd/ Mineral Resources Ltd, Kalgoorlie Lithium Hydroxide Facility, Australia
- Nemaska Lithium, Shawinigian plant, Canada (lithium hydroxide)
- Sayona Mining Limited, Authier Lithium Project, Quebec, Canada (lithium hydroxide)
- Avalon Advanced Materials, Separation Rapids Lithium Project, Ontario, Canada (lithium hydroxide)
- European Metals Holdings Ltd, Cinovec Lithium, Czech Republic (lithium carbonate)
- Critical Elements Corporation, Rose Lithium-Tantalum Project, Quebec, Canada (lithium carbonate)
- Bacanora Lithium, Sonora Lithium Project, Mexico (lithium carbonate)
- Keliber Oy, Keliber Lithium Project, Finland (lithium carbonate)

Table 5 Impact of facility emissions on national and state totals

Emissions Source	March 2018 Australian Emissions (Mt CO_2-e) [1]	2016 WA Emissions (Mt CO_2-e) [2]
Energy – Electricity	181.5	25.4
Energy – Stationary Energy excluding electricity	98.3	25.4
Energy – Transport	100.6	14.5
Energy – Fugitive Emissions	57.3	8.5
Industrial processes and product use	36.1	5.0
Agriculture	73.7	8.9
Waste	12.6	1.7
Land Use, Land Use Change and Forestry	-23.3	-7.2
Overall Total	**536.7**	**82.2**

Source:

1. Table 3, Department of the Environment and Energy "*Quarterly Update of Australia's National Greenhouse Gas Inventory: March 2018*", June 2018 (Commonwealth of Australia 2018b)
2. Table 12: Department of the Environment and Energy "*State and Territory Greenhouse Gas Inventories 2016*" February 2018 (Commonwealth of Australia 2018c)

4. GHG minimisation and continuous improvement

In line with the EPA 'Environmental Factor Guideline: Air Quality', the facility has been designed and will be operated to ensure GHG emissions are minimised. The measures outlined in this section summarise how Albemarle will approach the minimisation of scope 1 and scope 2 emissions arising from the construction phase and operation of the facility.

4.1 Environmental Management Systems and Processes

In relation to energy efficiency, Albemarle Corporation is an ENERGY STAR Partner and has made a fundamental commitment to protect the environment through the continuous improvement of energy performance. Albemarle implements an organisation-wide energy management approach.

The Albemarle Corporate Environmental Management System (EMS) includes a commitment to minimising the footprint of operations by actively pursuing opportunities to reduce emissions and energy usage.

Continuous improvement to plant and process will be facilitated through Albemarle's EMS.

4.2 Scope 1 Emissions

The minimisation of scope 1 emissions focuses on the selection and operation of plant and equipment during the construction phase and the selection of fuel sources, refrigerants, transport options and energy efficient processes and technology for the operation of the facility. Measures to minimise scope 1 emissions during the construction and operation of the facility are outlined in Table 6.

Table 6 GHG minimisation measures for scope 1 emissions

Phase	GHG minimisation measures
Construction	• Maintenance of vehicles and equipment in accordance with manufacturer's specifications. • Selection of low emissions producing plant and equipment.
Operations	***Plant*** • Steam boilers – economiser specified for high energy efficiency. • Heat recovery from roaster kiln flue gas • Insulation of the roaster kiln to minimise heat loss. • Hot milling process – selection of energy efficient process. • Incorporation of kiln chains as a superior heat transfer mechanism to improve heat efficiency by stabilising kiln burner operation. • Plant control / monitoring system will monitor critical process and performance parameters. • Plant and equipment will be maintained in accordance with manufacturer's specifications to minimise fuel consumption. • Use of electric forklifts in product warehouse – displacement of other fuels (e.g. LPG).

Phase	GHG minimisation measures
	Refrigeration • Use of ammonia as a refrigerant – this has a zero GWP and zero ozone depleting potential properties. ***Transport*** • Double trailer truck haulage – maximises tonnage per trip and minimises number of trips. • Internal road layout design – designed to smooth the trucking speeds to minimise stop/start. • Vehicles will be maintained in accordance with manufacturer's specifications to minimise fuel consumption. • Provision of EV charging car bays

4.3 Scope 2 emissions

4.3.1 Best Available Technology

During the environmental approvals process, a benchmarking assessment was carried out against Best Available Techniques (BAT) (Albemarle Lithium 2017a). Part of the BAT study assessed the facility against the European Commission Industrial Emissions Directive Best Available Techniques Reference Document for the Non-Ferrous Metals Industries (BREF Document) BAT 2 – Energy Management. A number of BAT 2 energy efficiency techniques were not applicable to the Albemarle process. Applicable energy efficiency techniques, to minimise grid electricity use, and hence scope 2 emissions, are included in Table 7 below.

4.3.2 Scope 2 emissions minimisation

No scope 2 emissions are expected to be generated during the construction stage.

The minimisation of scope 2 emissions focuses on energy efficiency in relation to grid electricity consumption for operational purposes. Measures to minimise scope 2 emissions are outlined in Table 7.

Table 7 GHG minimisation measures for scope 2 emissions

Phase	GHG minimisation measures
Operations	***Plant*** • Resizing of equipment to reduce the number of electrical drives • Use of variable speed drive for electric motors where applicable. ***Evaporation*** • Internal recuperative heat transfer within each evaporative system – maximises heat efficiency of each individual system • Further large recuperative heat transfer systems – maximises heat efficiency between individual systems. ***Process*** • Plant control/ monitoring system will monitor critical process and performance parameters. • Equipment will be maintained in accordance with manufacturer's specifications.

Phase	GHG minimisation measures
	Non-Process Infrastructure • Double glazed windows on north and east facing windows – reduces solar heat input. • Nominated LED energy efficient luminaries across majority of the site. • Zoning of office lighting to maximum 100 sqm and individual motion sensors for each zone.

4.4 Energy efficiency improvement opportunities

Some of the possible opportunities for minimisation of net emissions within the existing design are:

- Recovery of low grade heat resources within the plant to further improve energy and water usage efficiencies.
- Further optimisation of recuperative heat exchange within the process streams by pinch analysis.
- Improved water balance control to reduce evaporation loads
- Cascading of cooling water systems to further improve the efficiency of the higher powered refrigeration circuits.

5. GHG monitoring and reporting

5.1 Data collection

No direct measurement of GHG emissions will be conducted at the Kemerton facility. As such, the GHG emissions and the production and consumption of energy arising from the operation of the facility will be estimated as per the NGER requirements. In addition to the measurement and collection of NGER data, the record keeping requirements of the NGER Scheme are required to be adhered to.

The following data would require annual monitoring, in order to estimate GHG emissions and energy consumption:

- Natural gas use
- Diesel consumption in equipment
- Diesel consumption in any Albemarle transport fleet
- Limestone (or any other carbonate) use
- Grid electricity use
- Minor fuels such as oils and greases, LPG and acetylene, if above reporting thresholds.

5.2 GHG reporting

5.2.1 NGER

Under the NGER scheme, corporations that exceed the corporate and facility thresholds for emissions, energy production or energy consumption need to report annually to the Clean Energy Regulator (CER). The current (2018) reporting thresholds for facilities and corporate groups is outlined in Table 8.

Table 8 Current facility and corporate group reporting thresholds

Threshold type	Facility threshold	Corporate group threshold
Scope 1 and Scope 2 emissions	>25 kt CO_2-e	>50 kt CO_2-e
Production of energy	>100 TJ	>200 TJ
Consumption of energy	>100 TJ	>200 TJ

Scope 1 emissions associated with the operation of the facility will be above the threshold for facility and corporate level reporting of 25,000 t CO_2-e and 50,000 t CO_2-e respectively under the NGER Act 2007. The plant will also be above the facility and corporate reporting threshold for energy consumption.

Albemarle is required to register as a controlling corporation under the NGER Scheme and report annually. Reporting will be required for stage 1 capacity of 20,000 tpa lithium hydroxide product onwards. Scope 1 emissions for construction do not exceed the NGERS reporting threshold.

5.2.2 Safeguard mechanism

Scope 1 covered emissions arising from the operation of the facility are estimated to be above the Emissions Reduction Fund Safeguard Mechanism benchmark threshold of 100,000 t CO_2-e. Albemarle is required to apply for a baseline to be set by the CER prior to its Scope 1 emissions exceeding the threshold – this is expected to be before the first two trains are operational. The safeguard mechanism requires facilities whose net emissions exceed the safeguard threshold to keep emissions at or below the baseline set for that facility.

5.2.3 Public reporting

Consistent with Condition 9-3(3) of Statement 1085, Albemarle will include the following information in the Annual Compliance Assessment Report for the Project, which will be made publically available:

a. Facility-level greenhouse gas emissions;

b. Emissions intensity (emissions per unit of product) achieved *in practice;* and

c. Measures implemented to minimise greenhouse gas emissions.

References

Albemarle Lithium 2017a, *Albemarle Kemerton Plant Best Available Techniques Benchmarking*, Albemarle Lithium Pty Ltd, Forrest, ACT

Albemarle Lithium 2017b, *Albemarle Kemerton Plant Environmental Referral Supporting Report,* Albemarle Lithium Pty Ltd, Forrest, ACT

Commonwealth Department of the Environment and Energy 2018, *National Greenhouse Accounts Factors*, retrieved on 12 October 2018, from http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018

Commonwealth of Australia 2017, *National Greenhouse and Energy Reporting Act 2007*, Compilation No. 18, Office of Parliamentary Counsel, Canberra

Commonwealth of Australia 2018a, *National Greenhouse and Energy Reporting (Measurement) Determination 2008*, Compilation No. 10, Office of Parliamentary Counsel, Canberra

Commonwealth of Australia 2018b, *Quarterly Update of Australia's National Greenhouse Gas Inventory for March 2018*, retrieved 19 October 2018, from http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/quarterly-update-australias-national-greenhouse-gas-inventory-march-2018

Commonwealth of Australia 2018c, *State and Territory Greenhouse Gas Inventories 2016*, retrieved 19 October 2018, from http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/state-and-territory-greenhouse-gas-inventories-2016

DEFRA 2018, *Greenhouse Gas Conversion Factors 2018*, retrieved on 12 October 2018, from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018

Hatch 2017, *Study for the Development of Western Australia's Lithium Resources and Related Research and Processing Activities*, Hatch Pty Ltd, Perth, Western Australia

International Gas Union 2012, *Natural Gas Conversion Guide*, retrieved on 19 October 2018, from http://members.igu.org/old/IGU%20Events/wgc/wgc-2012/wgc-2012-proceedings/publications/igu-publications

Nemaska Lithium. 2018, *NI 43-101 Technical Report Feasibility Study on the Whabouchi Lithium Mine and Shawinigan Electrochemical Plant*, Nemaska Lithium Inc, Quebec

Sayona 2017 *ASX Announcement: Lithium Carbonate/ Hydroxide Concept Study Demonstrates Positive Technical and Economic Viability*, 30 August 2017, Sayona Mining Limited

TAGG 2013, *Greenhouse Gas Assessment Workbook for Road Projects*, retireneved 12 October 2018, from http://www.rms.nsw.gov.au/documents/about/environment/greenhouse-gas-assessment-workbook-road-projects.pdf

Tianqi Lithium Australia Pty Ltd 2017, *Stage 2 Lithium Hydroxide Process Plant Works Approval W5955/2016/1 Amendment Application*, retrieved from Department of Water and Environmental Regulation website

WA Environmental Protection Authority 2016, *Environmental Factor Guideline: Air Quality*, Environmental Protection Authority, Western Australia

WA Department of Water and Environmental Regulation, *Works Approval W5977/2016/1*, Tianqi Lithium Australia Pty Ltd, Lithium Hydroxide Processing Plant, retrieved from https://www.der.wa.gov.au/component/k2/itemlist/filter?fitem_all=tianqi&=&=&=&=&=&moduleId=94&Itemid=175

WA Department of Water and Environmental Regulation, *Works Approval W5977/2016/1 Amendment Notice 1,* Tianqi Lithium Australia Pty Ltd, Lithium Hydroxide Processing Plant, , retrieved from https://www.der.wa.gov.au/component/k2/itemlist/filter?fitem_all=tianqi&=&=&=&=&=&moduleId=94&Itemid=175

WA Environmental Protection Authority 2018, *Report and recommendations of the EPA Albemarle Kemerton Plant, Report 1618*, Environmental Protection Authority, Western Australia

GHD

1st Floor
10 Victoria Street
T: 61 8 9721 0700 F: 61 8 9721 0777 E: bunmail@ghd.com

G:\Bunbury\Projects\61\36286\Final\GHG MP\6136286-REP-R2_GHG MP.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	K McCaughan	S Trahair		Mat Brook		30/10/2018
B	K McCaughan	S Trahair		Mat Brook		31/10/2018
0	K McCaughan	S Trahair		Mat Brook		31/10/2018
1	K McCaughan	S Trahair		Mat Brook		31/10/2018
2	K McCaughan	S Trahair		Mat Brook		28/11/2018

www.ghd.com