Greenhouse Gas Impact Assessment

Document no: Final
Version: F0v9

Hexham Wind Farm Pty Ltd

Hexham Wind Farm
8 October 2025

Greenhouse Gas Impact Assessment

Client name:	Hexham Wind Farm Pty Ltd		
Project name:	Hexham Wind Farm		
		Project no:	IS454700
Document no:	Final	**Project manager:**	Luke Spencer
Version:	F0v9	**Prepared by:**	Sean Brennan
Date:	8 October 2025	**File name:**	IS454700_GHGIA_F0v9_Clean.docx

Document history and status

Version	Date	Description	Author	Checked	Reviewed	Approved
Draft1vA	22/05/2023	Initial draft for technical review	SB	JM	JM	
Draft2vA	31/05/2023	Initial draft for technical review	SB	JM	JM	
Final0v1	01/06/2023	Issued for TRG review	SB	JM	JM	
Final0v2	06/12/2024	Updates for minor project change	SB	LS	LS	
Final0v3	12/12/2024	Final following client review	SB	LS	LS	LS
Final0v4	31/01/2025	Final following second TRG review	SB	LS	LS	SH
Final0v5	29/05/2025	Final following third TRG review	RH	LS	LS	SH
Final0v6	26/06/2025	Final following fourth TRG review	LS	AH	AH	AH
Final0v7	05/08/2025	Final following fifth TRG review	SB	LS	SH	SH
Final0v8	15/09/2025	Final following minor project update	LS	SH	SH	SH
Final0v9	08/10/2025	Final following TRG review	SB	LS	SH	SH

Distribution of copies

Version	Issue approved	Date issued	Issued to	Comments
D1vA	22/02/2023	22/02/2023	MS	First draft for client review
D2vA	31/05/2023	31/05/2023		2nd draft for client review
F0v1	01/06/2023	01/06/2023		Final
F0v2	06/12/2024	09/12/2024	MG, RM	Updated Final report for review

F0v2	12/12/2024	13/12/2024	MG, RM	Final
F0v4	31/01/2025	05/02/2025	MG, RM	Final following second TRG review
F0v5	30/05/2025	30/05/2025	MG, RM	Final following third TRG review
F0v6	26/06/2025	26/06/2025	MG, RM	Final following fourth TRG review
F0v7	05/08/2025	05/08/2025	MG, RM	Final following fifth TRG review
F0v8	15/09/2025	21/09/2025	MG, RM	Final following minor project update
F0v9	08/10/2025	08/10/2025	MG, RM	Final following TRG review

Jacobs Group (Australia) Pty Ltd

Level 4, 12 Stewart Avenue
Newcastle West, NSW 2302
PO Box 2147
Dangar, NSW 2309
Australia

T +61 2 4979 2600
F +61 2 4979 2666
www.jacobs.com

Executive summary

Hexham Wind Farm Pty Ltd (the proponent) is developing the proposed Hexham Wind Farm (the Project) in Moyne Shire, Victoria. The Project will harness strong and reliable winds to generate renewable energy through the construction and operation of up to 106 wind turbines generators and would operate for a period of at least 25 years following a two-year construction period. The wind farm would generate approximately 2,850 gigawatt hours (GWh) of renewable electricity each year. Electricity produced by the Project would be fed through underground and overhead cables to a new on-site terminal station, where it would be exported to the national electricity network via the Moorabool to Heywood 500 kilovolt transmission line.

As determined by the Minister for Planning under the *Environment Effects Act 1978*, the proponent is required to prepare an environment effects statement (EES) for the Project. This Greenhouse Gas Impact Assessment addresses the Project draft scoping requirements, issued by the Minister for Planning, which require predictions of energy use and greenhouse gas (GHG) emissions associated with the Project, and the development of measures to minimise GHG emissions.

To address the scoping requirements, this assessment seeks to assess the GHG emissions associated with the construction, operation and decommissioning of the Project. This assessment also demonstrates how the proposed facility meets the requirements of the General Environmental Duty (GED) under the *Environment Protection Act 2017*, which requires Victorians to understand and minimise their risks of harm to human health and the environment, from pollution and waste, including the emission of greenhouse gasses. This assessment has regard to the potential contributions the Project may have to the State's GHG emissions as required by the *Climate Change Act 2017*.

The GHG Assessment has been prepared in accordance with EPA Victoria and National Greenhouse Accounts guidance and associated factors. The sources of GHG emissions associated with the Project include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These GHG emissions sources are categorised into the following scope types:

- **Scope 1:** Direct emissions from sources that are owned or operated by the reporting organisation, such as combustion of fuel used in on-site power generation
- **Scope 2**: Indirect emissions associated with the import of energy from another source, such as purchases of electricity
- **Scope 3:** Other indirect emissions which are a direct result of the operations of the organisation, but from sources not owned by them. Examples include emissions embedded in raw materials, business travel and product usage.

The scope of this study includes a GHG assessment for the construction and operation of the Project. The boundary of this study scope therefore includes all materials sources and sinks of emissions associated with the construction and operation of the Project over the design life of 25 years.

The construction phase emissions have been calculated as 1,325,425 tCO_2e. The raw operational emissions have been calculated as 82,620 tCO_2e per annum, decreasing to 308 tCO_2e per annum by 2050 (noting assumptions and limitations associated with emissions for BESS and SF_6 leakage). Over the 25-year life of the Project, the overall GHG emissions are expected to be 1,706,853 tCO_2e. However, the Project is anticipated to produce up to 2,559 GWh of wind-based electricity annually. Decommissioning activities have been assessed qualitatively and are generally assumed to be similar to construction, without the emissions attributed to the vegetation clearing and embedded emissions, alongside various additional energy efficiencies possible by the time the Project is decommissioned.

Due to the low emissions intensity for electricity produced by the Project, it is anticipated to be a positive development for reducing the State's GHG emissions. Still, an EPR was recommended to minimise GHG emissions through all stages of delivery.

Table E.1 Emissions summary

	Construction	Operation	Design Life (Construction + 25 years Operation)
Calculated Emissions (tCO_2e)	1,325,425	381,428	**1,706,853**

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs Group (Australia) Pty Ltd (Jacobs) is to undertake a greenhouse gas impact assessment for the Hexham Wind Farm in accordance with the scope of services set out in the contract between Jacobs and Hexham Wind Farm Pty Ltd (the proponent). That scope of services, as described in this report, was developed with the proponent.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the proponent and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the proponent (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the Project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full, and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of the proponent, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the proponent. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Contents

Executive summary i
Important note about your report iii
Acronyms and abbreviations vii
1. Introduction 1
1.1 Background 1
1.2 Purpose of this report 1
1.3 Report structure 1
2. EES Scoping requirements 3
2.1 EES evaluation objectives 3
2.2 Assessment of specific environmental effects 3
3. Project description 4
3.1 Project overview 4
3.2 Project details 4
3.3 Summary of key project activities 7
3.3.1 Construction 7
3.3.2 Operations 8
3.3.3 Decommissioning 8
4. Legislation, policy, and guidelines 9
4.1 International policy 9
4.1.2 The Greenhouse Gas Protocol 9
4.2 Commonwealth legislation 10
4.2.1 National Greenhouse and Energy Reporting Act 2007 10
4.2.2 Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 10
4.3 State legislation and policy 10
4.3.1 Victoria's Climate Change Act 2017 10
4.3.2 Environment Protection Act 2017 11
4.3.3 Victoria's Climate Change Strategy (2021) 11
4.3.4 Victoria's Renewable Energy Action Plan (2018) 11
4.3.5 Victoria Planning Provisions Scheme 11
4.3.6 Protocol for Environmental Management: Greenhouse gas emissions and energy efficiency in industry (2002) (PEM) 12
4.3.7 Publication 2048: Guideline for minimising greenhouse gas emissions 12
5. Methodology 13
5.1 Overview 13
5.2 Scope and study area 13
5.3 Existing conditions 13
5.4 Stakeholder engagement 14

5.5 Impact assessment ... 14
5.5.1 Overview ... 14
5.5.2 Sources of emissions ... 14
5.5.3 Greenhouse gas assessment boundaries ... 16
5.5.4 Emission factors ... 17
5.5.5 Grid electricity emission factors ... 20
5.5.6 Assessment of greenhouse gas impact ... 21
5.5.7 Assessment of decommissioning emissions ... 21
5.5.8 Cumulative Impacts ... 21
5.5.9 Development of mitigation measures ... 21
5.5.10 Determination of the significance of residual impacts ... 22
6. Existing conditions ... 23
7. Impact assessment ... 24
7.1 Construction ... 24
7.1.1 Energy related greenhouse gas emissions ... 24
7.1.2 Non-energy related greenhouse gas emissions ... 25
7.1.3 Total construction greenhouse gas emissions ... 26
7.1.4 Implications of construction greenhouse gas emissions ... 28
7.2 Operation ... 28
7.2.1 Energy related greenhouse gas emissions ... 28
7.2.2 Non-energy related greenhouse gas emissions ... 35
7.2.3 Total greenhouse gas emissions ... 36
7.2.4 Implications of operation greenhouse gas emissions ... 38
7.3 Decommissioning ... 38
7.3.1 Key issues ... 38
7.3.2 Decommissioning greenhouse gas impacts ... 38
7.4 Cumulative emissions profile ... 39
7.5 Cumulative greenhouse gas impacts ... 39
7.6 Operational Emissions Efficiency ... 39
8. Mitigation and management, reporting and EPRs ... 41
8.1 Best practice energy and greenhouse gas management ... 41
8.1.1 Construction ... 41
8.1.2 Operation ... 41
8.1.3 Decommissioning ... 42
8.1.4 Summary of mitigation ... 42
8.2 Greenhouse gas emissions reporting ... 43
8.3 General environmental duty ... 43
8.4 Environment Performance Requirements ... 43
9. Significance of greenhouse gas emission impacts ... 45

10. Conclusion **48**
11. References **49**

Appendices

Appendix A. Input Data **50**

Acronyms and abbreviations

Acronym	Definition
AGEIS	Australian Greenhouse Emissions Information System
BESS	Battery Energy Storage System
CH_4	Methane
CO_2	Carbon dioxide.
CO_2e	Carbon dioxide equivalent – the amount of CO_2 emissions with the same global warming potential as the equivalent amount of another greenhouse gas emissions. This allows for the global warming potential for a number of greenhouse gasses to be aggregated into a single indicator
COP	Conference of the Parties, referring to the countries that have signed up to the 1992 United Nations Framework Convention on Climate Change.
DCCEEW	Department of the Climate Change, Energy, the Environment and Water
DTP	Department of Transport and Planning
Environment Effects Act	*Environment Effects Act 1978*
EES	Environment Effects Statement
EPA	Environment Protection Authority (Victoria)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPR	Environmental Performance Requirements
GED	General Environmental Duty
GHG	Greenhouse Gas
GHG Protocol	The Greenhouse Gas Protocol is collaboration between the World Resources Institute and the World Business Council for Sustainable Development. The Protocol provides a globally standardized framework and guideline for the calculation and reporting of carbon footprints and developing mitigation measures.
Ha	Hectare
IPCC	Intergovernmental Panel on Climate Change.
ISC	Infrastructure Sustainability Council
kL	Kilolitre
km	Kilometre
N_2O	Nitrous Oxide
NGER	National Greenhouse and Energy Reporting
OLARS	Ozone Licensing and Reporting System (under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*)
PEM	*Protocol for Environmental Management: Greenhouse gas emissions and energy efficiency in industry (2002)*
State of knowledge	All of the information you should reasonably know about managing your business's risks
t	Tonne

UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

1.1 Background

Hexham Wind Farm Pty Ltd (the proponent) is seeking approval for the proposed Hexham Wind Farm (HWF) (the Project), located between the townships of Hexham, Caramut, Ellerslie and Minjah in Moyne Shire in southwest Victoria.

This Greenhouse Gas Impact Assessment (GHGIA), prepared by Jacobs Group (Australia) Pty Ltd (Jacobs) on behalf of the proponent, addresses the scoping requirements issued by the Department of Transport and Planning (DTP) for the project in September 2024 that are relevant to amenity impacts as part of an Environment Effects Statement (EES), as required under the *Environment Effects Act 1978* (refer to **Section 2**). The report also supports the planning permit application for the project, as required under the *Planning and Environment Act 1987*.

1.2 Purpose of this report

The purpose of this report is to address the scoping requirements by assessing the greenhouse gas (GHG) emissions associated with the construction and operation of the Project, and to define the Environmental Performance Requirements (EPRs) necessary to avoid and minimise environmental impacts, determine the environmental outcomes that the Project must meet, and address the EES evaluation objectives.

The specific objectives of the impact assessment are to:

- Predict and provide an understanding of the greenhouse gas emissions associated with the construction, operation and decommissioning of the Project.
- Place emissions from the Project in the context of state and Commonwealth goals and policy.
- Review and present appropriate mitigation measures to apply to the Project to reduce the predicted emissions.

1.3 Report structure

This report is structured in the following way:

- **Introduction** (this section) which provides background details for the Project and outlines the purpose and structure of the GHGIA.
- **EES scoping requirements** (**Section 2**) where the key matters that the Project poses to the achievement of the evaluation objective are identified.
- **Project description** (**Section 3**), where key details relevant to the assessment are explained.
- **Legislation, policy and guidelines** (**Section 4**) which lists the state, Commonwealth and other documents relevant to the assessment.
- **Methodology** (**Section 5**) where the approach applied to assess potential greenhouse gas impacts associated with the Project is explained.
- **Existing conditions** (**Section 6**) which establishes the historic and existing greenhouse gas emissions associated with Victoria and Australia, which the Project's greenhouse gas emission performance will be assessed against
- **Impact assessment (Section 7),** where initial greenhouse gas impacts during the construction, operation and decommissioning of the Project, including potential cumulative impacts are evaluated.

- **Mitigation and management, Environmental performance requirements (Section 8)** where measures to mitigate or otherwise effectively manage the potential impacts determined including EPRs are presented
- **Residual impacts (Section 9)** where residual impacts (with the application of the recommended mitigation and management measures, including EPRs) are presented
- **Conclusion** (**Section 10**) where the objectives, methods, outcomes and recommendations of the assessment are presented.

2. EES Scoping requirements

2.1 EES evaluation objectives

The scoping requirements (DTP, 2024) set out in detail the matters to be investigated, assessed and documented in the EES for the Project. The scoping requirements specify evaluation objectives which provide a framework to guide an integrated assessment of environmental effects of the Project, in accordance with the *Ministerial guidelines for assessment of environmental effects under the Environment Effects Act 1978, Eighth edition, 2023*.

The evaluation objectives relevant to the GHGIA from the scoping requirements include:

Section 3.3 (Project description and rationale): *…describe the project in sufficient detail both to allow an understanding of all components, processes and development stages, and to enable assessment of their likely potential environmental effects. The project description should canvass the following:*

- *predictions of energy use and greenhouse gas emissions associated with the project, as well as renewable energy generated over the life of the project,*

Section 4.4 (Amenity), design and mitigation: *Describe and propose siting, design, mitigation and management measures to control emissions to air from construction activities, including measures to minimise greenhouse gas emissions.*

In order to meet these evaluation objectives, it is necessary to understand the potential impact of the Project on state and federal greenhouse gas emissions so that impacts can be appropriately avoided or mitigated. Understanding these impacts requires an impact assessment which quantifies the potential greenhouse gas emissions associated with the construction, maintenance, operation and decommissioning of the Project.

2.2 Assessment of specific environmental effects

The scoping requirements set out the key issues that the Project poses to the achievement of the evaluation objectives. The scoping requirements also list potential effects of the Project and identify where mitigation measures may be required.

The scoping requirements pertaining to greenhouse gas are reproduced in **Table 2.1**, together with directions to the reader as to where these items have been addressed in this report (and other reports as applicable).

Table 2-1 EES scoping requirements – amenity

Category	Requirement relevant to GHG	Section addressing this requirement
Assessment	Predictions of energy use and greenhouse gas emissions associated with the project, as well as renewable energy generated over the life of the project	**Section 7**
Design and mitigation	Describe and propose siting, design, mitigation and management measures to control emissions to air from construction activities, including measures to minimise greenhouse gas emissions.	**Section 8**

3. Project description

3.1 Project overview

Hexham Wind Farm Pty Ltd (the proponent) is developing the project in Moyne Shire, Victoria. The project will harness strong and reliable winds to generate renewable energy through the construction and operation of up to 106 wind turbines generators and would operate for a period of at least 25 years following a two-year construction period. The wind farm would generate approximately 2,559 gigawatt hours (GWh) of renewable electricity each year. Electricity produced by the project would be fed through underground and overhead cables to a new on-site terminal station, where it would be exported to the national electricity network via the Moorabool to Heywood 500 kilovolt transmission line.

The project extends across approximately 16,000 hectares of private and public land located between the townships of Hexham, Caramut and Ellerslie in south-western Victoria. The main land use within the project site is agricultural (predominantly cattle and sheep grazing, along with some cropping). Much of the area has been cleared of native vegetation with remnant vegetation largely restricted to roadside reserves and along watercourses, with small, isolated areas on private land.

Around 151 kilometres of new access tracks, including upgrades to around 16.7 kilometres of existing access tracks within the project site, would be required to provide for construction and maintenance access from the public road network to each wind turbine and supporting infrastructure. These access tracks can also be used by emergency vehicles and by landowners for their farming operations.

Other project infrastructure would include:

- a 200 Megawatt (MW) /800 Megawatt-hour (MWh) battery energy storage system (BESS)
- an operations and maintenance (O&M) facility, consisting of site offices and amenities
- up to five meteorological masts, to be in place for the life of the project
- a main temporary construction compound, consisting of office facilities, amenities and car parking. Four additional temporary construction compounds are also planned
- up to 26 temporary staging areas.

A temporary on-site quarry is being investigated for the purposes of providing aggregate materials for access tracks and hardstand areas, and to minimise traffic movements on local roads during construction. If an on-site quarry is not deemed viable, aggregate material would be supplied from one or more nearby quarries. Potential quarries that have been investigated to supply the necessary raw materials required include Mt Shadwell Quarry, Mt Napier Quarry, Tarrone Quarry, Gillear Sand and Limestone Quarry and/or Camperdown quarries). All quarries have good access to the project site via major arterial roads.

Within 12 months of wind turbines permanently ceasing to generate electricity (assuming the turbines are not repowered), the wind farm would be decommissioned. This would include removing all above ground equipment, restoration of all areas associated with the project, unless otherwise useful to the ongoing management of the land, and post-decommissioning revegetation with pasture or crop (in consultation with and as agreed with the landowner).

3.2 Project details

Key details of the Project as relevant to construction, operation and decommissioning are listed below in **Table 3-1**.

Table 3-1. Project details (Source: Wind Prospect)

Project's main features	Details
Location	The project is approximately 15 kilometres west of Mortlake and approximately 15 kilometres north-east of Woolsthorpe in the Moyne Shire of south-west Victoria. The closest townships are Hexham, Caramut and Ellerslie, located approximately 3 kilometres north-east, 4 kilometres north-west and 3 kilometres south-west, respectively. The road network that borders and runs through the project area includes Hamilton Highway to the north, Woolsthorpe-Hexham Road and Hexham-Ballangeich Road to the east, Warrnambool-Caramut Road to the west and Gordons Lane to the south.
Setting	Agricultural is the predominant land use in the project area consisting mostly of grazing(cattle and sheep) along with some cropping. Native vegetation is largely restricted to roadside reserves with small, isolated areas on private land. Numerous indigenous scattered trees exist throughout the local area.
Landowners	14 landowner families with project infrastructure on their land.
Wind turbines and hardstand areas	Up to 106 with a maximum tip height of 260 meters, maximum rotor diameter up to 190 meters and minimum tip height of 40 meters. Maximum tower base width of between 5 and 6 metres. Blade length of up to 93 metres. Each wind turbine would have an adjacent hardstand area of around 6,500 square metres, which equates to 70 hectares for all project wind turbines.
Wind farm capacity	Around 721 MW
Annual generation	Approximately 2,559 GWh per year
Construction footprint	599.55 hectares (or around 3.7% of the project site)
Operational footprint	148.7 hectares (or around 0.9% of the project site)
Construction period	Approximately 24 months
Electrical reticulation	Approximately 119 kilometres of 33 kilovolt electricity cable laid in approximately 85 kilometres of trenches about one metre below the ground. The work area width for the excavator to operate and for stockpiling of soil would be about eight metres wide for all trenches assuming up to four cables are housed in each trench. Approximately 49.1 kilometres of overhead powerlines lines to connect wind turbines to the new on-site terminal station. The distribution voltage is expected to be 33 kilovolts. (although 132 kilovolts and 220 kilovolts are alternative options), with the overhead dual circuit distribution line consisting of either single or parallel pole line (i.e., single poles up to 26 metres high, with conductor circuits on each side). The overall linear length of the overhead cabling route would be around 22 kilometres.
On-site terminal station	Electricity generated by the project would be distributed by underground and overhead cables to the proposed new onsite terminal station located adjacent to the existing Moorabool to Heywood 500 kilovolt transmission line. On-site terminal station with a footprint of approximately 7.3 hectares in size.
Permanent met masts	Up to five permanent meteorological masts are proposed, to be in place for the life of the project.

	A single-lane access track roughly four meters in width would be constructed to provide access.
Operations and maintenance facility	An operations and maintenance facility would be located adjacent to the on-site terminal station and BESS providing office, storage, and maintenance facilities. Nominally 90 metres by 200 metres.
Staging areas and passing lanes	26 staging areas up to 300 metres x 15 metres in length. Several passing lanes of 25 metres in length.
Site access and access tracks	Approximately 134.6 kilometres of new internal access track and upgrades to approximately 16.7 kilometres of existing access track (i.e., a total of around 151.3 kilometres of access tracks). The final access tracks would be 9 metres wide (inclusive of drainage, where required) and a maximum 120 metre turning radius. The construction footprint of access tracks would be around 20 metres wide. Eleven site access points are proposed from two arterial and five local council roads, being: ▪ Up to two access points from Hamilton Highway ▪ One access point from Warrnambool-Caramut Road ▪ Four access points from Woolsthorpe-Hexham Road ▪ One access point from Keillors Road ▪ Three access points from Hexham-Ballangeich Road.
Battery Energy Storage System (BESS)	An on-site battery energy storage facility with a is proposed to be located adjacent to the on-site terminal station. A name plate capacity 200 megawatt. The BESS would consist of a series of 20-foot containerised batteries with transformers, high voltage AC (HVAC) coolers and other electrical plant. The BESS would be sited on a hardstand area of up to 3 hectares (nominally 413 metres x 67 metres).
Temporary components	A main temporary construction compound would be located within the project site and include office facilities, amenities, and car parking (8 hectares). Four additional temporary construction compounds are also planned (200m x 200m). Seven noise compliant concrete batching plants would be established to supply concrete for the wind turbine foundations, the on-site terminal station, and the BESS (around 50m x 100m each)
Temporary onsite quarry	The proposed quarry is in the western portion of the project area. The work authority area is 52.3 hectares with an approximate extraction area of 21.5 hectares, a material stockpile area of approximately 8.6 hectares and an area of approximately 0.5 hectares for amenities and light vehicle parking. The remaining area will be used for stockpiling overburden and for groundwater management infrastructure.
Life	A minimum 25-year operating life is expected, following a period of up to three years of pre-development and construction activities. Pre-development would include detailed design and early works, where permitted.
Decommissioning	Within 12 months of wind turbines permanently ceasing to generate electricity, the wind farm would be decommissioned. This would include removing all above ground equipment, restoration of all areas associated with the project, unless otherwise useful

	to the ongoing management of the land, and post-decommissioning revegetation with pasture or crop (in consultation with and as agreed with the landowner).

3.3 Summary of key project activities

3.3.1 Construction

Construction of the Project will occur over a period of approximately 24 months. The construction footprint totals approximately 599.5 ha (i.e., around 3.7% of the overall Project site). Key activities during construction will include:

- Delivery of key plant and construction vehicles.
- Construction of 12 site access points from two arterial and five local council roads.
- Construction of approximately 134.6 km of new internal access track and upgrades to approximately 16.7 km of existing access track (i.e., a total of around 151.3 km of access tracks).
- Construction of 26 temporary staging areas, up to 300 m x 15 m in length each.
- Construction of five permanent meteorological masts.
- Establishment of seven temporary concrete batch plants and temporary construction offices.
- Construction and use of an on-site temporary quarry to supply materials for the Project during construction.
- Construction of temporary construction compounds including office facilities, amenities, and car parking etc.
- Construction of up to 106 wind turbine generator (WTG) hardstand areas and footings. The WTGs will each have a temporary hardstand area of 90 m x 320 m during construction and a permanent hardstand area of approximately 6,500 m^2 at completion for each wind turbine.
- Installation of electrical reticulation comprising:
  - Approximately 119 km of 33 kV electricity cable laid in approximately 85 kilometres of trenches about one metre below the ground.
  - Approximately 49.1 km of overhead transmission lines.
- Construction of an on-site terminal station approximately 7.3 ha in size and located adjacent to the existing Moorabool to Heywood 500 kV transmission line.
- Installation of a battery energy storage system (BESS). The BESS would be sited on a hardstand area of around 3 ha area.
- Construction of permanent operation and maintenance facility which would be located adjacent to the on-site terminal station and provide office, storage, and maintenance facilities.

Towards the end of construction, the following activities will be undertaken:

- Removal of all temporary infrastructure, including the concrete batch plants, infrastructure, and construction compound from the HWF site.
- Rehabilitation of disturbed areas.

3.3.2 Operations

The operations phase of the project will include the testing and commissioning of the wind farm, following by ongoing operations and maintenance of the facility for the export of electricity. The operational life of the HWF is expected to be a minimum of 25 years.

There will be a permanent office and maintenance facilities located on-site for the operational phase. Together with the other permanent features, the operational footprint totals approximately 149 ha. This is equivalent to around 0.9 % of the overall Project site.

Light vehicles and small trucks would travel from the site office and maintenance yard to individual WTGs and substation, mostly via internal roads. There may be occasional larger vehicles for the delivery of larger equipment items.

3.3.3 Decommissioning

Within 12 months of wind turbines permanently ceasing to generate electricity, the wind farm would be decommissioned. This would include removing all above ground equipment, restoration of all areas associated with the project, unless otherwise useful to the ongoing management of the land, and post-decommissioning revegetation with pasture or crop (in consultation with and as agreed with the landowner)

Alternatives to this approach which may be considered closer to the time, and depending on assessment of economic viability, include continuing the operation of the wind farm with potential refurbishment or replacement of the WTGs.

4. Legislation, policy, and guidelines

This section provides an overview of key international, commonwealth and state legislation relevant to greenhouse gas matters, including identifying primary and likely secondary approval requirements for the Project.

4.1 International policy

4.1.1.1 United Nations COP21, COP26 and COP28

Following the 2015 Paris Climate Conference, known as COP21, international agreements were made for signatories to:

- Keep global warming well below 2.0 degrees Celsius, with an aspirational goal of 1.5 degrees Celsius
- Submit revised emission reduction targets every five years (from 2018), with the first being effective from 2020, and goals set to 2050
- Define a pathway to improve transparency and disclosure of emissions
- Make provisions for financing the commitments beyond 2020.

In response to this conference, Australia has committed to reduce emissions to 26 to 28 per cent of 2005 levels by 2030.

Further commitments were made following the 2021 Glasgow Climate Conference, COP26. Following COP26, Australia adopted a net zero emissions by 2050 target, along with several low emission technology stretch goals.

In August 2022, the Australian government further committed Australia to a new target, aimed at reducing greenhouse gas emissions by 43% below 2005 levels by 2030, a 15% increase on the previous 2030 target.

Additional to the commitments made through the outcomes of COP21 and COP26, the United Nations Framework Convention on Climate Change highlighted the influence of synthetic greenhouse gases on the greenhouse gas effect. Under Annex A of the Kyoto Protocol, four of the seven gases to which the protocol applied (hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride) were synthetic greenhouse gases.

COP28 was held in Dubai, with the outcomes of focus being based on the 'four pillars' of the conference, i) fast-tracking a just, orderly, and equitable energy transition; ii) fixing climate finance; iii) focusing on people, lives, and livelihoods; and iv) underpinning everything with full inclusivity.

As a result of COP28, Australia was one of 190 countries to agree to 'transition away from fossil fuels' under the COP28 UN climate change declaration. Additionally, Australia also committed to:

- Triple global renewable energy generation by 2030 under the global renewable and energy efficiency pledge
- An ambitious new framework on the global goal on adaptation, which will support a global step-up in adaptation action and support

4.1.2 The Greenhouse Gas Protocol

The Greenhouse Gas Protocol is collaboration between the World Resources Institute and the World Business Council for Sustainable Development. The Protocol provides a globally standardised framework and guideline for the calculation and reporting of carbon footprints and developing mitigation measures. This assessment has been undertaken in line with the principles of the Greenhouse Gas Protocol.

4.2 Commonwealth legislation

4.2.1 National Greenhouse and Energy Reporting Act 2007

The Commonwealth Government uses the National Greenhouse and Energy Reporting (NGER) legislation for the measurement, reporting and verification of Australian greenhouse gas emissions. This legislation is used for a range of purposes, including being used for international greenhouse gas reporting purposes. Corporations which meet the thresholds for reporting under NGER must register and report their greenhouse gas emissions.

Under the *National Greenhouse and Energy Reporting Act 2007* (NGER Act), constitutional corporations in Australia which exceed thresholds for greenhouse gas emissions, energy production or consumption are required to measure and report data to the Clean Energy Regulator on an annual basis. The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* identifies a number of methodologies to account for greenhouse gas from specific sources relevant to the Project. This includes emissions of greenhouse gases from direct fuel combustion (fuels for transport energy purposes), emissions associated with consumption of power from direct combustion of fuel (e.g., diesel generators used during construction), and from consumption of electricity from the grid. Where relevant, these, methodologies were also applied in this assessment.

4.2.2 Ozone Protection and Synthetic Greenhouse Gas Management Act 1989

The *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (OPSGM ACT) is the Commonwealth legislation which address the import, export, and usage of ozone depleting substances along with synthetic greenhouse gases.

The key objectives of the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 are to:

- control and manage the manufacturing, import, export, usage and disposal of ozone depleting substances and synthetic greenhouse gases
- achieve a faster and greater reduction in the levels of production and use of ozone depleting substances than are required under the Montreal Protocol (international treaty)
- promote responsible management and handling of ozone depleting substances and synthetic greenhouse gases to minimise their impact on the atmosphere.

One tool that exists under the OPSGM Act is the Ozone Licensing and Reporting System (OLARS). OLARS is a licencing system developed to facilitate the control the manufacture, importation, exportation and usage of ozone depleting substances and synthetic greenhouse gases. Through the system, the government can manage these substances by enforcing licences on substances and quantities, and requires licences to report their manufacture, importation, exportation, and usage to facilitate the tracking of the substances.

4.3 State legislation and policy

4.3.1 Victoria’s Climate Change Act 2017

Victoria's *Climate Change Act 2017* establishes a long-term target of net zero greenhouse gas emissions by 2050. The *Climate Change Act 2017* also requires five yearly interim emissions reduction targets, developed as part of a Climate Change Strategy.

The *Climate Change Act 2017* introduced a new set of policy objectives and an updated set of guiding principles to embed climate change in government decision making. From 2021, the legislation also requires the development of ‘Adaptation Action Plans’ for key systems that are vulnerable to the impacts of climate change, by reducing emissions from government operation and across key market sectors. The *Climate Change Act 2017* has also developed a system of periodic reporting, which includes the requirement for annual greenhouse gas emissions reporting and regular standalone reports from independent bodies on the science and data related to greenhouse gas emissions and climate change in Victoria.

4.3.2 Environment Protection Act 2017

The Victorian *Environment Protection Act 2017* came into effect on 1 July 2021. The Act focuses on preventing waste and pollution impacts, rather than managing those impacts after they have occurred.

The cornerstone of the new environmental protection legislation is the general environmental duty (GED). The GED requires Victorians to understand and minimise their risks of harm to human health and the environment, from pollution and waste, including the emission of greenhouse gasses. Under the *Environment Protection Act 2017*, this duty requires minimising these risks so far as reasonably practicable.

When dealing with a risk or harm, demonstrating that the person or business undertaking the activity has adopted the measures that are reasonably practicable under the GED can be achieved through assessing the level of severity of the risk, implementing measures that are suitable and available to the business to eliminate or reduce the risk, and reviewing controls to ensure they are effective.

Consistent with the *Environment Protection Act 2017*, this impact assessment has recommended measures to reduce carbon emissions from the Project so far as reasonably practicable

4.3.3 Victoria's Climate Change Strategy (2021)

Victoria's Climate Change Strategy is a roadmap to net-zero emissions and a climate resilient Victoria by 2050 developed by the former Department of Environment, Land, Water and Planning (DELWP). The Government has set ambitious, but achievable targets to reduce the state's greenhouse gas emissions from 2005 levels by 28 to 33% by 2025 and 45 to 50% by 2030.

Victoria's Climate Change Strategy includes actions to achieve these emissions reduction targets. This includes a commitment for all Victorian Government operations, including metropolitan trains, to be powered by 100% renewable energy by 2025. As part of the strategy, six Renewable Energy Zones will be developed, including West Victoria, where renewable energy infrastructure will be built and connected to the market through transmission networks, allowing for the allowing for the adoption of large-scale renewables and reducing Victoria's reliance on fossil fuels.

The goals of the strategy inform the context surrounding the justification for the Project.

4.3.4 Victoria's Renewable Energy Action Plan (2018)

The Renewable Energy Action Plan outlines the action that the Victorian Government is taking to encourage investment in its energy sector to ensure energy security and move away from fossil fuel energy sources.

The Action Plan invests $146 million across three focus areas, with incentives to reduce greenhouse gas producing energy sources and invest in renewable energy infrastructure.

4.3.5 Victoria Planning Provisions Scheme

The Victorian Planning Provisions Scheme provide policies, provisions, and ordinances to control and manage land use and development. The schemes are comprised of a number of clauses with varying purposes and goals in relation to planning and development. Below are excerpts of three clauses pertaining to greenhouse gas emissions, in reference to energy and infrastructure:

- **Clause 01 – Purposes of this planning scheme:**
  - To provide a clear and consistent framework within which decisions about the use and development of land can be made.

  - To provide for the implementation of State, regional and local policies affecting land use and development.
  - To support responses to climate change.
- **Clause 15 – Built environment and heritage:**
  - Planning should promote development that is environmentally sustainable and minimise detrimental impacts on the built and natural environment.
  - Planning should facilitate development that supports the transition to net zero greenhouse gas emissions.

The clauses establish goals pertaining to greenhouse gas in relation to infrastructure and utilities planning and development which the Project falls under.

4.3.6 Protocol for Environmental Management: Greenhouse gas emissions and energy efficiency in industry (2002) (PEM)

The PEM was an incorporated document of State Environment Protection Policy (Air Quality Management) (SEPP (AQM)) which specified the steps that needed to be taken by businesses to demonstrate compliance with the policy principles and provisions of SEPP (AQM) related to energy efficiency and greenhouse gas emissions. The PEM was the regulatory instrument that was used to align GHG assessment methodology and approach with the requirements under the EP Act and SEPP (AQM).

The PEM's objectives were as follows:

> *The protocol aims to ensure that Victorian businesses subject to EPA works approvals and licensing system that have an impact on the environment in terms of their energy consumption and greenhouse gas emissions (as defined in the protocol):*
>
> - *Take up cost-effective opportunities for greenhouse gas mitigation, noting that in many cases they will achieve cost savings through greater energy efficiency*
> - *Integrate consideration of greenhouse and energy issues within existing environmental management procedures and programs.*

While the PEM is no longer an incorporated document, it still informs the state of knowledge on minimising greenhouse gas emissions.

4.3.7 Publication 2048: Guideline for minimising greenhouse gas emissions

'Publication 2048: Guideline for minimising greenhouse gas emissions', (EPA, 2022) forms the primary documentation used by business to understand their obligations under the GED in relation to greenhouse gas emissions under the Environment Protection Act 2017.

Publication 2048 details the steps required for the assessment of GHG emissions in line with the requirements of the Environment Protection Act 2017:

- **Step 1:** Identification of greenhouse gas emission sources
- **Step 2:** Assessing the risks of harm from greenhouse gas emissions
- **Step 3:** Identify and implement controls to minimise risks arising from greenhouse gas emissions
- **Step 4:** Review controls to ensure they are effective.

This assessment was completed in general accordance with the steps outlined in Publication 2048.

5. Methodology

5.1 Overview

This section of the report describes the key steps that were applied to assess the potential greenhouse gas related impacts of the Project. These steps included:

- Determining the scope and study area for the assessment (**Section 5.2**)
- Characterising existing conditions (**Section 5.3**)
- Stakeholder engagement (**Section 5.4**)
- Assessing the potential for impacts and developing controls, monitoring and EPRs (**Section 5.5**).

5.2 Scope and study area

The scope of this assessment is to complete a greenhouse gas impact assessment in line with the principles established in the Greenhouse Gas Protocol, and to show the projected emissions of the Project within the context of state and federal emissions. The assessment will also compare the performance of the Project against state and federal emissions targets.

The boundary of the assessment is designed to meet the scope requirements and includes all material GHG emissions within the construction and operation boundary. The following subsections outline the emissions sources included, and their Scope in line with the definitions in the GHG Protocol. Note that some emissions sources have more than one 'Scope'. This occurs when emissions are split between the direct component (e.g., emissions associated with combustion of fuel on site) and indirect components (e.g., emissions associated with the upstream extraction, refining and delivery of the fuel).

The study area for the greenhouse gas impact assessment spans well beyond the construction and operational boundary of the Project. Greenhouse gas emissions and the resulting impacts on climate are a global issue, and the effects of emissions from this Project could have a contributing impact on climate issues across the world. A number of emissions associated with the Project are Scope 3 emissions (i.e. indirect emissions, **Figure 5-1**), such as embedded emissions in construction materials and fuel, which would be produced outside of the Project locations. Additionally, the emissions associated with the Project will fall into the total emissions for Victoria and Australia as a whole and hence will play a part in state-wide and nationwide greenhouse gas accounting, goals, and targets.

5.3 Existing conditions

To understand the baseline greenhouse gas emissions for comparison with Project emissions, reported greenhouse gas data from the Australia's National Greenhouse Accounts were adopted.

Australia's National Greenhouse Accounts, a series of reports published by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW), details annual reported greenhouse gas emissions. The accounts are used to provide the official basis for tracking progress towards Australia's emission reduction commitments, inform future emission reduction commitments and support the creation of domestic reduction policies.

Australia's National Greenhouse Accounts (DCCEEW, 2024) provides a detailed database of state and federal greenhouse gas emission data. This includes a breakdown of emissions by year and by state.

The reported Victorian and Australian level greenhouse gas emission data from the last ten years of reporting (2012 – 2022) provided in Australia's National Greenhouse Accounts were compiled to determine current emissions and emissions trends. The emissions data for the most recent available year (2022) were then used as a benchmark to determine the contribution the Project is making to Victorian and Australian emissions. The results of this are detailed in **Section 6**.

5.4 Stakeholder engagement

Stakeholders were consulted to support the preparation of this report and to inform the development of the Project and understanding of its potential impacts. **Table 5-1** lists specific engagement activities and matters discussed and raised that occurred in relation to greenhouse gases.

Table 5-1 Stakeholder engagement undertaken for GHGIA

Stakeholder	Matters discussed/raised
EPA	▪ Review of emissions during operations and decommissioning ▪ Clarification of emissions associated with quarrying activities, including end-of-life considerations ▪ Alternatives to SF_6 in switching gear.
DTP Impact Assessment Unit (IAU)	▪ Providing descriptions of potential sources of SF_6 leakages ▪ Clarification of emissions associated with quarrying activities ▪ Implications of the BESS for the impact assessment.

5.5 Impact assessment

5.5.1 Overview

This section outlines the assessment methodology adopted to determine GHG emissions associated with the Project. The approach follows the requirements that are outlined in the 'Protocol for Environmental Management: Greenhouse gas emissions and energy efficiency in industry' 2002 (PEM). While the PEM is no longer an incorporated document it still informs the state of knowledge on minimising greenhouse gas emissions.

The PEM includes requirements for outlining the scope and boundary of the study, identifying the various emission sources, emission factors to be used and the process for calculating emissions for the Project. Section 2.1 of the PEM sets out the following compliance requirements for applicants:

- **Step 1:** Estimate annual energy consumption by energy type and associated GHG emissions
- **Step 2:** Estimate direct (non-energy related) GHG emissions (e.g. business travel or use of products)
- **Step 3:** Identify and evaluate opportunities to reduce GHG emissions
- **Step 4:** Document the information generated in Steps 1 – 3.

These requirements are also generally consistent with the processes outlined in Publication 2048.

This process has been followed, as outlined herein. Additional supporting information is provided in **Appendix A**.

5.5.2 Sources of emissions

The GHG inventory has been prepared in accordance with:

- The Greenhouse Gas Protocol

- 'ISO 14064-1:2006 Greenhouse gases - Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals'.

The GHGs associated with the Project include:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O).

GHG emissions sources are categorised into three different scopes in the GHG Protocol as follows (refer to **Figure 5-1** for a schematic diagram distinguishing scope types):

- **Scope 1**: Direct emissions from sources that are owned or operated by a reporting organisation (examples – combustion of fuel used in on-site power generation equipment)
- **Scope 2**: Indirect emissions associated with the import of energy from another source (examples – purchases of electricity)
- **Scope 3**: Other indirect emissions (other than Scope 2 energy imports) which are a direct result of the operations of the organisation but from sources not owned or operated by them (examples include embedded emissions in raw materials, business travel by air/rail and product usage).

In the PEM and Publication 2048, GHG emissions are categorised into energy and non-energy related GHG expressed in CO_2 equivalent terms (or CO_2e). Energy related GHG emissions include emissions from the use of fuels or consumption of electricity. Non-energy related GHG emissions include process emissions (e.g. emissions from chemical reactions or direct releases of greenhouse gases from activities such as land clearing)).

The initial action for a greenhouse gas assessment is to determine the sources of greenhouse gas emissions, assess their likely significance and set a boundary for the study.

The results of this study are presented in terms of the above-listed 'Scopes' to help understand the direct and indirect impacts of the Project.

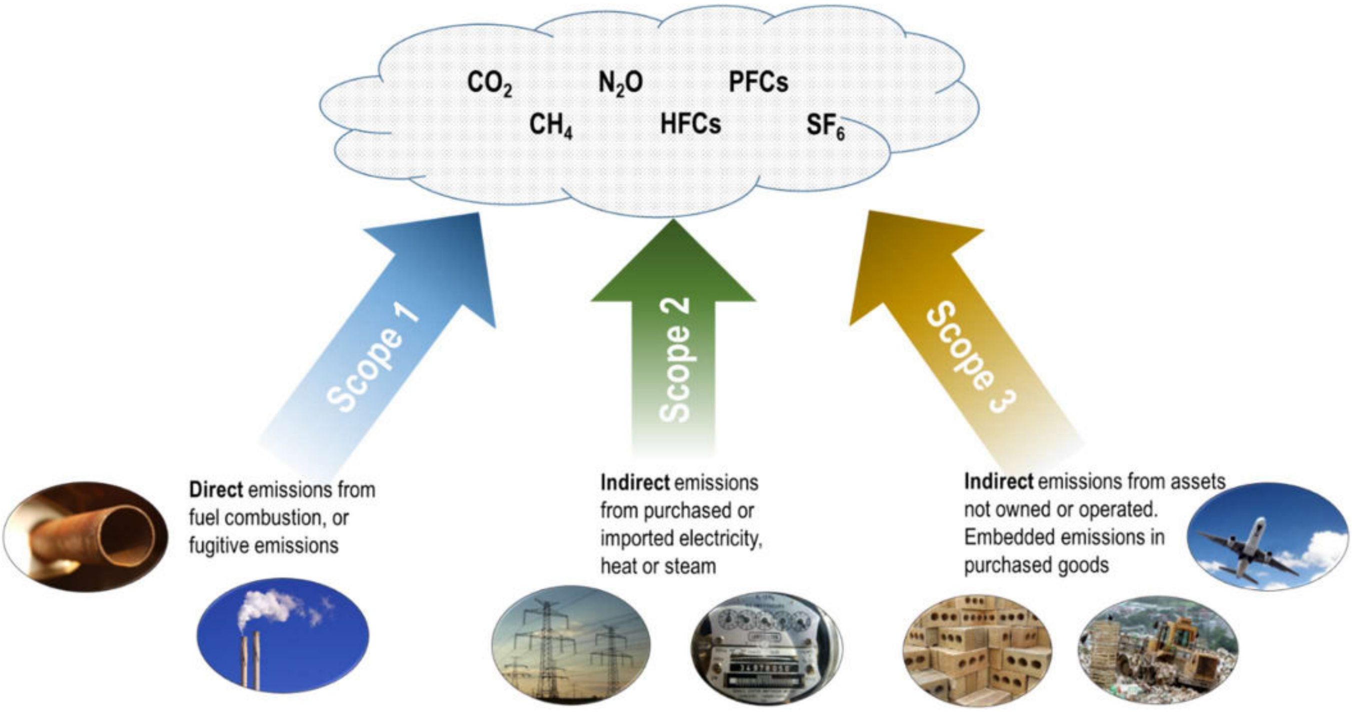

Figure 5-1 Sources of greenhouse gases

5.5.3 Greenhouse gas assessment boundaries

The assessment boundaries define the source and scope of greenhouse gas emissions to be included in the assessment. They summarise the emissions sources and activities considered within the Project's assessment boundary for construction and operation, according to scope. Note that some emissions sources are split into more than one scope. This is typically the case where there are direct emissions (e.g., combustion of fuel in a vehicle operated as part of the Project) as well as indirect emissions (extraction and processing of the fuel before it is used).

The sources of emissions for construction of the Project are provided in **Table 5-2**.

Table 5-2 Construction greenhouse gas emission sources

Emission Source	Scope 1	Scope 2	Scope 3
Energy related			
Fuel use – diesel consumption in plant and equipment during construction	●		●
Fuel use – transport of construction materials			●
Fuel use – transport of spoil and other earth			●
Fuel use – transport of construction waste			●
Electricity use – electricity consumed in Project offices		●	●
Non-Energy related			
Construction materials			●
Blasting – quarrying activities	●		
Loss of carbon sink – land clearing and soil disturbance	●		

The sources of emissions for operation of the Project are provided in **Table 5-3**.

Table 5-3 Operational greenhouse gas emission sources

Emission Source	Scope 1	Scope 2	Scope 3
Energy related			
Grid electricity usage in site infrastructure		●	●
Electricity lost in battery charge and discharge		●	●
Fuel use – transport of maintenance materials			●
Fuel use – transport of maintenance waste			●
Non-Energy related			
Fuel use – diesel consumption in plant and equipment during maintenance	●		●

Emission Source	Scope 1	Scope 2	Scope 3
Maintenance materials			●
Sulphur hexafluoride losses	●		

Noting the likelihood of changes in technologies and policy which could impact Greenhouse gas emissions by the time in which decommissioning could occur, it is difficult to predict the emissions associated with decommissioning.

As such, the emissions resulting from the decommissioning of the Project have been qualitatively assessed to determine the greenhouse gas risk for the decommissioning process.

5.5.4 Emission factors

Emissions factors are used to determine emissions of greenhouse gases from processes or activities, where it is impractical to directly measure (or model) emissions. Standard factors are published by numerous sources for a range of common emission-generating activities, and it is appropriate to use them in the calculation of greenhouse gas footprints.

Appropriate emissions factors for the Project were derived from the National Greenhouse Accounts (NGA) Factors published by the Commonwealth Department of Climate Change, Energy, Environment and Water. The emissions factors for relevant sources are presented in **Table 5-4**.

Table 5-4 Emissions factors summary with references

Activity	Emissions Factor	Reference
Diesel use (transport)	Scope 1 CO_2 – 2.698 tCO_2e / kL CH_4 - 0.0004 tCO_2e / kL N_2O - 0.019 tCO_2e / kL Scope 3 0.6678 tCO_2e / kL	National Greenhouse Accounts Factors 2024, (NGA, 2024)
Diesel use (stationary)	Scope 1 CO_2 – 2.698 tCO_2e / kL CH_4 - 0.004 tCO_2e / kL N_2O - 0.008 tCO_2e / kL Scope 3 0.6678 tCO_2e / kL	National Greenhouse Accounts Factors 2024, (NGA, 2024)
Material use - Steel	2.65 tCO_2e / t	EPD - BlueScope XLERPLATE® steel plate 2020 (EPD558)
Material Use – Steel Reinforcement	1.98 tCO_2e / t	InfraBuild Reinforcing Rod, Bar & Wire 2020 (EPD855): Reinforcing rod and wire
Material Use – Composite	9.23 tCO_2e / t	AusLCI Shadow database - Fibre Reinforced Plastic (FRP) referenced as Glass fibre reinforced plastic, polyamide, injection moulding, at plant/RER U/AusSD U

Activity	Emissions Factor	Reference
Material use - Concrete	0.974 tCO_2e / t	AusLCI - ordinary portland cement, Australian average/AU U + 200 tkm transport, truck, 40t load/AU U
Material use - Aggregate	0.005 tCO_2e / t	AusLCI Shadow database - Gravel, unspecified, at mine/CH U/AusSD U
Material use – Aluminium	19.993 tCO_2e / t	AusLCI Shadow database – Aluminium – referenced to 'Aluminium, primary, at plant/RER U/UssSD U'
Material use – Asphalt	0.056 tCO_2e / t	AusLCI – Asphalt, Hot mix, 4.75% virgin bitumen, at plant/AU U
Material Use – BESS Components – Battery Module	0.103 tCO2e / kWh (2.892 tCO2e / 28 kWh battery)	*GHG Emissions from the Production of Lithium-Ion Batteries for Electric Vehicles in China, Han Hao, Zhexuan Mu, Shuhua Jiang, Zongwei Liu and Fuquan Zhao, Sustainability 2017, 9, 504*
Material Use – BESS Components – Battery Racks	3.26 tCO2e / t	EPD & AusLCI Shadow database – Steel – referenced to Steel, hot rolled metal coated - Australian & Powder coating, steel/RER U/AusSD U'
Material Use – BESS Components – Battery Container	3.26 tCO2e / t	EPD & AusLCI Shadow database – Steel – referenced to Steel, hot rolled metal coated - Australian & Powder coating, steel/RER U/AusSD U'
Material Use – BESS Components – Inverters	4.08 tCO2e / t	*Assessment of the Carbon Footprint, Social Benefit of Carbon Reduction, and Energy Payback Time of a High-Concentration Photovoltaic System, Allen H. Hu, Lance Hongwei Huang, Sylvia Lou, Chien-Hung Kuo, Chin-Yao Huang, Ke-Jen Chian, Hao-Ting Chien and Hwen-Fen Hong, Sustainability 2017, 9, 27; doi:10.3390/su9010027*
Material Use – BESS Components – Transformer	5.44 tCO_2e / t	*Factor 2007, EcoInvent V2.2 (2010)*
Material Use – BESS Components – Cabling	2.88 tCO_2e / t	AusLCI Shadow database – Copper Cabling – referenced to 'Power cables, copper conductor(s), Assumed 60% copper, 40% PE'
Sulphur Hexafluoride Leakage from terminal station circuit breakers	23,500 tCO_2e / t	National Greenhouse Accounts Factors 2024, (NGA, 2024)
Haulage (Articulated truck (>33t) 0% Laden)	Scope 3 CO_2 – 0.61785 kg CO_2e / km CH_4 – 0.00015 kg CO_2e / km	UK Government GHG Conversion Factors for Company Reporting – Department for

Activity	Emissions Factor	Reference
	N_2O – 0.01438 kg CO_2e / km	Business, Energy & Industrial Strategy (UK) – 2024 (DBEIS, 2024)
Haulage (Articulated truck (>33t) 100% Laden)	Scope 3 CO_2 – 0.05709 kg CO_2e /t. km CH_4 – 0.00001 kg CO_2e / t.km N_2O – 0.00079 kg CO_2e / t.km	UK Government GHG Conversion Factors for Company Reporting – Department for Business, Energy & Industrial Strategy (UK) – 2024 (DBEIS, 2024)
General Cargo Ship (Average)	Scope 3 CO_2 – 0.01305 kg CO_2e /t. km CH_4 – 0.000000 kg CO_2e / t.km N_2O – 0.00016 kg CO_2e / t.km	UK Government GHG Conversion Factors for Company Reporting – Department for Business, Energy & Industrial Strategy (UK) – 2024 (DBEIS, 2024)
Blasting	Scope 1 CO_2 – 0.17 t CO_2e / t explosives	Emission factors from NGA Factors (DCC, 2008) combined with the quantity of explosives expected to be used per year. Blasting emissions are not reported in recent NGA Factors publications.

5.5.5 Grid electricity emission factors

Factors relating to the usage of grid electricity expected to change over the modelled life of the Project. Victoria's electricity grid is Projected to become less carbon intensive over the lifetime of the Project. The federal Department of Climate Change, Energy, the Environment and Water's *Australia's emissions Projections 2023* provides Projected grid electricity factors up to 2035. For years beyond 2035, the Projections note that net zero emissions are predicted by 2050. As such, a linear reduction in emissions factors associated with the grid from 2035 to 2050 has been assumed.

Table 5-5 Emission factor Projections for grid electricity - Victoria

Factor	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
VIC - Scope 2 kg CO_2e /kWh	0.79	0.75	0.7	0.68	0.63	0.59	0.4	0.39	0.38	0.31	0.24	0.12	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VIC - Scope 3 kg CO_2e /kWh	0.06	0.06	0.05	0.06	0.06	0.05	0.03	0.03	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.5.6 Assessment of greenhouse gas impact

The significance of the Project emissions on a state and Commonwealth level is then assessed by comparing the total Project greenhouse gas emissions against annual state and Commonwealth greenhouse gas emissions. The results of this analysis are used to qualitatively assess the performance of the Project against the Victorian *Climate Change Act 2017* target of net zero emissions by 2050, and the Commonwealth *2030 Emissions Reduction Target* to reduce greenhouse emissions impacts to 2005 levels by 2030.

5.5.7 Assessment of decommissioning emissions

It is noted that the design life of the Project will extend multiple decades into the future, and as a result there is a high likelihood that changes in technologies and policy would have a significant impact on greenhouse gas emissions by the time of decommissioning. Due to this, it is difficult to accurately predict the emissions associated with decommissioning activities.

As such, a qualitative assessment of the greenhouse gas emissions resulting from the decommissioning of the Project has been adopted. The assessment considers greenhouse gas emitting activities associated with typical decommissioning works, and based on these activities suggests mitigation measures typically used to reduce greenhouse gas emissions during these activities.

5.5.8 Cumulative Impacts

In order to understand the cumulative greenhouse gas impacts, the Project and its emissions are placed within the context of other emission sources in Australia and the world, noting the global contribution of greenhouse gasses to the atmosphere. The Project is also placed into the context of its adjoining infrastructure (i.e., renewable energy sources) to identify the positive impact the Project will have by facilitating renewable energy usage of the electrical grid.

5.5.9 Development of mitigation measures

Following the assessment of greenhouse gas impacts, the identification of the tonnage of CO_2e produced and the key sources of emissions, mitigation measures will be developed. The mitigation measures should be focused on measures to address key emissions sources and be feasible in their implementation.

An energy reduction hierarchy has been adopted to guide and assist in the development of mitigation measures. The hierarchy has been detailed in **Table 5-6**.

Table 5-6 Energy Reduction Hierarchy

Tier	Sustainability	Measure	Description
1	Most Sustainable	Avoid emissions	Avoid carbon intensive activities
2	↓	Reduce emissions	Increase energy efficiency of activities, reuse materials
3		Replace emissions	Replace high carbon emission sources with low-carbon alternatives
4		Offset emissions	Sequester or offset unavoidable emissions that cannot be eliminated by the above activities
5	Least Sustainable	Business as Usual	Adopt conventional fossil fuels and undertake activities with a 'business as usual' approach

5.5.10 Determination of the significance of residual impacts

Following the determination of the greenhouse gas emissions associated with the construction and operation of the Project, along with the development of mitigation measures, the significance of the residual impacts (that being, the impact remaining after mitigation has been applied) will be assessed against criteria ranging from “Negligible” to “Very High”.

For most environmental fields, aspects such as the magnitude, extent, and duration of the impact, alongside the sensitivity of the receiver in question play a role in determining the significance of the impact. However, due to the overarching and holistic nature of the impact of greenhouse gas emission to climate change, determining the significance of greenhouse gas emissions is not suitable through these parameters. Instead, as shown in **Table 5-7** the significance of the impacts in this assessment have been determined based on the amount of CO_2e emitted.

Table 5-7 Impact significance criteria

Rating	Greenhouse gas impact significance criteria
Very High	Construction or operational Scope 1 and Scope 2 GHG emissions represent a non-negligible proportion of Victoria’s total GHG emissions (> 1%).
High	Construction or operational Scope 1 and Scope 2 GHG emissions exceed the individual referral trigger under the Environment Effects Act 1978 (200,000 t CO2e p.a.).
Moderate	Construction or operational Scope 1 and Scope 2 GHG emissions trigger the NGER Scheme reporting threshold (25,000 t CO2e p.a.).
Low	Construction or operational Scope 1 and Scope 2 GHG emissions are below the NGER Scheme reporting threshold (25,000 t CO2e p.a.).
Negligible	Construction Scope 1 and Scope 2 GHG emissions are insignificant, that is emissions are less than 5,000 t CO2e p.a. Operational Scope 1 and Scope 2 GHG emissions are insignificant, i.e., the Project is near to or on par with the ‘no project’ scenario.

6. Existing conditions

Greenhouse gas emissions produced in Victoria and Australia have been tracked and detailed through Australia's National Greenhouse Accounts, a series of reports published by DCCEEW. These accounts are used to fulfil Australia's greenhouse gas inventory reporting commitments, provide the official basis for tracking progress towards Australia's emission reduction commitments, inform future emission reduction commitments and support the creation of domestic reduction policies.

Australia's National Greenhouse Accounts (DCCEEW, 2024) provides a detailed database of state and federal greenhouse gas emissions data. These inventories are used to track and monitor greenhouse gas emissions both at a state and Commonwealth level. The Victorian and Australian greenhouse gas emissions from 2012 to 2022 have been compiled and detailed in **Table 6-1**.

Table 6-1 Victorian and Australian greenhouse gas emissions, 2012 - 2022

Source of Emissions	Reported greenhouse gas emissions (Mt CO_2e)										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Victoria	133	120	113	113	104	100	91	87	83	80	85
Australia	579	561	556	541	512	510	514	506	494	465	433

As displayed in **Figure 6-1**, state and federal greenhouse gas emissions between 2012 and 2022 have been steadily trending downwards.

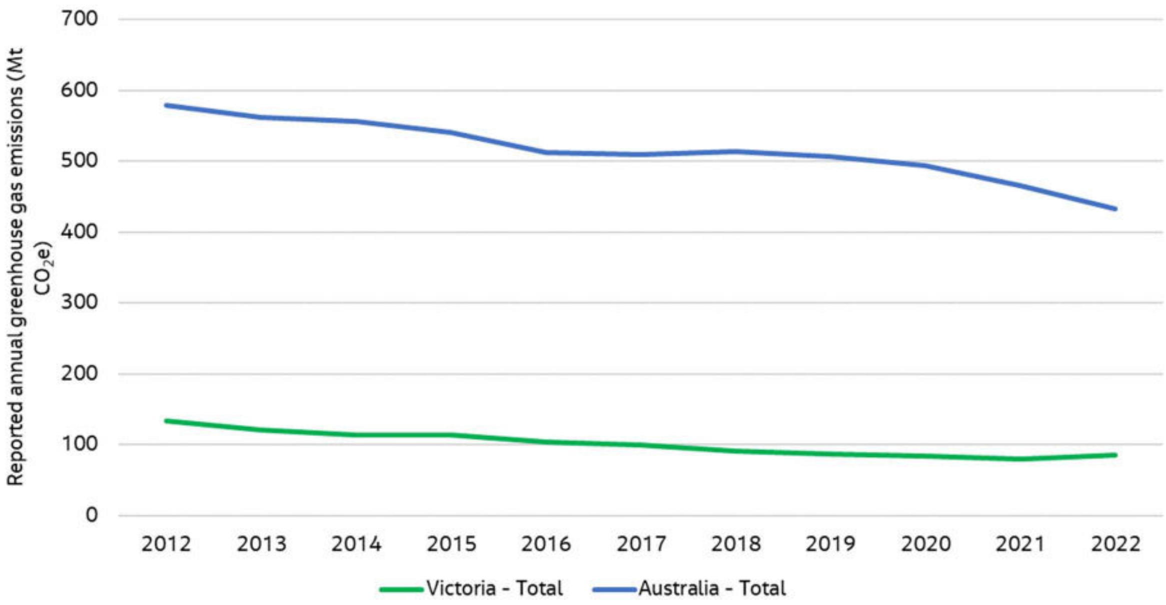

Figure 6-1 Trends in Victorian and Australian greenhouse gas emissions, 2012 - 2022

As emissions inventories for 2023 and 2024 are not currently available, greenhouse gas emission inventory data for the most recent available year (2022) has been adopted as the benchmark for assessing the implications of the greenhouse emissions produced by the Project. The overall emissions from the construction and operation of the Project will be compared to the emissions of both Australia and Victoria to determine the potential contribution of greenhouse gas emissions the Project is making at a state and Commonwealth level.

7. Impact assessment

7.1 Construction

The following section details the greenhouse gas emissions projected to result from the construction of the Project. Emissions are presented and discussed as follows:

- Energy related emissions
- Non-energy related emissions
- Total emissions
- Implications of construction emissions.

7.1.1 Energy related greenhouse gas emissions

Energy related emissions associated with the construction of the Project include those from the consumption of fuel used on site. This is detailed in the section below.

7.1.1.1 Fuel consumption

Fuel will be required during the construction of the Project to power the construction plant and equipment, as well as site vehicles. **Table 7-1** displays the emissions Projected to occur from the combustion of fuel during construction.

Table 7-1 Emissions associated with the combustion of fuel during construction

Emissions Source	Fuel	Fuel Combusted (kL)	Energy Consumption (GJ)	Scope 1 Emissions Factor (t CO_2e / kL)	Scope 3 Emissions Factor (kg CO_2e / GJ)	Scope 1 Emissions (t CO_2e)	Scope 3 Emissions (t CO_2e)	Total Emissions (t CO_2e)
Construction plant and equipment, (including quarrying)	Diesel	6,735	259,970	2.71	17.3	18,250	4,008	22,258
Site vehicles		82	3,150	2.71	17.3	222	48	270
Batching Plants		7,199	277,877	2.71	17.3	19,507	4,284	23,791
Total		**14,016**	**540,997**			**37,979**	**8,340**	**46,319**

7.1.1.2 Grid electricity consumption

Electricity from the grid will be required during the construction of the Project to power site offices. **Table 7-2** displays the emissions Projected to occur from the consumption of grid energy during construction.

Table 7-2 Emissions associated with the consumption of grid electricity during construction

Emissions Source	Energy Consumption (MWh)	Energy Consumption (GJ)	Scope 2 Emissions Factor (t CO_2e / MWh)	Scope 3 Emissions Factor (t CO_2e / MWh)	Scope 2 Emissions (t CO_2e)	Scope 3 Emissions (t CO_2e)	Total Emissions (t CO_2e)
Site offices	136	488	0.85	0.07	104	12	116
Total	**136**	**488**			**104**	**12**	**116**

7.1.1.3 Haulage of material

Emissions will result from the combustion of diesel during the haulage of construction materials to site, the removal of excavated soil (cut and spoil) and waste from site, and the transfer of materials from the on-site quarry. The emissions for the quarried aggregate scenario are displayed in **Table 7-3** below.

Table 7-3 Emissions associated with haulage during construction

Hauled Material	Haulage Route	Tonne Kilometres (t.km)	Scope 3 Emissions Factor (t CO_2e / t.km)	Scope 3 Emissions (t CO_2e)
Steel, Aluminium and BESS Components (by sea to port)	Port of Shanghai to Port of Geelong	2,980,821,535	0.00001321	39,377
Construction material haulage to site (by land)	Port of Geelong to Site	88,148,00	0.00007447	6,564
Construction Waste Haulage	Site to Corangamite Regional Landfill	35,892	0.00007447	3
Total		**3,053,954,202**		**45,944**

7.1.2 Non-energy related greenhouse gas emissions

Non-energy related emissions associated with the construction of the Project include embedded emissions in construction materials, emissions from blasting, clearance of vegetation and the transport of waste and materials. These are detailed in the sections below.

7.1.2.1 Embedded emissions in construction materials

Embedded emissions refer to the CO_2e emissions associated with the production of the materials used in the construction of the Project. **Table 7-4** displays the embedded emissions Projected to result from the construction of the Project.

Table 7-4 Embedded emissions associated with the materials used during construction

Material	Quantity (t)	Scope 3 Emissions Factor (t CO_2e / t)	Scope 3 Emissions (t CO_2e)
Total Steel	247,863	2.65	656,838
Total Concrete 40MPA	179,760	0.97	175,036
Total Aggregate	2,380,000	0.01	11,986
Total Aluminium	46	19.99	929
Total Composite	24,115	9.23	222,481
Total Steel Reinforcement Bar	22,360	1.98	44,273
Total BESS Battery Module	970,000	0.10	97,000
Total BESS Battery Racks	1,300	3.26	4,238
Total BESS Battery Container	3,000	3.26	9,780
Total BESS Inverters	1,800	4.08	7,344
Total BESS Transformer	246	5.44	1,338
Total BESS Cabling	40	2.88	115

Material	Quantity (t)	Scope 3 Emissions Factor (t CO_2e / t)	Scope 3 Emissions (t CO_2e)
Total	**2,096,807**	**-**	**1,231,358**

7.1.2.2 Emissions from blasting at the quarry

Blasting would be undertaken at the quarry to facilitate materials extraction. Estimated greenhouse gas emissions associated with this activity are summarised below in **Table 7-5**.

Table 7-5 Emissions associated with quarry blasting activities during construction

Emission source	Quantity (no. blasts during construction)	Quantity of explosives (tonnes) used	Scope 1 Emissions Factor (t CO_2e / tonne explosives used)	Scope 1 Emissions (t CO_2e)
Blasting at quarry	75	638	0.17	108
Total	75	**638**	**-**	**108**

7.1.2.3 Loss of carbon sink

Approximately 14 Ha of native vegetation within the Project site will require clearing in order to facilitate the construction of the Project. This will primarily be grassland and rushland, which based on discussion with the Jacobs ecology team, fall under the Class I definition. It was also identified that four trees will require clearing, however the biomass of these trees was considered immaterial in comparison with the 14 ha of Class I grassland cleared. Total emissions associated with the Project will be affected by the vegetation clearing as a result of the loss of carbon sink that would result. The associated emissions are shown in **Table 7-6**.

Table 7-6 Emissions associated with the loss of carbon sink during construction

Estimated Vegetation Clearance	Quantity (ha)	Scope 1 Emissions Factor (t CO_2e / ha)	Scope 1 Emissions (t CO_2e)
Class I (Grassland)	14.36	110	1,580
Total	**14.36**	**-**	**1,580**

7.1.3 Total construction greenhouse gas emissions

By combining the individual source and activity estimates determined above, the Project was predicted to result in overall greenhouse gas emission of 1,217,914 t CO_2e over the construction period (608,957 t CO_2e annually). The breakdown of emissions is provided in **Table 7-7**.

Table 7-7 Total construction Project emissions

Emissions Source	Energy Consumption (GJ)	Scope 1 Emissions (t CO_2e)	Scope 2 Emissions (t CO_2e)	Scope 3 Emissions (t CO_2e)	Total Emissions (t CO_2e)
Fuel consumption	540,637	37,979	-	8,341	46,319
Grid electricity consumption	488	-	104	12	117
Embedded emissions	N/A	0	0	1,231,358	1,231,358
Haulage	N/A	0	0	45,944	45,944
Vegetation clearance	N/A	1,580	0	0	1,580

Emissions Source	Energy Consumption (GJ)	Scope 1 Emissions (t CO_2e)	Scope 2 Emissions (t CO_2e)	Scope 3 Emissions (t CO_2e)	Total Emissions (t CO_2e)
Blasting	N/A	108	-	-	108
Total	**541,125**	**39,667**	**104**	**1,285,654**	**1,325,425**
Annual Total (Assumed 2-year construction period)	**270,563**	**19,833**	**52**	**642,827**	**662,713**

As illustrated in **Figure 7-1**, embedded emissions in the construction materials form the vast majority of overall construction emissions for the Project. Emissions from haulage form approximately 3% of construction emissions while the majority of the remaining emissions are derived from fuel combustion on site (around 4%).

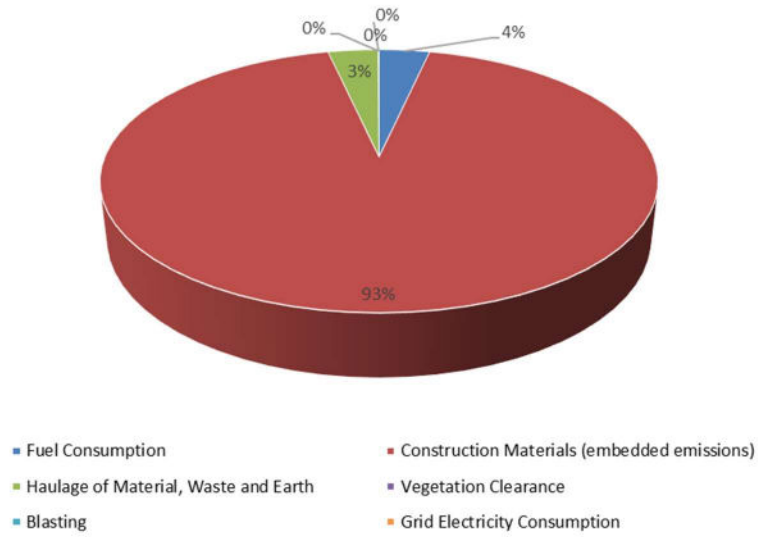

Figure 7-1 Construction emissions by source

As displayed in **Figure 7-2**, emissions from the Project are almost entirely comprised of Scope 3 emissions, with Scope 1 and 2 emissions accounting for approximately 3% of overall emissions.

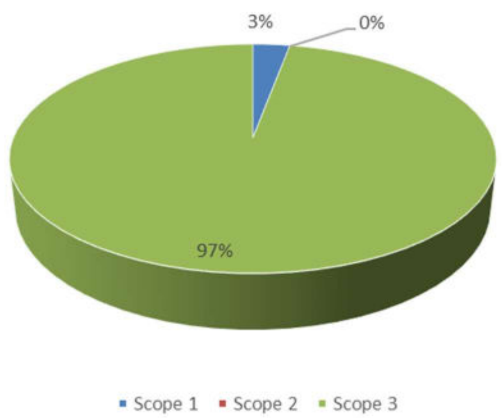

Figure 7-2 Construction emissions by scope

7.1.4 Implications of construction greenhouse gas emissions

As the annual, unmitigated Scope 1 and Scope 2 emissions from the construction of the Project would be greater 5,000 t CO_2e but less than 25,000 t CO_2e annually (totally around 19,886 t CO_2e per year), it would fall under the 'Minor' significance rating as described in **Table 5-7**. The annual, unmitigated emission contributions of the construction of the Project towards the total annual emissions of Victoria and Australia (from the State and Territories GHG Inventory 2022 (DCCEEW, 2024)) are detailed in **Table 7-8**. As displayed, the construction of the Project would constitute less than 1% of both Victoria and Australia's overall greenhouse gas emissions. Noting that construction would last two years in duration and given the generally low emissions in comparison to the Victorian total emissions, in addition to the Project's intention to introduce renewable energy to the national grid, the Project is in line with the requirements of the *Climate Change Act 2017*. Likewise, this would fit with the goals of the Commonwealth *2030 Emissions Reduction Target*.

Table 7-8 Emission contributions of the Project in the context of overall state and Commonwealth emissions

Stage of Project	Project emissions (Mt CO_2e/year)	2022 Victorian emissions (Mt CO_2e/ year)	2022 Australian emissions (Mt CO_2e/ year)	Project contribution to Victorian annual emissions	Project contribution to Australian annual emissions
Construction	0.66	84.7	432.6	0.78%	0.15%

7.2 Operation

Energy related emissions associated with the operation of the Project include those from the consumption of fuel during inspection and maintenance activities as well electricity usage by site infrastructure. These are detailed in the sections below, including an evaluation of their significance with reference to state and federal emissions.

Uncertainties are noted in relation to the BESS. It has been assumed that it would be charged by the grid. The round-trip efficiency of the batteries and number of charge cycles undertaken by the BESS will both have a material impact of greenhouse gas emissions. As these details are currently unknown, assumptions have been made on the BESS emissions. However, due to the variable nature of BESS operations, the assumed BESS related greenhouse gas emissions in this report may change significantly as the design develops. Additionally, it is known that some electrical components which will be used on site, such as switch gears, often contain SF_6. The potential annual leakage of these components depends on the number of these components and the potential leakage rates of the individual components themselves. As such, due to the early stage of the design, potential SF_6 leakage estimates cannot be made. As such, it should be noted that the overall operational GHG emissions presented will increase when details of these components are known.

7.2.1 Energy related greenhouse gas emissions

7.2.1.1 Fuel consumption

Fuel will be required during the operation of the Project, to power vehicles used for inspections and maintenance activities. Maintenance activities will be undertaken at scheduled intervals twice per year, in addition to an as-needed basis. Emissions from a-hoc maintenance were estimated based on the typical small-scale maintenance activities that typically take place one to three times per turbine per year. It should be noted that as the function of the turbines is reliant on timely and effective maintenance, not undertaking or inadequately undertaking maintenance may result in additional emissions as a result of lost efficiency or the requirement of emergency maintenance works.

Table 7-9 displays the emissions Projected to occur from the combustion of fuel during operation.

Table 7-9 Emissions associated with the combustion of fuel during operation

Emissions Source	Fuel Type	Diesel Combusted (kL)	Energy Consumption (GJ)	Scope 1 Emissions Factor (t CO_2e / kL)	Scope 3 Emissions Factor (kg CO_2e / GJ)	Annual Scope 1 Emissions (t CO_2e)	Annual Scope 3 Emissions (t CO_2e)	Total Annual Emissions (t CO_2e)
Inspection and Maintenance vehicles and plant	Diesel	92	3,552	2.71	17.3	250	55	305
Total		**92**	**3,552**			**250**	**55**	**305**

7.2.1.2 Electricity consumption

Ancillary infrastructure is required for the continued operation of the Project including the O&M Facility which will consume electricity to perform standard operations. Associated estimated emissions are summarised below in **Table 7-10**.

Table 7-10 Emissions associated with grid electricity consumption for the O&M Facility

Emissions Source	Annual electricity usage (MWh)	Annual energy Consumption (GJ)	Scope 2 Emissions Factor (t CO_2e / MWh)	Scope 3 Emissions Factor (t CO_2e / MWh)	Annual Scope 2 Emissions (t CO_2e)	Annual Scope 3 Emissions (t CO_2e)	Total Annual Emissions (t CO_2e)
O&M Facility	25	90	Variable – see **Section 5.5.5** Maximum (Projected): 2027 0.63: Minimum (Projected): 2035 0.01 2036 Onwards: 0	Variable – see **Section 5.5.5** Maximum (Projected): 2027 0.06: Minimum (Projected): 2034 0.01 2035 Onwards: 0	0 to 16 (2027 to 2050)	0 to 2 (2027 to 2050)	0 to 17 (2027 to 2050)
Total	**25**	**90**			**0 to 16** **(2027 to 2050)**	**0 to 2** **(2027 to 2050)**	**0 to 17** **(2027 to 2050)**

As discussed in **Section 5.5.5**, as the grid continues to undergo decarbonisation, the emissions associated with the usage of grid electricity will in turn reduce, until full decarbonisation in 2050. As such, over the 25-year life of the Project, the emissions associated with operations which require electricity inputs will progressively reduce to zero over time. The emissions associated with the electricity consumption by the Project are detailed in **Table 7-11**.

Table 7-11 Emissions associated with the usage of electricity in the operation of non-BESS infrastructure in the Project over time

Emissions (t/CO_2e)	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050+
Scope 2	16	15	10	10	10	8	6	3	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scope 3	2	1	1	1	1	1	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	17	16	11	11	10	9	7	3	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

7.2.1.3 Battery Energy Storage System

Based on discussions with the client, it has been confirmed that the current operational approach is for the BESS to be powered by the grid and not the wind farm. During periods of low demand, the BESS would charge with grid energy and would discharge that energy during peak periods. It is important to note that not all electricity charged into the BESS will be discharged back to the grid, with some electricity lost in the charge/discharge process. The electricity lost in this round trip accounts for the emissions associated with the BESS and is considered in the section below.

Currently, a number of details regarding the Battery Energy System (BESS) are not known, and as such, assumptions have been made. The BESS is noted as being up to 800MW in capacity. Based on this, the BESS was assumed to be 800MWh, based on the similarly sized BESS detailed within the *Yanco Delta Windfarm Environmental Impact Statement* (Jacobs, 2022). The Return Trip Efficiency of the BESS, of 71%, was based on the BESS assessed in the *Liddell Battery and Bayswater Ancillary Works Environmental Impact Statement* (Jacobs, 2021). Likewise, the degradation of the battery (shown in **Table 7-12**) was also adopted from the *Liddell Battery and Bayswater Ancillary Works Environmental Impact Statement* (Jacobs, 2021). The number of annual charge cycles was set to 365 cycles annually as a conservative estimation.

Table 7-12 Battery degradation curve

Year	Degradation Curve
0 (As new)	100.00%
1	98.44%
2	95.52%
3	92.73%
4	90.40%
5	88.09%
6	86.36%
7	84.43%
8	82.48%
9	80.81%
10	79.22%
11	77.69%
12	75.98%
13	74.46%
14	73.11%
15	71.75%
16	70.47%
17	69.17%
18	67.83%
19	66.43%
20	65.06%
21	61.58%*

Year	Degradation Curve
22	59.86%*
23	58.14%*
24	56.42%*

** Values based on linear trend of years 0 -20*

Based on the above assumptions, the emissions have been predicted for each year of the Project, from the Project commencement in 2027 to the predicted Project end of life in 2051 (25 years post Project commencement). The annual and Project life emissions are detailed in **Table 7-13**.

Table 7-13 BESS estimated operational energy consumption

Year	BESS (MWh per cycle)	BESS (MWh per year)	Round trip efficiency	Total MWh input	Total MWh consumed (losses in RTE including all kit)	Scope 2 emissions factor (t CO_2e / MWh)	Scope 3 emissions factor (t CO_2e / MWh)	Annual scope 2 emissions (t CO_2e)	Annual scope 3 emissions (t CO_2e)	Annual total emissions (t CO_2e)
2027	800	292,000	0.71	411,268	119,268	0.63	0.06	75,139	7,156	82,295
2028	788	287,445	0.71	404,852	117,407	0.59	0.05	69,270	5,870	75,140
2029	764	278,918	0.71	392,843	113,924	0.40	0.03	45,570	3,418	48,987
2030	742	270,772	0.71	381,368	110,597	0.39	0.03	43,133	3,318	46,451
2031	723	263,968	0.71	371,786	107,818	0.38	0.03	40,971	3,235	44,205
2032	705	257,223	0.71	362,286	105,063	0.31	0.03	32,569	3,152	35,721
2033	691	252,171	0.71	355,171	103,000	0.24	0.02	24,720	2,060	26,780
2034	675	246,536	0.71	347,233	100,698	0.12	0.01	12,084	1,007	13,091
2035	660	240,842	0.71	339,214	98,372	0.01	0.00	984	-	984
2036	646	235,965	0.71	332,345	96,380	0.00	0.00	-	-	-
2037	634	231,322	0.71	325,806	94,484	0.00	0.00	-	-	-
2038	622	226,855	0.71	319,514	92,659	0.00	0.00	-	-	-
2039	608	221,862	0.71	312,481	90,620	0.00	0.00	-	-	-
2040	596	217,423	0.71	306,230	88,807	0.00	0.00	-	-	-
2041	585	213,481	0.71	300,678	87,197	0.00	0.00	-	-	-
2042	574	209,510	0.71	295,085	85,575	0.00	0.00	-	-	-
2043	564	205,772	0.71	289,820	84,048	0.00	0.00	-	-	-
2044	553	201,976	0.71	284,474	82,497	0.00	0.00	-	-	-
2045	543	198,064	0.71	278,963	80,899	0.00	0.00	-	-	-

Year	BESS (MWh per cycle)	BESS (MWh per year)	Round trip efficiency	Total MWh input	Total MWh consumed (losses in RTE including all kit)	Scope 2 emissions factor (t CO_2e / MWh)	Scope 3 emissions factor (t CO_2e / MWh)	Annual scope 2 emissions (t CO_2e)	Annual scope 3 emissions (t CO_2e)	Annual total emissions (t CO_2e)
2046	531	193,976	0.71	273,205	79,229	0.00	0.00	-	-	-
2047	520	189,975	0.71	267,571	77,596	0.00	0.00	-	-	-
2048	493	179,811	0.71	253,254	73,444	0.00	0.00	-	-	-
2049	479	174,789	0.71	246,181	71,393	0.00	0.00	-	-	-
2050	465	169,767	0.71	239,108	69,341	0.00	0.00	-	-	-
2051	451	164,745	0.71	232,035	67,290	0.00	0.00	-	-	-
Total				**5,494,845**	**1,593,505**			**344,439**	**29,215**	**373,654**

7.2.1.4 Haulage of equipment and components

Over the life of the Project, certain plant equipment and components may need to be replaced. Emissions associated with the transport and disposal of materials for typical operational minor maintenance activities are summarised below in **Table 7-14**.

Table 7-14 Emissions associated with haulage during typical operational maintenance

Hauled Material	Haulage Route	Tonne Kilometres (t.km)	Scope 3 Emissions Factor (t CO_2e / t.km)	Scope 3 Emissions (t CO_2e)
Typical replacement maintenance components (by sea to port)	Port of Shanghai to Port of Geelong	7,646	0.00001321	0.1
Operational maintenance material haulage to site (by land)	Port of Geelong to Site	143	0.00007447	0
Operational maintenance waste haulage	Site to Corangamite Regional Landfill	48	0.00007447	0
Total		**7,837**		**0.1**

7.2.2 Non-energy related greenhouse gas emissions

Non-energy related emissions associated with the construction of the Project include embedded emissions in replacement materials and the leakage of SF_6 from terminal stations. These are detailed in the sections below.

7.2.2.1 Embedded emissions

Embedded emissions associated with the materials contained in replacement equipment and components used for typical minor maintenance activities were also estimated. These are detailed below in **Table 7-15**.

Table 7-15 Embedded emissions associated with the materials used during typical minor maintenance during construction

Material	Quantity (t)	Scope 3 Emissions Factor (t CO_2e / t)	Scope 3 Emissions (t CO_2e)
Total Steel	0.80	2.65	2.11
Total Porcelain	0.80	0.34	0.27
Total	**1.60**	**-**	**2.37**

7.2.2.2 Leakage of HFCs and SF_6

Generally, energy Projects are sometimes associated with the use of fluorinated gases such as HFCs or PFCs, in addition to SF_6. It is known that some electrical components which will be used on site, such as switch gears, often contain SF_6. The potential annual leakage of these components depends on the number of these components and the potential leakage rates of the individual components themselves. A review of similar wind farm Projects found that fluorinated gas and SF_6 leakage and emission was generally negligible. As such, the leakage of these gasses from the Project has been considered negligible. Overall estimates presented in this report may increase once details of these components for the Project are known such that these emissions can be accounted for.

7.2.3 Total greenhouse gas emissions

The operation of the Project is predicted to have an overall greenhouse gas emission of 82,620 to 307.48 tonnes of CO_2e annually over the period 2027 to 2050. The breakdown of annual emissions is provided in **Table 7-16**, while total emissions over the Project's 25-year life are displayed in **Table 7-17**. Again, it is noted that these estimates do not include SF_6 emissions, and a number of assumptions have been applied in the estimation of emissions from the BESS. The values below would likely change when more accurate specific BESS and SF_6 related emissions are considered.

Table 7-16 Annual operational Project emissions

Emissions Source	Energy Consumption (GJ)	Scope 1 Emissions (t CO_2e)	Scope 2 Emissions (t CO_2e)	Scope 3 Emissions (t CO_2e)	Total Emissions (t CO_2e)
Fuel Consumption	3,552	250	-	55	305
Grid electricity consumption	90	-	16 to 0 (2027 to 2050)	2 to 0 (2027 to 2050)	17 to 0 (2027 to 2050)
Electricity loss in BESS	429,363	-	75,139 to 0 (2027 to 2050)	7,156 to 0 (2027 to 2050)	82,295 to 0 (2027 to 2050)
Embedded emissions	N/A	-	-	2.37	2.37
Haulage	N/A	-	-	0.11	0.11
HFC and SF_6 Leakage	N/A	Negligible	Negligible	Negligible	Negligible
Total	**433,005**	**250**	**75,154 to 0 (2027 to 2050)**	**7,215 to 57.48 (2027 to 2050)**	**82,620 to 307.48 (2027 to 2050)**

Table 7-17 Total operational Project emissions (25 years)

Emissions Source	Energy Consumption (GJ)	Scope 1 Emissions (t CO_2e)	Scope 2 Emissions (t CO_2e)	Scope 3 Emissions (t CO_2e)	Total Emissions (t CO_2e)
Fuel Consumption	88,801	6,255	-	1,373	7,628
Grid electricity consumption	2,250	-	77	7	83
Electricity loss in BESS	8,271,372	-	344,439	29,215	373,654
Embedded emissions	N/A	-	-	59	59
Haulage	N/A	-	-	3.15	3.15
HFC and SF_6 Leakage	N/A	Negligible	Negligible	Negligible	Negligible
Total	**8,362,422**	**6,255**	**344,516**	**30,658**	**381,428**

As displayed in **Table 7-16** and **Table 7-17**, emissions associated with the BESS operation outweigh the emissions associated with all other emissions sources. This remains the case until 2035 As the grid continues to undergo decarbonisation over time, this will reduce and fuel combustion will become a greater source of emissions from the Project, becoming nearly 100% of project emissions after the predicted full grid decarbonisation in 2050. This is displayed in **Figure 7-3**.

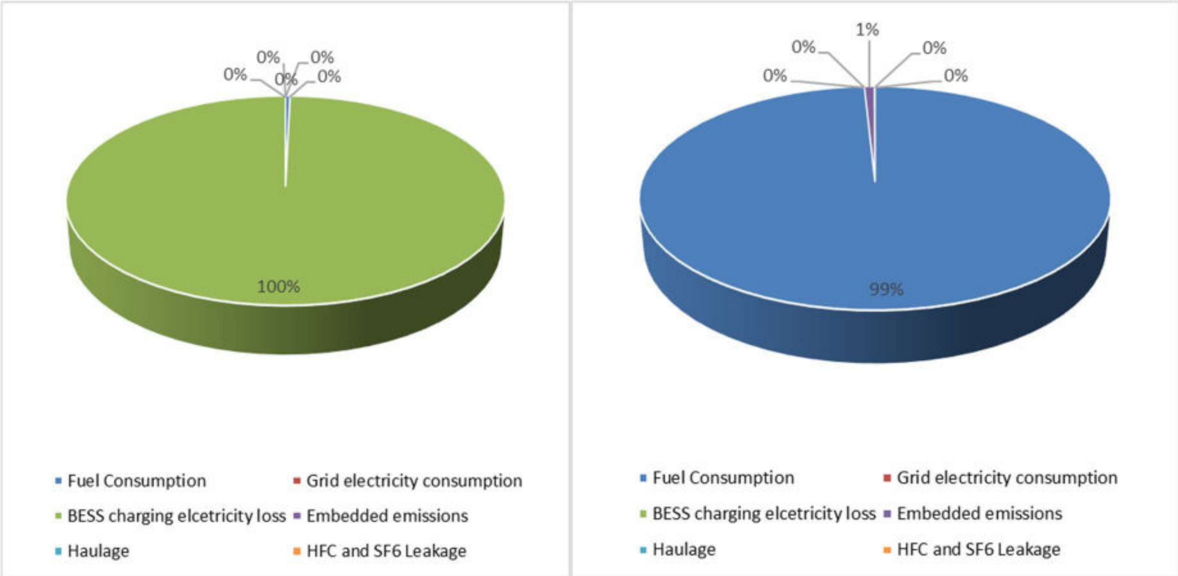

Figure 7-3 Change in emission source contributions over time (Year of Opening (Left) vs Year of Closure (Right))

During the Project opening in 2027, the emission scopes closely aligned with electricity usage (i.e. Scopes 2 and 3) have been Projected to be the greatest form of emissions associated with the operation of the Project. Towards the end of the project's life as the grid reaches full decarbonisation, Scope 1 emissions will replace Scope 2 emissions as largest emission scope, with the proportion of Scope 3 emissions increasing slightly as well. This is displayed in **Figure 7-4**.

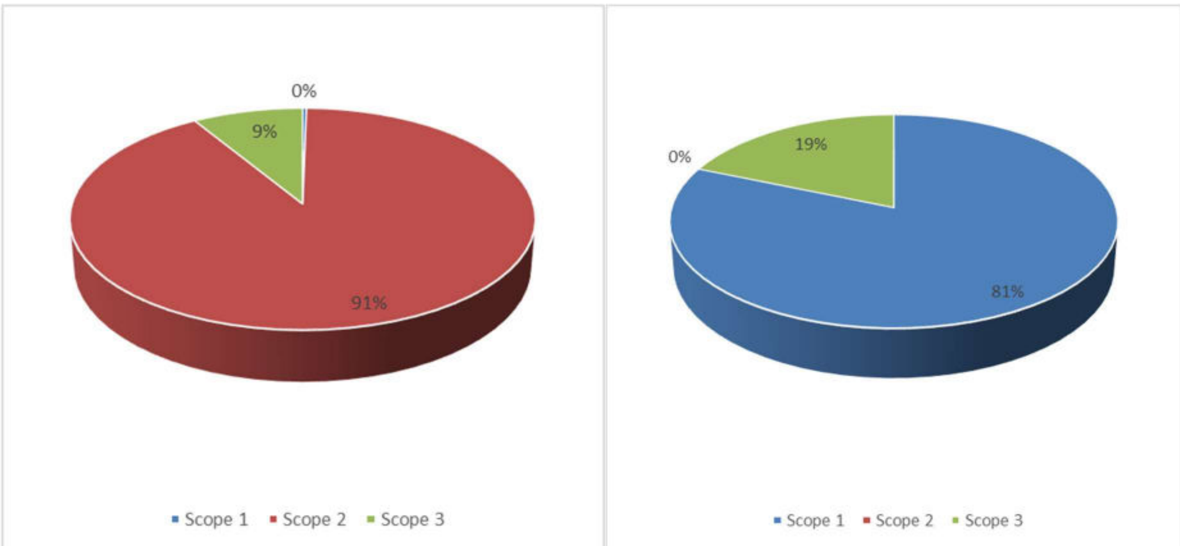

Figure 7-4 Operational emissions by scope (Year of Opening (Left) vs Year of Closure (Right))

7.2.4 Implications of operation greenhouse gas emissions

As the annual, unmitigated Scope 1 and Scope 2 emissions from the operation of the Project would initially be greater than 25,000 t CO_2e annually, it would fall under the 'Moderate' significance rating as described in **Table 5-7**. However, as grid decarbonization continues, this would reduce down to a 'Negligible' significance rating. The annual, unmitigated emission contributions of the operation of the Project towards the total annual emissions of Victoria and Australia from the State and Territories GHG Inventory 2022 (DCCEEW, 2024)) are detailed in **Table 7-18**. As displayed, the operation of the Project would constitute between 0.1% to less than 0.001% of Victoria's overall greenhouse gas emissions, and between 0.02% to less than 0.001% of Australia's overall greenhouse gas emissions. Given the generally low emissions in comparison to the State and Federal emissions, in addition to the Project's intention to introduce renewable energy to the national grid, the Project is in line with the requirements of the *Climate Change Act 2017*. Likewise, this would fit with the goals of the Commonwealth *2030 Emissions Reduction Target*.

Table 7-18 Emission contributions of the Project in the context of overall Victorian and Australian emissions

Stage of Project	Annual Project emissions (Mt CO_2e/year)	2022 Victorian emissions (Mt CO_2e/ year)	2022 Australian emissions (Mt CO_2e/ year)	Project contribution to Victorian annual emissions	Project contribution to Australian annual emissions
Operation	0.08 to 0.0003	84.7	432.6	0.1% to <0.001%	0.02% to <0.001%

7.3 Decommissioning

7.3.1 Key issues

Noting the likelihood of changes in technologies and policy which could impact greenhouse gas emissions by the time in which decommissioning could occur, it is difficult to predict the emissions associated with decommissioning.

As such, the emissions resulting from the decommissioning of the Project have been qualitatively assessed to determine the greenhouse gas risk for the decommissioning process. Generally, the activities to be undertaken for the decommissioning are similar to construction activities, though without the emissions attributed to the clearing of vegetation and embedded emissions.

7.3.2 Decommissioning greenhouse gas impacts

Emission source during the decommission stages would most likely result from energy consumption, in the following forms:

- Plant and equipment dismantling the turbines, BESS, buildings, and terminal station
- Plant and equipment to excavate the concrete footings
- Plant and equipment in site restoration and rehabilitation
- Site vehicles operating on site
- Site offices
- Haulage of material from site to the disposal destination
- Haulage of fill to site for site restoration and landscaping.

Due to the predominant materials used in the Project being steel and concrete, a large portion of Project materials could be recycled and reused. This would have a positive greenhouse gas impact by supplanting some of the demand for these materials which otherwise could have been filled by newly produced (and more emissions intensive) materials. Still, generally, the activities to be undertaken for the decommissioning are similar to construction activities, though without the emissions attributed to the clearing of vegetation, blasting and embedded emissions and associated emissions may be comparable (excluding these sources).

7.4 Cumulative emissions profile

The cumulative emissions over the lifetime of the Project are presented in **Table 7-19**. As shown in the table, the emissions associated with the operation of the Project make up a smaller fraction of the overall emissions from the Project when compared with the construction of the Project. This is mainly as a result of the large number of embedded emissions associated in the materials required to build the Project, particularly the high emission materials such as steel and concrete.

Table 7-19 Cumulative emissions summary

	Construction emissions (tCO_2e)	Operation Energy-related emissions (tCO_2e)	Total emissions (tCO_2e)
Construction	1,325,425	-	1,325,425
Years 1-25 (annual)	-	82,620 to 307 (2027 to 2050)	82,620 to 307 (2027 to 2050)
Total (25 years)	**1,325,425**	**381,428**	**1,706,853**

7.5 Cumulative greenhouse gas impacts

The Project will result in a cumulative impact in the context of Victorian, Australian and global greenhouse gas emissions. The Project is adding additional greenhouse gas emissions to the existing emissions being produced at a state, Commonwealth and global level (mostly related to construction). Ultimately, this means, along with all other greenhouse gas emitters, that the Project is contributing to the continued accumulation of greenhouse gases in the atmosphere and the resulting climate impacts.

However, the Project is also contributing to the reduction in greenhouse gas emissions. By increasing renewable energy sources in Victoria, the Project is assisting with the supply of renewable energy and reduced usage of fossil fuels for power generation. This in turn is assisting with other actions to reduce the overall emissions of Victoria to achieve the targets of the Victorian *Climate Change Act 2017* as well as Australia as a whole, in line with the goals of the Commonwealth *2030 Emissions Reduction Target*. Further details of these benefits are provided in **Section 7.6** below.

7.6 Operational Emissions Efficiency

Based on initial Projections of electricity generation, the Project is expected to produce 2559 GWh of electricity annually, remaining consistent until the end of Project life.

As different fuel sources for power generation have varying emissions, using the emissions intensity is a useful method of comparing the emissions of each fuel source. The emissions intensity is calculated through dividing annual Scope 1 emissions (in t CO_2e) by the annual energy production (in MWh). **Figure 7-5** shows the emissions intensity for common grid connected fuel sources, as well as the Project and other prominent energy producing facilities in Victoria.

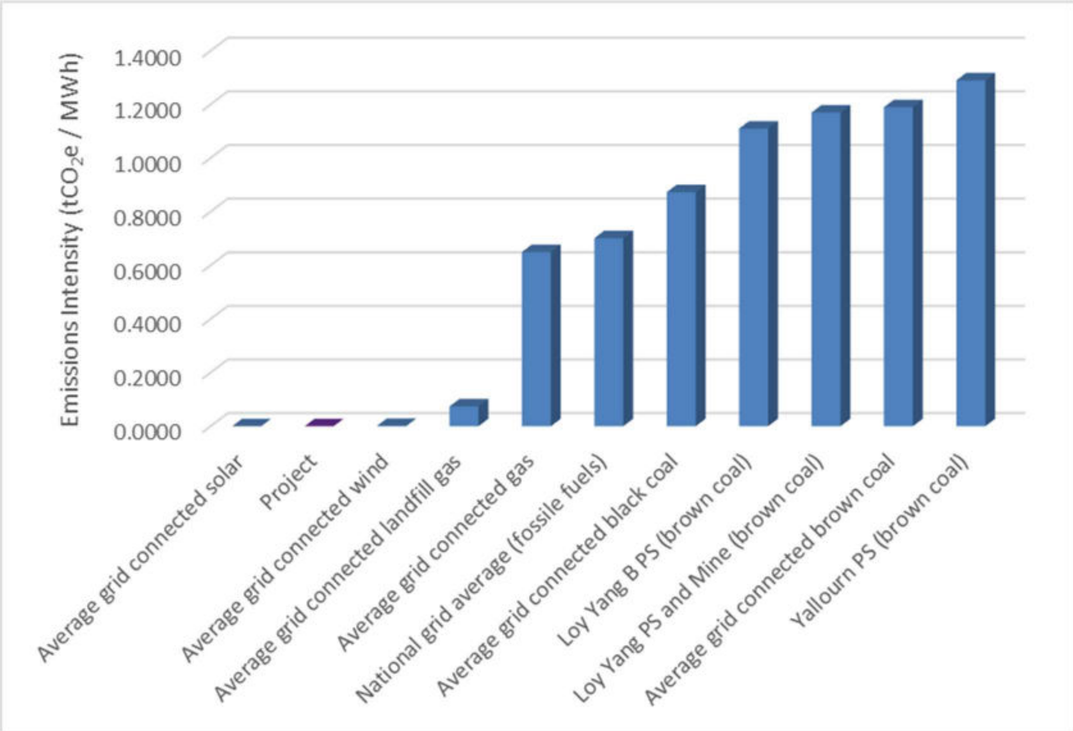

Figure 7-5 Emissions intensity comparison for common grid connected fuel sources

As shown in the figure above, the Project, like solar Projects and other wind Projects, will have an exceedingly low emissions intensity in comparison to traditional fossil fuel sources such as coal and gas. As such, the Project is well placed to play a role in the continued decarbonisation of the grid.

The yearly carbon offset can be calculated by multiplying the emissions intensity by the yearly output of the Project (2,850 GWh). As shown in **Table 7-20**, if all wind power generated replaces the power from black coal, the carbon offset is around 2.2 million tonnes of CO_2e per year. Similarly, if all wind power generated replaces power from gas, approximately 1.7 million tonnes of CO_2e is offset per year.

The carbon payback period is the time taken for the Project to offset the emissions due to construction. For black coal this payback period is approximately 0.59 years, whereas if gas power is being offset the payback is 0.80 years.

Table 7-20 Yearly carbon offset and carbon payback periods for different power generation

Power generation method	Emissions intensity (tCO2e / MWh)	Carbon offset (tCO2e / year)	Construction emissions carbon payback period (years)
Grid connected black coal average	0.87	2,233,751	0.59
Grid connected fossil fuels average	0.70	1,794,627	0.74
Grid connected gas	0.65	1,662,582	0.80
Renewable energy	0.00	0	N/A

8. Mitigation and management, reporting and EPRs

8.1 Best practice energy and greenhouse gas management

Under the GED of the *Environment Protection Act 2017,* proponents are required to minimise environmental risks, including greenhouse gas emissions, as far as reasonably practicable. The following subsections detail how these risks can be managed.

8.1.1 Construction

Opportunities which could be undertaken to reduce greenhouse gas emissions during the construction of the Project include:

- During the procurement process, particularly at the supplier selection stage, show strong consideration for the adoption of innovative technologies where technically possible and cost effective, such as:
  - fly ash as a supplementary cementitious material (to replace traditional Portland cement)
  - reclaimed aggregate (if not quarried on site)
  - high recycled content and/or low carbon steel.
- It is important to note that the embedded emissions within steel and concrete make up a significant portion of the overall construction (and Project) emissions. The emissions factors used in this assessment for these materials are generic and may not even fully account for the full range of emissions embedded in these materials. As such, this measures to reduce embedded emissions in these materials should be seen as a priority
- Undertaking detailed modelling to ensure that cut and fill balances are managed to minimise any unnecessary movements of material and reduce emissions associated with haulage
- Develop inspection and maintenance procedures to ensure that plant and equipment are being operated in a proper and efficient manner and switched off when not required so that fuel combustion is minimised where possible.
- Review opportunities to use renewable energy sources in construction and quarrying plant and equipment based on site for excessive periods, reducing emissions associated with the construction activities.

8.1.2 Operation

Opportunities which could be undertaken to reduce greenhouse gas emissions during the operation of the Project include:

- Adopt inspection and maintenance procedures to minimise fuel combustion where possible, such as shutting off equipment when not in use and adopting more fuel-efficient equipment.
- Explore opportunities to use renewable energy sources in inspection vehicles where practical
- Review BESS operations to assure the most efficient (and low carbon) usage of energy. This could include considering the prioritisation or purchase of renewable energy specifically for charging the BESS or charging the BESS with energy from the wind farm. Both options could significantly drop associated emissions.

As noted in **Section 4** Victoria is aiming to become carbon neutral by the year 2050. The generation of electricity from wind will contribute to Victoria in achieving this.

8.1.3 Decommissioning

The management measures required for greenhouse gas during the decommissioning phase pertain to the maintenance and inspection activities, therefore, some mitigation measures for construction are also applicable for the operational phase. These could include:

- Implement procedures to minimise energy usage where possible during decommissioning activities. This includes inspections and processes to ensure that equipment and shut down when not in use, operated and maintained so that it operates in an efficient manner, and selecting equipment for use on the site that is most fuel and energy efficient
- Explore opportunities to recycle steel, concrete and other materials as an alternative to sending the material to landfill.

8.1.4 Summary of mitigation

As shown in **Section 5.5.9**, an energy reduction hierarchy has been adopted to guide and assist in the development of mitigation measures. In order to better understand the mitigation measures and their application, each mitigation measure above has been classified by its priority in the energy reduction hierarchy, the responsible person, and the timing of application. This classification has been provided in **Table 8-1**.

Table 8-1 Project mitigation measures

Phase	Management measure	Priority in Energy Reduction Hierarchy	Responsibility	Timing
Construction	During the procurement process, wherever possible adopt innovative technologies that minimise fuel and energy consumption	2 - Energy Efficiency	Contractor	Detailed Design
	Undertake detailed modelling to ensure that cut and fill balances are managed to minimise any unnecessary movements of material.	1 - Energy Saving	Contractor	Detailed Design
	Develop inspection and maintenance procedures to ensure that plant and equipment are operated in a proper and efficient manner and switched off when not required so that fuel combustion is minimised where possible. This also involves selecting more fuel and energy-efficient equipment for the project wherever possible.	1 - Energy Saving	Contractor	Detailed Design
	Explore opportunities to use renewable energy sources during construction.	3 – Renewable Technology	Contractor	Detailed Design and construction
Operation	Adopt inspection and maintenance procedures to minimise fuel combustion where possible. This includes shutting off equipment when not in use and adopting more fuel-efficient equipment.	1 - Energy Saving	Contractor	During operations
	Explore opportunities to use renewable energy sources in inspection vehicles where practical.	3 – Renewable Technology	Contractor	During operations
	Review BESS operations to assure the most efficient (and low carbon) usage of energy	2 - Energy Efficiency	Proponent	During operations
Decommissioning	Adopt procedures to minimise energy usage where possible during decommissioning activities. This includes	1 - Energy Saving	Contractor	Decommission Planning

Phase	Management measure	Priority in Energy Reduction Hierarchy	Responsibility	Timing
	shutting off equipment when not in use and adopting more fuel-efficient equipment.			
	Explore opportunities to recycle steel, concrete and other materials as an alternative to sending the material to landfill.	3 – Renewable Technology	Contractor	Decommission Planning

8.2 Greenhouse gas emissions reporting

With the current assumed BESS operations, the project, in it's opening year, has been predicted to:

- Produce 73 kt CO_2e in Scope 1 and Scope 2 emissions
- Produce up to 10,260 TJ of energy
- Consume up to 433 TJ of energy.

As such, the project is above all three criteria of the NGERs individual project reporting thresholds of:

- Produce 25 kt CO_2e or more in Scope 1 and 2 emissions annually
- Produce 100 TJ or more annually
- Consume 100 TJ or more annually.

As well as being above all three criteria of the NGERs corporate group thresholds of:

- Produce 50 kt CO_2e or more in Scope 1 and 2 emissions annually
- Produce 200 TJ or more annually
- Consume 200 TJ or more annually.

As such, the proponent would be required to report the project's emissions to the Clean Energy Regulator each year. It is also important to note that the estimated wind farm generation (2,850 GWh/10,260 TJ) alone would produce more energy than both reporting thresholds, meaning the proponent would be required to report to the Clean Energy Regulator regardless of the final BESS arrangement or change in emissions over time resulting from grid decarbonisation.

8.3 General environmental duty

The GED requires that risks to the environment and human health from pollution or waste are minimised so far as reasonably practicable. With regards to the risks associated with greenhouse gas emissions these are being minimised in the approaches outlined above.

Overall, this Project represents improved environmental outcomes, and reduced greenhouse impacts by generating renewable electricity to offset emissions from traditional fossil fuel sources. The Project also contributes to the gradual decarbonisation of the grid through the cumulative uptake of renewable energy sources and the rollback of traditional fossil fuels. As such, the Project provides both short- and long-term environmental benefits, in line with the *Environment Protection Act 2017* goals of preventing waste and pollution impacts.

8.4 Environment Performance Requirements

To meet the EES evaluation objective of avoiding and/or minimising greenhouse gas risks, the EPR below is recommended:

- **EPR GHG1 (Develop and implement a Sustainability Management Plan):** Develop sustainability targets and specify ratings to reduce construction, operational and decommissioning greenhouse gas emissions from a 'business as usual' benchmark. To aid in achieving the targets, a Sustainability Management Plan (SMP) is to be developed and implemented a that contains measures to meet the sustainability targets and specified ratings, and includes the requirement to monitor and report on the progress of achieving the sustainability targets and implementation of the Sustainability Management Plan. Regarding design and construction, the SMP must include the following:
  - During the design and procurement process, describe how innovative technologies and the use of sustainable design practices and renewable energy sources during construction would be reviewed and wherever reasonable and feasible be adopted
  - Describe the process of how vendors would review and where reasonable and feasible, implement alternatives which avoid or otherwise minimise SF_6 utilisation
  - Detailed modelling to ensure that cut and fill balances are managed to minimise any unnecessary movements of material.
  - Inspection and maintenance procedures to ensure that plant and equipment are operated in a proper and efficient manner and switched off when not required so that fuel combustion is minimised where possible. This also involves selecting more fuel and energy-efficient equipment for the project wherever possible.

  During operation, the SMP must:
  - Include measures to track and manage SF_6 utilisation, and also include a leak detection and repair (LDAR) strategy to effectively detect and rapidly manage any SF_6 spills
  - Detail how renewable energy sources in operational inspection vehicles would be reviewed and implemented where practical, and to review BESS operations to assure the most efficient (and low carbon) usage of energy
  - Adopt inspection and maintenance procedures to minimise fuel combustion where possible. This includes shutting off equipment when not in use and adopting more fuel-efficient equipment.

  Finally, regarding decommissioning, the SMP must include:
  - Procedures to minimise energy usage where possible during decommissioning activities. This includes shutting off equipment when not in use and adopting more fuel-efficient equipment
  - Ways to recycle steel, concrete and other materials as an alternative to sending the material to landfill.

9. Significance of greenhouse gas emission impacts

Based on the assessment of greenhouse gas emissions in **Section 7**, and the mitigation measures developed in **Section 8**, the residual impacts associated with the greenhouse gas emissions from the Project can be determined. These residual impacts are displayed in **Table 9-1**. Additionally, the residual impacts have been compared against the impact significance criteria detailed in **Table 5-7** to determine the overall significance of the impacts.

Table 9-1 Significance of impact rating

Value	Impact pathway	Project phase	Mitigation and management measures	Residual impact
Construction emissions	Scope 1 and 2 emissions from activities undertaken during construction. Scope 3 emissions associated with embedded emissions.	Construction	Adoption, where possible, of the mitigation measures recommended above: Adoption of innovative technologies and low carbon materials. Manage cut and fill balances to minimise any unnecessary emissions associated with haulage. Adopt inspection and maintenance procedures to minimise fuel combustion. Explore opportunities to use renewable energy sources in construction and quarrying plant and equipment.	**'Minor'**. Mitigation measures will assist in reducing the overall emissions during construction. However, due to the extent of construction related emissions, the majority of emissions will remain. As per **Table 7-20**, the operation of the Project will take approximately half a year to pay back the construction related emissions.
Operation emissions	Scope 1 and 2 emissions from activities undertaken during operation. Scope 3 emissions associated with embedded emissions.	Operation	Adoption, where possible, of the mitigation measures recommended above: Adopt inspection and maintenance procedures to minimise fuel combustion. Explore opportunities to use renewable energy sources in inspection vehicles. Review BESS operations to assure the most efficient usage of energy.	**'Moderate'** to **'Negligible'**. Mitigation measures will assist in reducing the overall emissions during operation. However, due to the nature of operation related emissions, the majority of emissions will remain although these will decrease as the grid continues to undergo decarbonisation. It is important to note that while the project will be producing its own emissions, the project will also be producing renewable energy, supplanting emissions from fossil fuel sources.
Decommissioning emissions	Scope 1 and 2 emissions from activities undertaken during operation. Scope 3 emissions associated with	Decommissioning	Adoption, where possible, of the mitigation measures recommended above: Adopt procedures to minimise energy usage where possible. Explore opportunities to recycle steel, concrete and other materials	**'Minor'**. Mitigation measures will assist in reducing the overall emissions during decommissioning. However, due to the extent of decommissioning related emissions, the majority of emissions are expected to remain.

	embedded emissions.			

10. Conclusion

The Greenhouse Gas Assessment has been conducted in accordance with EPA Victoria and National Greenhouse Accounts guidance and associated factors. The GHG emissions were calculated for the construction and operational phases of the Project, with the operational phase GHG emissions divided into energy and non-energy related emissions.

The construction phase emissions have been calculated as 1,325,425 tCO_2e. The raw operational emissions have been calculated as 82,620 tCO_2e per annum, decreasing to 308 tCO_2e per annum by 2050 (noting assumptions and limitations associated with emissions for BESS and SF_6 leakage). Over the 25-year life of the Project, the overall GHG emissions are expected to be 1,706,853 tonnes of CO_2e. However, the Project is anticipated to produce up to 2,559 GWh of wind-based electricity annually. Decommissioning activities have been assessed qualitatively and are generally assumed to be similar to construction, without the emissions attributed to the vegetation clearing and embedded emissions, alongside various additional energy efficiencies possible by the time the Project is decommissioned.

Due to the low emissions intensity predicted from the Project, the Project is anticipated to be a positive development for reducing the State's GHG emissions. **Table 10-1** shows the calculated GHG emissions for the Project.

Table 10-1 Emissions summary

	Construction	Operation	Design Life (Construction + 25 years Operation)
Calculated Emissions (tCO_2e)	1,325,425	381,428	**1,706,853**

The Project will have a positive greenhouse gas contribution and has minimised the risks associated with its greenhouse gas emissions so far as reasonably practicable.

11. References

Assessment of the Carbon Footprint, Social Benefit of Carbon Reduction, and Energy Payback Time of a High-Concentration Photovoltaic System, Allen H. Hu, Lance Hongwei Huang, Sylvia Lou, Chien-Hung Kuo, Chin-Yao Huang, Ke-Jen Chian, Hao-Ting Chien and Hwen-Fen Hong, Sustainability 2017, 9, 27; doi:10.3390/su9010027

AusLCI (2011). AusLCI Material Dataset. Received 1 May 2023 from: https://www.auslci.com.au/Datasets/Material.php

Clean Energy Regulator (2023). Greenhouse and energy information by designated generation facility 2021-22. Clean Energy Regulator, Canberra, ACT

DEFRA (2024). Greenhouse Gas Reporting: Conversion Factors 2024. Department for Environment, Food & Rural Affairs

Department of Climate Change, Energy, the Environment and Water (DCCEEW). 2024. Australia's emissions Projections 2024. Canberra.

Department of Climate Change, Energy, the Environment and Water (2024). Australian Greenhouse Emissions Information System (AGEIS). Received 26 Mar 2024 from: https://ageis.climatechange.gov.au/

EcoInvent, EcoInvent V2.2 (2010)

EPD Australasia (2022), EPD855: Reinforcing Rod, Bar and Wire. EPD Australasia, Nelson, New Zealand

GHG Emissions from the Production of Lithium-Ion Batteries for Electric Vehicles in China, Hao, H.; Mu, Z.; Jiang, S.; Liu, Z.; Zhao, F., Sustainability 2017, 9, 504. https://doi.org/10.3390/su9040504

GHG Protocol - A Corporate Accounting and Reporting Standard (Revised Edition), World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI). http://www.ghgprotocol.org/sites/default/files/ghgp/standards/ghg-protocol-revised.pdf

Intergovernmental Panel on Climate Change (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Institute for Global Environmental Strategies on behalf of the IPCC, Hayama, Japan

Jacobs (2021). Liddell Battery and Bayswater Ancillary Works Environmental Impact Statement. Jacobs Group Australia Pty Ltd, Newcastle West, NSW, Australia

Jacobs (2022). Yanco Delta Windfarm Environmental Impact Statement. Jacobs Group Australia Pty Ltd, North Sydney, NSW, Australia

NGA (2021). National Greenhouse Accounts (NGA) Factors August 2021. Australian Government Department of the Environment and Energy

Transport Authorities Greenhouse Group (TAGG). 2013. Greenhouse Gas Assessment Workbook for Road Projects. February 14

Appendix A. Input Data

This appendix provides details of the inputs used in the development of the greenhouse gas calculations.

A.1 Construction

A.1.1 Fuel usage

Fuel usage by construction plant and equipment has been calculated based on construction timeline estimations made for similar wind farm Projects. The total fuel consumption from construction presented in the *Yanco Delta Windfarm Environmental Impact Statement* (Jacobs, 2022) was scaled based on the number of wind turbines (factor of 0.52), giving a total of 3,313kL of fuel usage over the construction period.

Details relating to the batching plants and the situation where quarrying works occurs on site are tabulated in **Table A-1** below.

Table A-1 Construction equipment usage for the Project

Structure	Equipment Used in Construction	Duration of works	UoM
Batching Plant (x7)	Generator	24 months at 8 hrs a day, 5 days a week.	kL/kWh
Quarrying and other site activities	2 x Mobile generators	18 Months	kL/month
	2 x Portable screening and crushing plant	18 Months	kL/month
	4 x Excavators	18 Months	kL/month
	4 x 40t haul trucks	18 Months	kL/month
	1 x Crane	18 Months	kL/month
	2 x Loaders	18 Months	kL/month
	1 x Dozer	18 Months	kL/month
	1 x Forklift	18 Months	kL/month

A.1.2 Material Quantities

Material quantities for the Project are based on data provided by the client and estimations for similar wind farm Projects assessed by Jacobs. These are simplified and detailed in **Table A-2** below:

Table A-2 Material requirements of Project infrastructure

Component	Material	Amount
Turbine	Concrete	63,600 t
	Composite	24,115 t
	Steel	247,457 t
	Steel Reinforcement	22,260 t
Terminal Station	Steel	404 t
	Concrete	70,080 t
Operation and Maintenance Building	Concrete	17,280 t
BESS	Battery Modules	970,000 kWh

Component	Material	Amount
	Battery Rack	1,300 t
	Inverters	1,800 t
	Transformer – Large	240 t
	Transformer – Small	6 t
	Battery Container	3000 t
	Steel Reinforcement Bar	100 t
	Concrete	11,520 t
	Copper Cabling	40 t
Meteorological Mast	Steel	2.5 t
Total material from quarry (including overburden) for use Turbine Hardstand, BESS Hardstand, Terminal Station Hardstand, Access Tracks	Product and overburden	2,380,000t

A.1.3 Cut and Fill

Cut and Fill balances were confirmed by the client. It is not expected that any significant tonnages of fill will be imported onto site for construction. Where quarrying works take place on site, cut and fill of aggregate is assumed to use 0.001 kL of fuel per cubic metre of aggregate (TAGG, 2013).

A.1.4 Waste

Calculations for the waste generated during construction were scaled based off non-demolition related waste in the *Yanco Delta Windfarm Environmental Impact Statement* (Jacobs, 2022). These have been simplified and detailed in **Table A-3**.

Table A-3 Waste estimations for construction

Waste Type	Total Waste (t)
Plastic Packaging	0.1
Plastics (PET)	0.2
Cardboard Packaging/ Paper waste	166
Recyclable domestic waste	0
PPE	1
Empty Chemical Drums	331
Oil Spill Clean-up Material	0.2
Waste oils, lubricants and liquids	2
Domestic Waste	13

A.1.5 Haulage

Based on the client's intention of sourcing materials, a distance of 180km (distance to Port of Geelong) was adopted for shipped and manufactured materials. For shipped materials, an assumption was provided that

that these materials were shipped from Shanghai to Melbourne based on the sourcing of steel in other power related Projects in the region.

Waste disposal is assumed to be at the Corangamite Regional Landfill, approximately 70km from the Project site.

A.1.6 Site vehicles

The *Greenhouse Gas Assessment Workbook for Road Projects* (TAGG, 2013) provides an assumed fuel usage from site vehicles based on the monetary size of a Project as well as the construction duration (in months). This assumption process was to calculate the vehicle fuel usage in this Project. It is noted that this is a low sensitivity input compared with other factors considered during construction.

A.1.7 Vegetation clearance

Greenhouse gas impacts resulting from the clearance of vegetation along the alignment are based on the Greenhouse Gas Assessment Workbook for Road Projects (TAGG, 2013). The workbook establishes 'Biomass Classes' (determined through the location of the Project) and 'Vegetation Classes' (based on the specific type of vegetation being cleared). Based on this workbook, the most appropriate biomass class is 'Class 3'.

The key types of vegetation Projected to be cleared were identified/defined based on data provided by the Department of Environment Land Water and Planning, in addition to field measurements and site surveys. These have been provided in **Table A-4**.

Table A-4 Cleared Vegetation Classification

Ecological Vegetation Community	Area (Hectares)	Greenhouse Gas Assessment Workbook for Road Projects Vegetation Class
Natural Temperate Grassland of the Victorian Volcanic Plains	14.361	Class I - Grasslands
Seasonal Herbaceous Wetland of the Lower Temperate Plains		Class I - Grasslands
Remaining unspecified grassland		Class I - Grasslands

A.1.8 Electricity Consumption

It was identified by the client that a main site office and four supporting compounds would utilise grid electricity. Assumptions have been developed based on similar sized offices. The electricity assumptions have been provided in **Table A-5**.

Table A-5 Electricity Consumption During Construction

Plant	Electricity Consumption (kWh)	Daily Hours of Operation	Total Electricity Consumption over Construction Period (MWh)
Site Office	5.14	50 (i.e., 8 x 5)	135.61

A.1.9 Quarry blasting

Inputs for assessment of emissions associated with quarry blasting activities to facilitate extraction are summarised below:

Table A-6 Quarry blasting activities during construction

Emission source	Quantity (no. blasts during construction)	Quantity of explosives (tonnes) used
Blasting at quarry	75	638

A.2 Operation

A.2.1 Inspection vehicles

Predictions for inspection vehicle usage during the operation of the wind farm were based on assumptions made using data provided by the client. These are summarised in **Table A-7**.

Table A-7 Average annual equipment usage for inspection works

Equipment	Time (months)
2 x Light vehicles	2
2 x Small trucks	2

A.2.2 Maintenance equipment

Likewise, predictions for scheduled maintenance during the operation of the wind farm was based on assumptions made using data provided by the client. These are summarised in **Table A-8**.

Table A-8 Average maintenance equipment usage for inspection works

Equipment	Time (months)
2 x Light vehicles	2
2 x Small trucks	2
2 x Large truck	1
1x Crane	1
1 x Loader	1
1 x Forklift	1

A.2.3 Replacement materials

Assumed 2.5 kg of steel and 2.5 kg of porcelain per instance of minor maintenance works. These activities were assessed as occurring 3 times per year per wind turbine.

A.2.4 Grid electricity usage

It is noted that a number of Project elements will require electricity during their operation. These components will draw energy from both the grid and the Project itself, which in turn affects the emissions associated from each. Details on electricity usage is displayed below in **Table 11-9**.

Table 11-9 Electricity usage in terminal stations

Facility	Annual electricity usage	Electricity source
O & M	25,000 kWh	Energy Grid

A.2.5 BESS-related emissions

Assumptions for BESS operation were adopted from similar wind farm and BESS projects. These are detailed in **Table A-10**. Again, the round-trip efficiency of the batteries and number of charge cycles undertaken by the BESS will both have a material impact of greenhouse gas emissions, noting that assumptions have been applied.

Table A-10 Electricity usage by BESS

Component	Assumed value	Source
BESS capacity (MW)	800 MW	RFI response from proponent
BESS capacity (MWh)	800 MWh	*Yanco Delta Windfarm Environmental Impact Statement* (Jacobs, 2022)
Battery degradation curve	As per **Table 7-12**	*Liddell Battery and Bayswater Ancillary Works Environmental Impact Statement* (Jacobs, 2021)
Round trip efficiency	71%	*Liddell Battery and Bayswater Ancillary Works Environmental Impact Statement* (Jacobs, 2021)
Charge cycles	365 annually	Conservative assumption