Transgrid

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HumeLink

Greenhouse Gas Assessment
EIS Technical Report 18

HUMELINK

EIS Technical Report 18 - Greenhouse Gas Assessment

Prepared for Transgrid

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PREPARED BY

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Aurecon (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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EXECUTIVE SUMMARY

Transgrid proposes to increase the energy network capacity in southern New South Wales (NSW) through the development of around 360 kilometres of new 500 kilovolt (kV) high-voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle. This project is collectively referred to as HumeLink. The purpose of this report is to quantify the potential greenhouse gas (GHG) emissions from construction and operation of the project, and to assess their significance in relation to state and national emissions as well as relevant policies and guidelines, to support the environmental assessment of the project in accordance with Division 5.2 of the *Environmental Planning and Assessment Act 1979*.

This assessment was performed as a desktop study. The calculation of GHG emissions from the project has been performed in a five stage process:

1. definition of the project boundary (ie the project footprint)
2. identification of GHG emission sources within the project footprint
3. identification of emission calculation methods and emission factors for each source
4. identification of the activity data for each emission source required for the calculations
5. calculation of estimated GHG emissions.

The GHG emissions estimated for the project were then compared against the most recent publicly available state and national GHG emissions to assess their potential contribution to Australia's emissions inventory and their potential impact on Australia's ability to meet GHG reduction targets and policies.

The estimated GHG emissions during construction are shown in **Table ES-1**. The total direct Scope 1 emissions over the 2.5 year construction schedule are estimated at 16,886 tonnes of carbon dioxide equivalents (t CO_2-e), which is equivalent to 6,754 t CO_2-e per annum. The estimated annual Scope 2 emissions associated with electricity consumption at the construction compounds, worker accommodation facility and substation construction work are 1,735 t CO_2-e. This gives a total combined Scope 1 and Scope 2 annual emission estimate of 8,489 t CO_2- e. The main source of Scope 1 and Scope 2 emissions is diesel combustion, accounting for 54 per cent of the total emissions.

The estimated Scope 3 emissions during construction are 312,961 t CO_2- e and predominantly relate to energy embodied in construction materials. Emissions associated with the production and supply of fuels contribute less than one per cent of the estimated Scope 3 emissions.

The annual GHG emissions estimated for operation are shown in **Table ES-2.** The main source of emissions associated with the ongoing operation of the project are Scope 2 emissions related to transmission losses. For Scope 1 emissions, the main source is associated with leakage of sulfur hexafluoride (SF_6), due to its potency as a GHG.

EXECUTIVE SUMMARY

Table ES-1 Estimated GHG emissions - construction

Scope	Activity/source	Estimated emissions (t CO_2-e)	
		Total 2.5 year construction period	Annual average
1	Diesel consumption - off-road and stationary	52,535	21,014
1	Diesel consumption - mobile/on-road	1,480	592
1	Unleaded fuel consumption	2,584	1,019
1	Consumption of oils (lubricants)	27.7	11.1
1	Consumption of greases	3.2	1.3
Total Scope 1		***56,593***	***22,637***
2	Electricity consumption	4,189	1,676
Total Scope 2		***4,189***	***1,676***
3	Extraction and production of diesel consumed	2,770	1,108
3	Extraction and production of petrol consumed	132	53
3	Extraction and production of purchased materials- steel	68,893	27,557
3	Extraction and production of purchased materials- concrete	155,279	62,112
3	Extraction and production of purchased materials- copper	994	398
3	Extraction and production of purchased materials- aluminium	82,750	33,100
3	Employee commuting	297	119
3	Disposal of waste generated	1,847	739
Total Scope 3		***312,961***	***125,184***

Table ES-2 Estimated GHG emissions - operation

Scope	Activity/Source	Estimated emissions (t CO_2-e/annum)
1	Diesel consumption	61.8
1	Petrol consumption	20.5
1	Aviation gasoline (avgas) consumption	6.2
1	SF_6 leakage	1,922
Total Scope 1		***2,010***
2	Transmission losses	127,980
Total Scope 2		***127,980***
3	Extraction and production of fuels used	4.54
Total Scope 3		***4.54***

EXECUTIVE SUMMARY

The estimated annual average construction and operation GHG emissions from the project are compared to the most recent GHG emission estimates for NSW and Australia in **Table ES-3.** As shown in the table, the impact of the project on the state and national GHG emission loads is estimated to be negligible, with the operation annual emission estimate representing less than 0.1 per cent of NSW's annual emissions. The construction annual average emissions are even lower, and while the actual annual emissions may be higher in some years than others, depending on the staging of activities, the project would still be a very minor contributor to Australia's GHG emissions.

Based on the above, it can be concluded that HumeLink would not impact on Australia's ability to meet its emission reduction target under the Paris Agreement.

Table ES-3 Potential contributions of the project to state and national GHG emissions

Year	Estimated annual Scope 1 and Scope 2 project emissions (t CO_2-e/annum)	Percentage of NSW emissions	Percentage of Australia's emissions
Construction	24,313	0.018	0.005
Operation	129,990	0.095	0.026

To assist in the monitoring and reporting of GHG emissions from the project, a GHG management plan would be prepared for the project and would include strategies to reduce GHG emissions. The objectives of the plan would be to:

- reduce greenhouse gas emissions associated with the project and all relevant emissions sources
- incorporate energy efficiency initiatives into project design, procurement, engineering, construction and operation
- integrate greenhouse gas management and energy efficiency initiatives into business decision making at all stages of the project
- provide consistent and accurate reports on greenhouse gas emission levels in compliance with relevant legislation.

The project would support the transfer of energy from existing renewable generation as well as facilitate development of new renewable generation in the Wagga Wagga and Tumut Renewable Energy Zones (REZs), which would result in reductions in the GHG emissions intensity of the electricity network. The existing congested transmission network gives rise to potentially higher transmission losses, which increase the cost of electricity as well as contribute to Scope 2 GHG emissions. The project would assist in easing this congestion by improving the efficiency and reliability of the current energy transfer in this part of the network, and as a result, would also facilitate reductions in the GHG emissions intensity of the electricity network as the renewable energy projects come online.

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GLOSSARY, ACRONYMS and ABBREVIATIONS

Abbreviation or term	Description
°C	degrees Celsius
ACCU	Australian Carbon Credit Unit
ACT	Australian Capital Territory
avgas	aviation gasoline
CCA	Climate Change Authority
CH_4	methane
Climate change	A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed, largely, to the increased levels of atmospheric greenhouse gases.
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalence
Direct GHG emissions	GHG emissions produced from sources within the geographical/operational boundary defined for an organisation/project and as a result of the organisation's/project's activities.
DISR	Department of Industry, Science and Resources
EIS	Environmental Impact Statement
ERF	Emissions Reduction Fund
FullCAM	Full Carbon Accounting Model
GHG	A greenhouse gas (GHG) is a gas that absorbs and emits radiant energy within the thermal infrared range. Greenhouse gases cause the greenhouse effect on planets. The greenhouse gases that are reported under the National Greenhouse and Energy Reporting Scheme include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6) and specified kinds of hydro fluorocarbons and perfluorocarbons.
GJ	gigajoules
GWh	gigawatt-hour (equivalent to 1,000,000 kilowatt-hours
GWP	Global warming potential
ICE	Inventory of Carbon and Energy
IFC	International Finance Corporation
Indirect GHG emissions	GHG emissions generated in the wider economy as a consequence of an organisation's/project's activities but are physically produced by the activities of another organisation.
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
kg	kilogram
kL	kilolitre
km	kilometre
kV	kilovolt
kWh	kilowatt-hour
LGA	Local Government Area
Mt	million tonnes
MW	megawatt, equal to one million (10^6) watts
MWh	megawatt-hour, equal to 1 megawatt of electricity used continuously for one hour

GLOSSARY, ACRONYMS and ABBREVIATIONS

Abbreviation or term	Description
NEM	National Electricity Market
NGA	National Greenhouse Accounts
NGO	non-governmental organisation
N_2O	nitrous oxide
NGER Act	National Greenhouse and Energy Reporting from *National Greenhouse and Energy Reporting Act 2007*
NGERS	National Greenhouse and Energy Reporting Scheme
NSW	New South Wales
project footprint	The area that has been assumed for the purpose of this EIS to be directly affected by the construction and operation of the project. It includes the indicative location of project infrastructure, the area that would be directly disturbed during construction as well as any easement required during operation.
QLD	Queensland
REZ	Renewable Energy Zone
SA	South Australia
Scope 1 emissions	Direct GHG emissions released to the atmosphere as a direct result of an activity, or series of activities at a facility level.
Scope 2 emissions	Indirect GHG emissions released to the atmosphere from the indirect consumption of an energy commodity.
Scope 3 emissions	Indirect GHG emissions other than Scope 2 emissions that are generated in the wider economy that occur as a consequence of the activities of a facility, but from sources not owned or controlled by that facility's business.
SF_6	sulfur hexafluoride
t	tonne
TAS	Tasmania
the project	The construction and operation of high voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle, collectively referred to as HumeLink.
UNFCCC	United Nations Framework Convention on Climate Change
VIC	Victoria
WBCSD	World Business Council for Sustainable Development, a Geneva-based coalition of 170 international companies
WRI	World Resources Institute, a US-based environmental NGO

1 Introduction

1.1 Overview

The Australian energy landscape is transitioning to a greater mix of low-emission renewable energy sources, such as wind and solar. To support this transition, meet our future energy demands and connect Australian communities and businesses to these lower cost energy sources, the national electricity grid needs to evolve.

Transgrid proposes to increase the energy network capacity in southern New South Wales (NSW) through the development of around 360 kilometres of new 500 kilovolt (kV) high-voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle. This project is collectively referred to as HumeLink. The project would be located across five Local Government Areas (LGAs) including Wagga Wagga City, Snowy Valleys, Cootamundra-Gundagai Regional, Upper Lachlan Shire and Yass Valley. The location of the project is shown on **Figure 1-1**.

HumeLink would involve construction of a new substation east of Wagga Wagga as well as connection to existing substations at Wagga Wagga and Bannaby and a future substation at Maragle in the Snowy Mountains (referred to as the future Maragle 500 kV substation). The future Maragle 500 kV substation is subject to a separate major project assessment and approval (reference SSI-9717, EPBC 2018/836).

The project would deliver a cheaper, more reliable and more sustainable grid by increasing the amount of renewable energy that can be delivered across the national electricity grid, helping to transition Australia to a low carbon future. It would achieve this by supporting the transfer of energy from existing renewable generation as well as facilitate development of new renewable generation in the Wagga Wagga and Tumut Renewable Energy Zones (REZs). The project would provide the required support for the network in southern NSW, allowing for the increase in transfer capacity between new renewable generation sources and the state's demand centres of Sydney, Newcastle and Wollongong. The project would also improve the efficiency and reliability of the current energy transfer in this part of the network.

Furthermore, HumeLink would form a key part of the transmission line infrastructure that supports the transfer of energy within the National Electricity Market (NEM) by connecting with other major interconnectors. The NEM incorporates around 40,000 kilometres of transmission lines across Queensland (QLD), NSW, Australian Capital Territory (ACT), Victoria (VIC), South Australia (SA) and Tasmania (TAS).

Construction of the project is targeted to commence in 2024, subject to the required planning and regulatory approvals. Once construction has commenced, the project is estimated to take approximately 2.5 years to build and would become operational by the end of 2026.

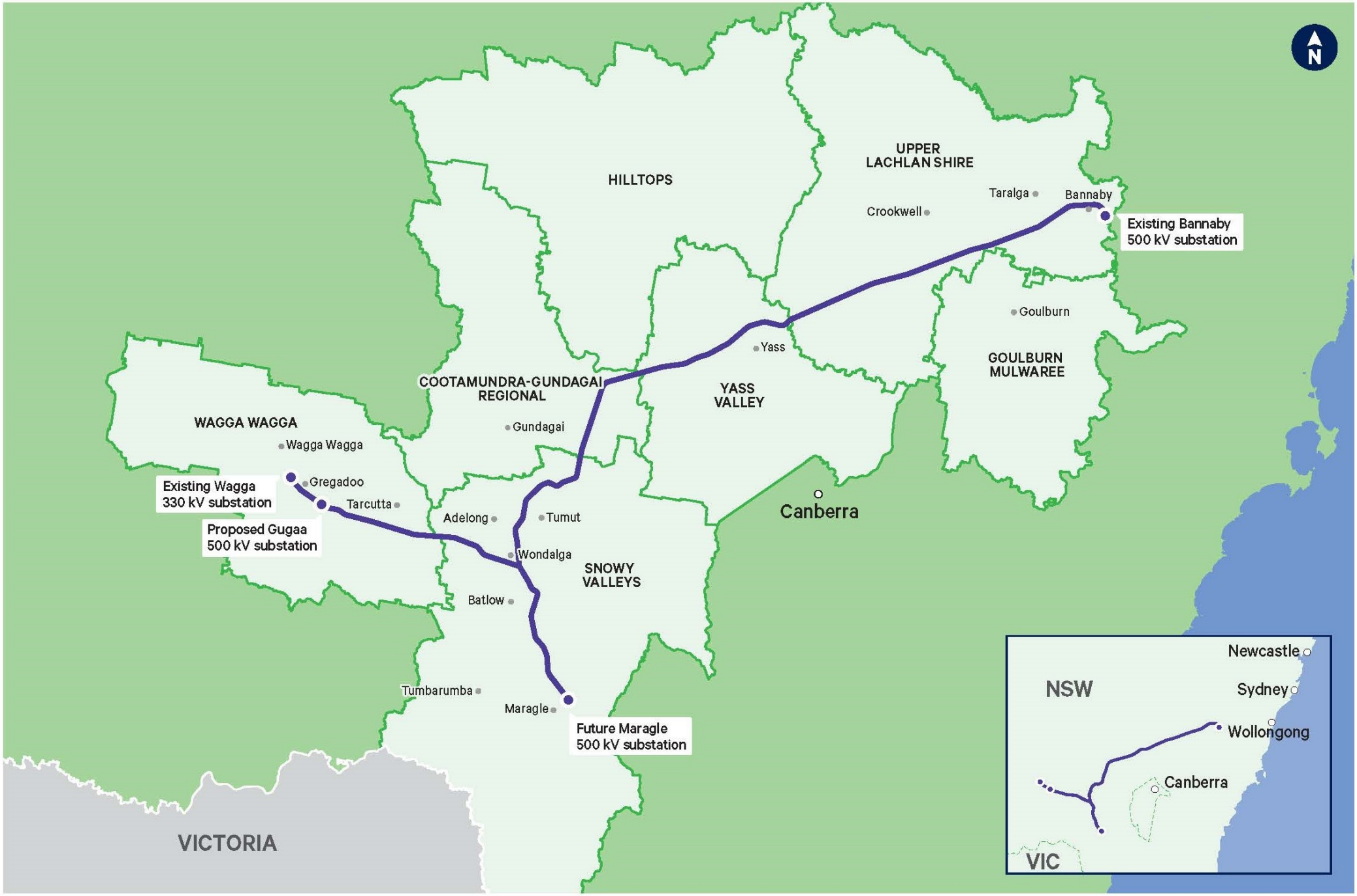
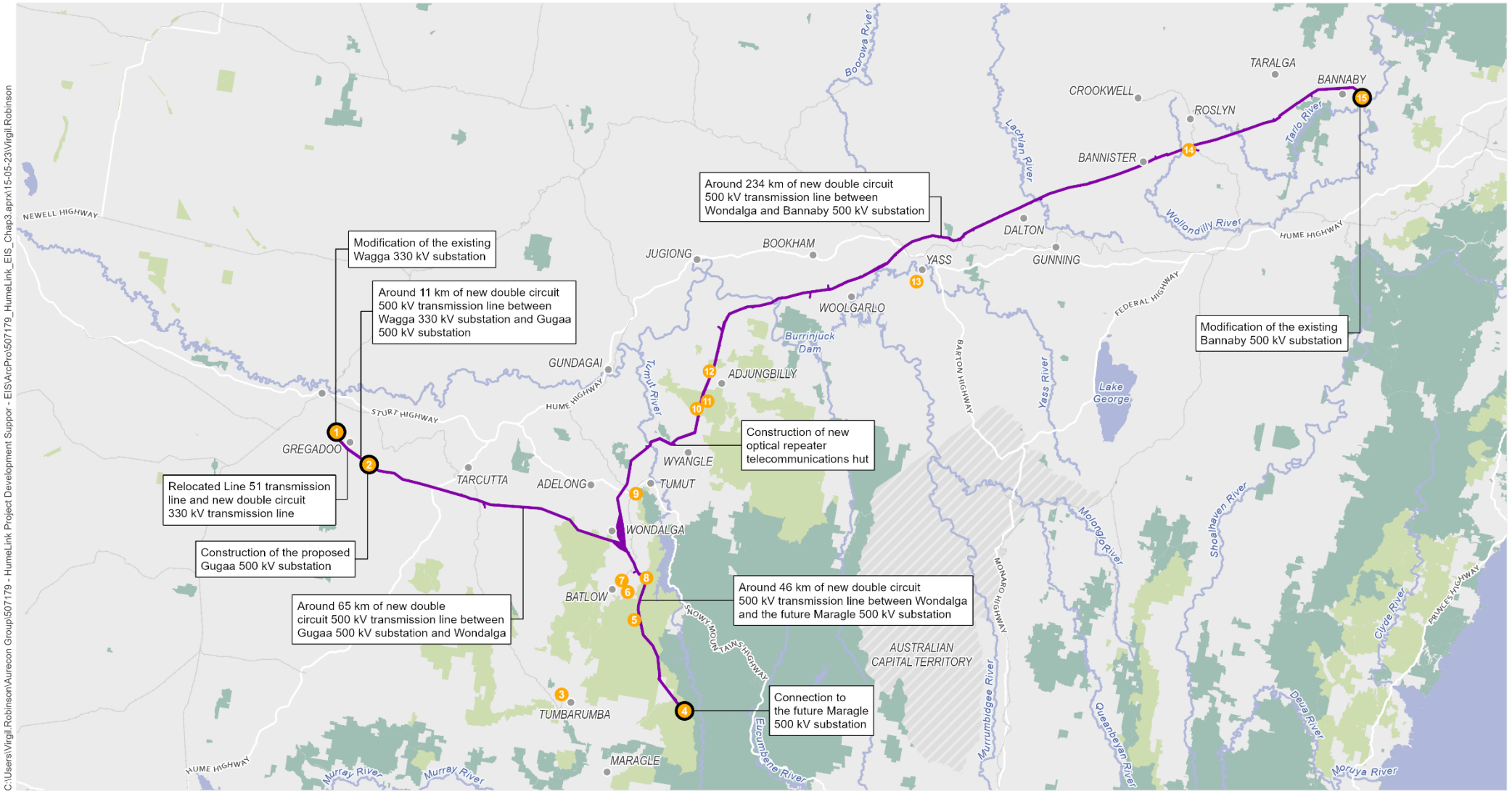


FIGURE 1-1: Location of the project

1.2 Key components of the project

The key components of HumeLink include (refer to **Figure 1-2**):

- construction and operation of around 360 kilometres of new double circuit 500 kV transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle
- construction of a new 500/330 kV substation at Gregadoo (Gugaa 500 kV substation) approximately 11 kilometres south-east of the existing Wagga 330/132 kV substation (Wagga 330 kV substation)
- demolition and rebuild of a section of Line 51 (around two kilometres in length) as a double circuit 330 kV transmission line connecting into the Wagga 330 kV substation
- modification of the existing Wagga 330 kV substation and Bannaby 500/330 kV substation (Bannaby 500 kV substation) to accommodate the new transmission line connections
- connection of transmission lines to the future Maragle 500/330 kV substation (Maragle 500 kV substation approved under the Snowy 2.0 Transmission Connection Project (SSI 9717))
- provision of one optical repeater telecommunications hut and associated connections to existing local electrical infrastructure
- establishment of new and/or upgraded temporary and permanent access tracks
- ancillary works required for construction of the project such as construction compounds, worker accommodation facility, utility connections and/or relocations, brake and winch sites, and helipad/helicopter support facilities.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:925,000

0 20 40km

Projection: GDA 1994 MGA Zone 55

HumeLink

FIGURE 1-2: Key components of the project

1.3 Purpose and scope of this report

The purpose of this report is to identify and quantify the potential greenhouse gas (GHG) emissions from construction and operation of the project, and to assess their significance in relation to state and national emissions as well as relevant policies and guidelines, to support the environmental assessment of the project in accordance with Division 5.2 of the *Environmental Planning and Assessment Act 1979*.

This report provides the basis for the development of a GHG Management Plan for the project.

1.4 Secretary's Environmental Assessment Requirements

The Planning Secretary's Environmental Assessment Requirements issued for the project on 14 March 2022 do not mention greenhouse gas or carbon emissions.

This assessment has been prepared to fulfill Transgrid's sustainability strategy requirements and to assist Transgrid in meeting its Net Zero GHG emission targets. It has been prepared in accordance with current industry practice for such assessments and with reference to the policies and guidelines discussed in **Chapter 4.**

1.5 Structure of this report

The structure of this report is as follows:

- **Chapter 1** presents an overview of the project, the purpose and scope of this report, and outlines the report structure.
- **Chapter 2** presents a description of the key components of the project.
- **Chapter 3** provides background information on what the greenhouse effect is, identifies the key GHGs associated with human-induced climate change and fundamental concepts on how GHG emissions are categorised and reported.
- **Chapter 4** summarises the international response to the need to reduce GHG emissions, key Australian legislation and policies relating to GHG emission reporting and management, and the key features of Transgrid's GHG policies and processes.
- **Chapter 5** presents the GHG assessment requirements and outlines the methodology used in the study to quantify and assess the project's impact on Australia's GHG emissions.
- **Chapter 6** presents a summary of Australia's and NSW's current GHG emissions based on the latest publicly available data.
- **Chapter 7** presents the estimated GHG emissions for construction of the project.
- **Chapter 8** presents the estimated GHG emissions for operation of the project
- **Chapter 9** provides an assessment of the estimated construction and operational GHG emissions by comparing them to current state and national emission rates.
- **Chapter 10** describes the potential GHG benefits of the project through a discussion of the project's anticipated impact on the energy mix within the NSW electricity network and its anticipated contribution to enabling Australia to meet its renewable energy targets.
- **Chapter 11** presents recommendations for the mitigation and monitoring of key GHG emission sources associated with the project to provide a basis for the development of a GHG Management Plan for the project as part of the sustainability strategy and Infrastructure Sustainability Rating Scheme pathway.
- **Chapter 12** summarises the main conclusions of the assessment.

1.6 Key project terms

The key project terms used in this report relevant to the greenhouse gas impacts of the project are:

- Project footprint: The area that has been assumed for the purpose of this EIS to be directly affected by the construction and operation of the project. It includes the indicative location of project infrastructure, the area that would be directly disturbed during construction and any easement required during operation.
- GHG geographical assessment boundary: The geographical boundary set for the Scope 1 and 2 emissions considered in the GHG assessment covers the project footprint, comprising the proposed transmission line corridor, construction compounds, worker accommodation locations, the telecommunications hut and substations. Scope 1 and 2 GHG emissions associated with activities at the Transgrid offices outside the project footprint during the design, construction and operation of the project were deemed to be outside the geographical boundary of the assessment. The Scope 3 emissions included in the assessment occur outside the GHG geographical assessment boundary.
- Scope 1 emissions: Direct GHG emissions released to the atmosphere as a direct result of an activity, or series of activities at a facility level.
- Scope 2 emissions: Indirect GHG emissions released to the atmosphere from the indirect consumption of an energy commodity.
- Scope 3 emissions: Indirect GHG emissions other than Scope 2 emissions that are generated in the wider economy that occur as a consequence of the activities of a facility, but from sources not owned or controlled by that facility's business.

2 Project description summary

The project description in this chapter is based on a concept design and indicative construction methodology for the project. The design and construction methodology would continue to be refined and confirmed during detailed design and construction planning by the construction contractors. Further details on the project are provided in Chapters 3 and 4 of the Environmental Impact Statement (EIS).

2.1 Summary of key components of the project

Key components of the project are summarised in **Table 2-1**.

Table 2-1 Summary of key components of the project

Component	Description
Transmission lines and supporting infrastructure	
Transmission lines and structures	The project includes the construction of new 500 kV transmission line sections between: - Wagga 330 kV substation and Gugaa 500 kV substation (approximately 11 km) - Gugaa 500 kV substation and Wondalga (approximately 65 km) - Wondalga and Maragle 500 kV substation (approximately 46 km) - Wondalga and Bannaby 500 kV substation (approximately 234 km). The transmission line section between the Wagga 330 kV substation and proposed Gugaa 500 kV substation would operate at 330 kV under HumeLink. The project also includes the rebuild of approximately 2 km of Line 51 as a new 330 kV transmission line between the Wagga 330 kV substation and around Ivydale Road, Gregadoo. This would be adjacent to the new transmission line between the existing Wagga 330 kV and proposed Gugaa 500 kV substations. The 500 kV transmission lines would be supported on a series of free-standing steel lattice structures that would range between around 50 m up to a maximum of 76 m in height and generally spaced between 300 to 600 m apart. The typical transmission line structure height would be around 60 m. Earth wire and communications cables would be co-located on the transmission line structures. The 330 kV structures for the rebuild of Line 51 would range between 24 m and 50 m in height and have a typical height of 40 m. Indicative configurations of transmission line structures that may be used as part of the project are shown in **Figure 2-1**. The type and arrangement of the structures would be refined during detailed design. The footings of each structure would require an area of up to 300 m^2 to 450 m^2, depending on ground conditions and the proposed structure type. Additional disturbance at each structure site may be required to facilitate structure assembly and stringing.
Transmission line easements	The easements for the 500 kV transmission lines are typically 70 m wide. However, a number of locations may require wider easements of up to 110 m wide at transposition locations and up to 130 m wide where the new transmission line would parallel the relocated section of Line 51. The easement provides a right of access to construct, maintain and operate the transmission line and other operational assets. The easement also generally identifies the zone of initial vegetation clearance and ongoing vegetation management to ensure safe electrical clearances during the operation of the lines. Vegetation management beyond the easement may also occur where nearby trees have the potential to fall and breach safety clearances.

Component	Description
Telecommunications huts	Telecommunications huts, which contain optical repeaters, would be required to boost the signal in the optical fibre ground wire (OPGW). One telecommunications hut would be required for the project. The telecommunications hut would be located adjacent to existing transmission line structures. Cables would be installed between the transmission line structure and the local power supply. The telecommunications hut would be surrounded by a security fence. A new easement would be established for the telecommunications hut power connection. The project also involves a telecommunications connection of OPGW between two proposed transmission line structures and the future Rye Park Wind Farm substation (SSD-6693). This removes the need for an additional telecommunications hut in this area of the project.
Substation activities	
Construction of the proposed Gugaa 500 kV substation	A new 500/330 kV substation would be constructed at Gregadoo, about 11 km south-east of the Wagga 330 kV substation. The substation would include seven new 500/330 kV transformers and three 500 kV reactors. The proposed Gugaa 500 kV substation is expected to occupy an area of approximately 22 ha.
Modification of the existing Bannaby 500 kV substation	The existing Bannaby 500 kV substation on Hanworth Road, Bannaby would be expanded to accommodate connections for new 500 kV transmission line circuits. The modification would include changes to the busbars, line bays, bench and associated earthworks, steelwork, drainage, external fence, internal/external substation roads, secondary containment dams, sediment containment dams, cabling, and secondary systems. All of the works would be restricted to the existing substation property.
Modification of the existing Wagga 330 kV substation	The existing Wagga 330 kV substation on Ashfords Road, Gregadoo would be reconfigured to accommodate new bays for two new 500 kV transmission line circuits within the existing substation property. This would include modifications to the busbars, line bays, existing line connections, bench and associated earthworks, relocation of existing high voltage equipment, drainage, external fence, internal substation roads, steelwork, cabling, and secondary systems.
Connection to the future Maragle 500 kV substation	The project would connect to the future Maragle 500 kV substation approved under the Snowy 2.0 Transmission Connection Project (SS1-9717). Construction of the Maragle substation is proposed to be undertaken between 2023 and 2026. Further detail on the Snowy 2.0 Transmission Connection project is available at the Department of Planning and Environment's Major Projects website: www.planningportal.nsw.gov.au/major-projects/project/10591.
Ancillary facilities	
Access tracks	Access to the transmission line structures and the substations would be required during construction and operation. Wherever possible, existing roads, tracks and other existing disturbed areas would be used to minimise vegetation clearing or disturbance. Upgrades to existing access tracks may be required. In areas where there are no existing roads or tracks, suitable access would be constructed. This may include waterway crossings.
Construction compounds	Construction compounds would be required during construction to support staging and equipment laydown, concrete batching, temporary storage of materials, plant and equipment and worker parking required to construct the various elements of the project. Fourteen potential construction compound locations have been identified. The proposed use of the construction compounds and their proposed boundaries/layout would be refined as the project design develops in consultation with relevant stakeholders and the construction contractors.

Component	Description
Worker accommodation facility	Existing accommodation facilities within towns adjacent to the project would provide temporary accommodation for the majority of the construction workers. However, a potential shortage in accommodation has been identified close to the project footprint. A potential option to provide additional temporary worker accommodation during the construction period is the establishment of a temporary worker accommodation facility at the corner of Courabyra Road and Alfred Street, Tumbarumba to accommodate about 200 construction workers. The worker accommodation facility would consist of demountable cabins and would be connected to existing utilities. All required amenities for the accommodation facility would be provided including services and worker parking for light and heavy vehicles. However, the ultimate delivery of the project may include multiple temporary worker accommodation facilities in various forms, which would be outlined in the Worker Accommodation Strategy for the project. The strategy will be developed in consultation with councils, and other relevant stakeholders. Any new or changed worker accommodation facility would be subject to additional environmental assessment, as required.
Helipad/helicopter facilities	To facilitate construction of the project, helicopters may be used to deliver materials/equipment and transfer personnel to construction areas particularly within high alpine regions. To enable helicopters to operate safely and allow easy access to the site, a helicopter landing pad would be required. The helipad is expected to occupy an area of around 30 m by 30 m, and would be remediated after construction. These areas would typically be located on existing disturbed land not subject to inundation and a reasonable distance from waterways, sensitive receivers and drainage lines. Eight locations have been identified and assessed as potential helipad locations. The exact locations to be used would be confirmed during detailed design by the construction contractors. In addition to this, the existing facilities at the Wagga Wagga Airport and Tumut Airport may be used.
Utility connections, adjustments and protection	The project would require utility connections, adjustments and protection. Such works include interfaces with other transmission lines and connections to existing services for temporary facilities. Potential impacts to existing services and utilities would be confirmed during detailed design and any proposed relocation and/or protection works would be determined in consultation with the relevant asset owners.

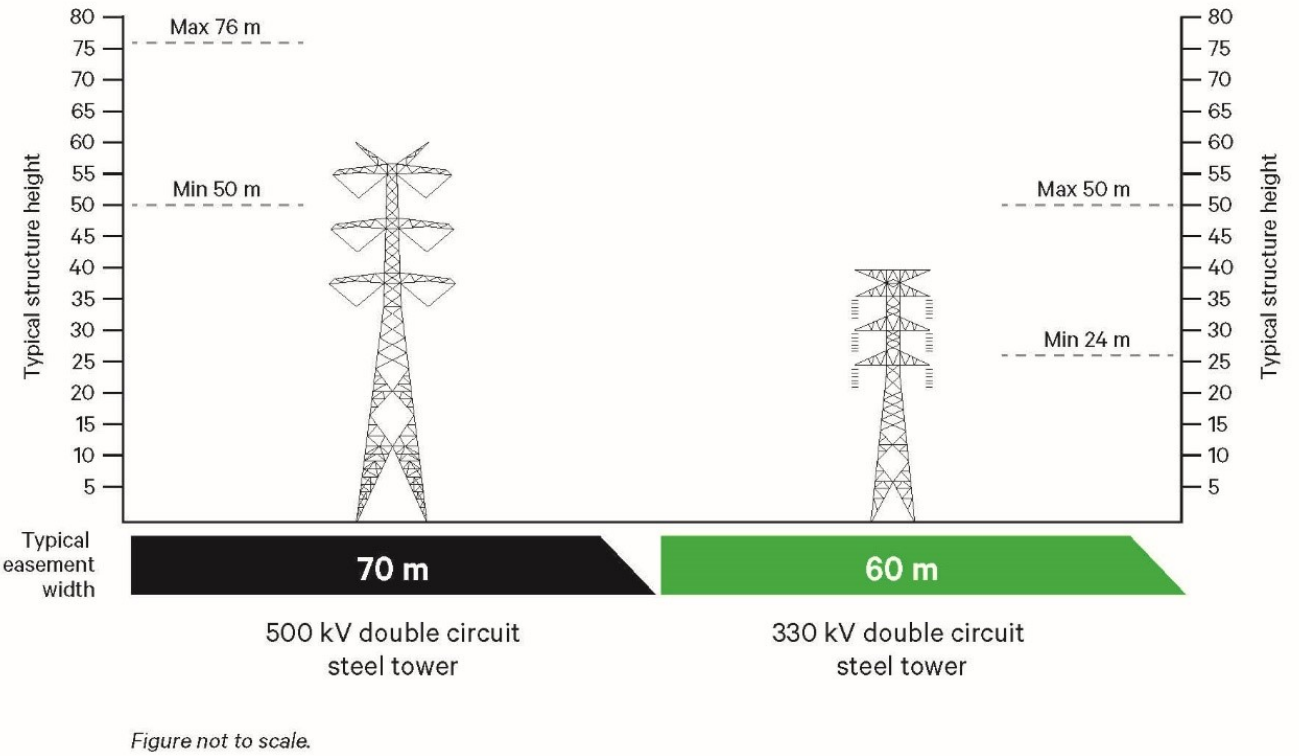


Figure 2-1 Indicative transmission line structures

2.2 Construction of the project

2.2.1 Construction activities

Key construction activities would generally include (but are not limited to):

- site establishment works, such as:
  - clearing of vegetation and topsoil
  - establishment of construction compounds and helipad/helicopter facilities
  - utility relocations and/or adjustments
  - construction of new access tracks and waterway crossings and/or upgrade of existing access tracks to transmission line structures
  - road improvement works
  - establishment of environmental management measures and security fencing
  - construction of temporary workforce accommodation
- construction of the transmission lines, including:
  - earthworks and establishment of construction benches and brake and winch sites for each transmission line structure
  - construction of footings and foundation work for the new transmission line structures including boring and/or excavation, steel fabrication works and concrete pours
  - erection of the new transmission line structures

- stringing of conductors, overhead earth wires and OPGW
- installation of associated transmission line structure fittings inclusive of all earthing below ground level.

- relocation of a section of Line 51, including:
  - demolition of the existing section of Line 51
  - erection of new transmission line structures for the rebuild of Line 51 in a new location
  - stringing of conductors, overhead earth wires and OPGW
  - installation of associated transmission line structure fittings inclusive of all earthing below ground level.
- construction of the proposed Gugaa 500 kV substation, including:
  - bulk earthworks to form the substation bench, access roads, drainage and oil containment structures
  - installation of concrete foundations, bund walls, fire walls, noise walls and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - installation of electrical conduits, electrical trenches, site stormwater drainage, oil containment work and associated concrete pits, pipes and tanks including excavation
  - installation of new ancillary and equipment control buildings
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - erection of the substation site boundary security fencing, including site access gates
  - connection of the proposed transmission lines to the substation.
- modification of the existing Wagga 330 kV substation to enable the proposed connection and operation of the new transmission lines, including:
  - demolition and removal of redundant electrical equipment, fencing and cabling
  - bulk earthworks to form the extended substation bench and modified drainage structures
  - installation of concrete foundations and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of electrical conduits, electrical trenches, and modified site stormwater drainage including excavation
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - installation of fencing, lighting and other security features
  - testing and commissioning
  - connection of the proposed transmission lines to the substation.

- modification of the existing Bannaby 500 kV substation to enable the proposed connection and operation of the new transmission lines, including:
  - bulk earthworks to form the extended substation bench, new access road, modified stormwater drainage, modified oil containment and modified sediment control structures
  - installation of concrete foundations, retaining walls, bund walls, fire walls and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of electrical conduits, electrical trenches, site stormwater drainage, oil containment works and associated concrete pits, pipes and tanks including excavation
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - installation of fencing, lighting and other security features
  - demolish redundant fencing including footings and kerbs
  - testing and commissioning
  - connection of the proposed transmission lines to the substation.
- connection of the proposed transmission lines to the future Maragle 500 kV substation, including:
  - stringing conductors between transmission line structures and the future Maragle 500 kV substation gantry (including overhead earth wire (OHEW) and OPGW)
  - installing droppers from the future substation gantry to the switchgear.
- construction of the telecommunications hut, including:
  - bulk earthworks to form the pad for the hut
  - excavation and preparation for concrete foundations
  - installation of reinforced concrete and piled foundations
  - excavation and installation of electrical equipment conduits, trenches and general site drainage works
  - installation of the building, site wiring and electrical equipment
  - installation of security fencing and site access gates.
- installation of buried cabling from the 500 kV transmission line structures to Rye Park Wind Farm substation
- testing and commissioning of new electrical infrastructure
- demobilisation and rehabilitation of areas disturbed by construction activities.

A number of activities are expected to commence in accordance with the project conditions of approval before the key construction activities outlined above. These activities are considered pre-construction minor work and would comprise low impact activities that would begin after planning approval but prior to approval of the Construction Environmental Management Plan.

2.2.2 Construction program

Construction of the project is targeted to commence in 2024 and is estimated to take about 2.5 years to complete. The project is expected to be fully operational by the end of 2026 (refer to **Figure 2-2**).

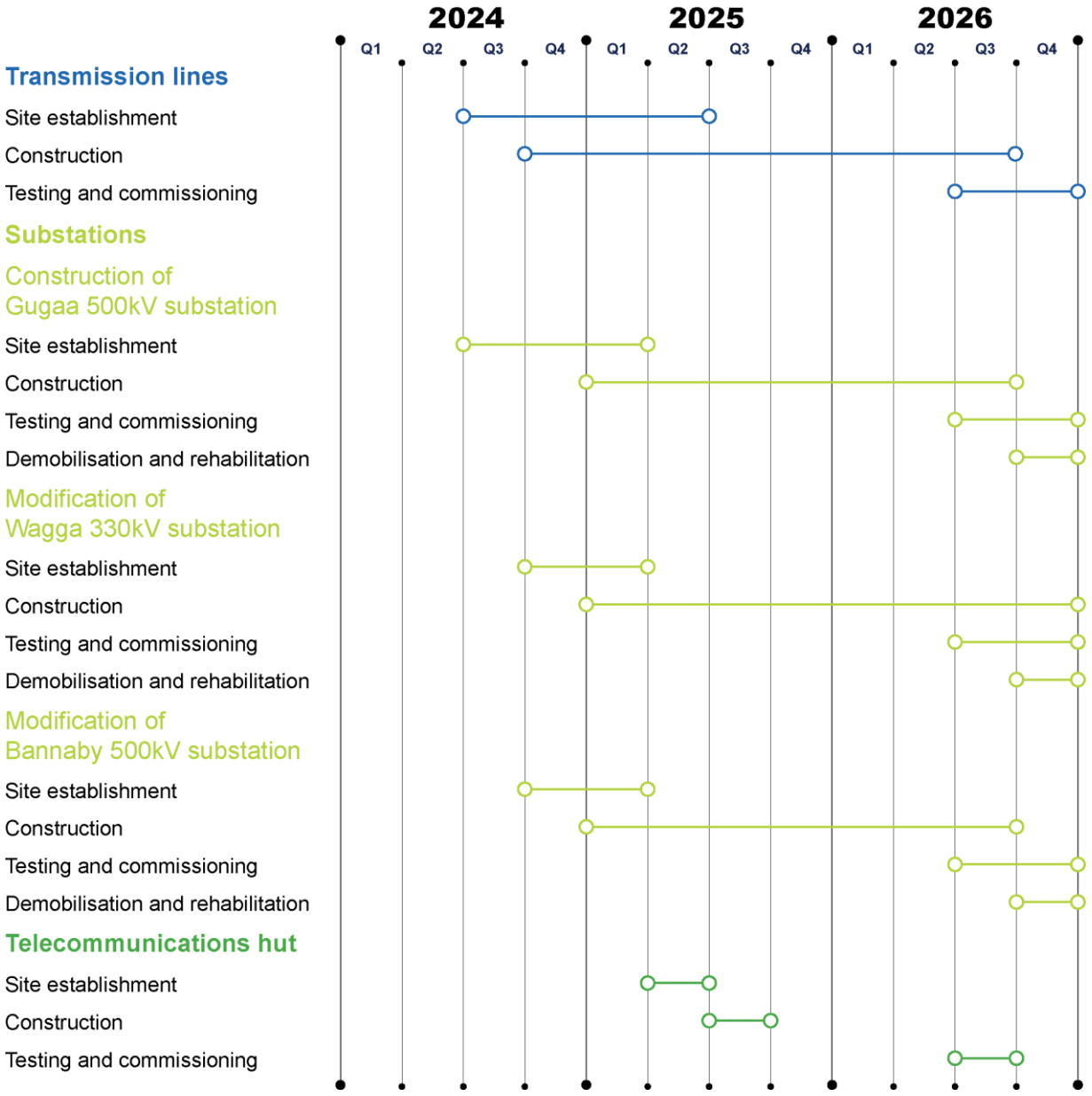


Figure 2-2 HumeLink indicative construction programIndicative duration of construction activities

Construction at each transmission line structure would be intermittent and construction activities would not occur for the full duration at any one location. Durations of any particular construction activity, and inactive/respite periods, may vary for a number of reasons including (but not limited to):

- multiple work fronts
- resource and engineering constraints
- works sequencing and location.

Figure 2-3 presents an indicative duration of construction activities associated with an individual transmission line structure.

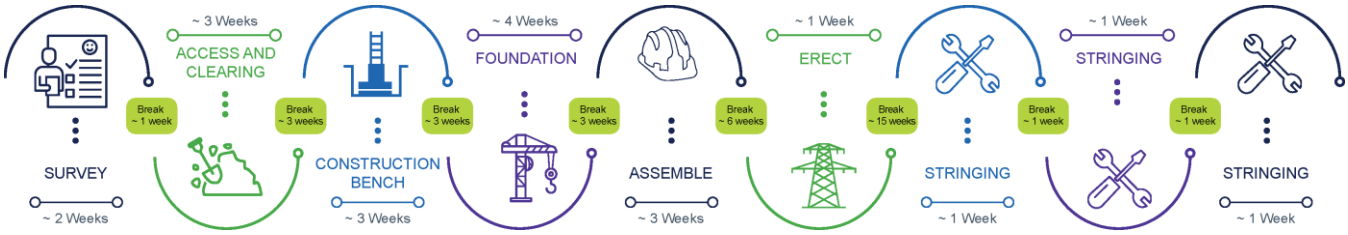


Figure 2-3 Indicative duration and sequence of construction activities for transmission line structures

Construction of the proposed Gugaa 500 kV substation could take up to 2.5 years.

2.2.3 Construction hours

It is expected that construction activities would largely be undertaken during standard construction hours. However, there would be times when working outside of standard construction hours would be required (as defined by the *Interim Construction Noise Guideline* (DECC, 2009)), subject to approval. As the details of construction methodology and project needs are developed, these hours will be refined for certain activities.

Where extended hours are proposed for activities in proximity to sensitive receivers, additional measures would be implemented and the work would be managed through an out-of-hours work protocol.

A series of work outside the standard construction hours is anticipated to include (but is not limited to) the following:

- transmission line construction at crossings of a main road or railway as these locations are expected to have restricted construction hours requiring some night work for activities such as conductor stringing over the crossing(s)
- works where a road occupancy licence (or similar) is required, depending on licence conditions
- transmission line cutover and commissioning
- the delivery of equipment or materials outside standard hours requested by police or other authorities for safety reasons (such as the delivery of transformer units)
- limited substation assembly works (eg oil filling of the transformers)
- connection of the new assets to existing assets under outage conditions (eg modification and/or connection work at Bannaby 500 kV substation, Wagga 330 kV substation and Maragle 500 kV substation), which is likely to require longer working hours
- emergency work to avoid the loss of lives and/or property and/or to prevent environmental harm
- work timed to correlate with system planning outages
- situations where agreement is reached with affected sensitive receivers
- activities that do not generate noise in excess of the applicable noise management level at any sensitive receiver.

2.2.4 Construction plant and equipment

An indicative list of construction plant and equipment likely to be required during construction is provided below.

- air compressor
- backhoe
- bobcat
- bulldozers
- concrete agitator
- concrete pump
- cranes (various sizes up to 400 tonnes)
- crawler crane with grab attachments
- drill and blast units and associated support plant/equipment
- drones
- dumper trucks
- elevated working platforms
- excavators (various sizes)
- flatbed Hiab trucks
- fuel trucks
- generators
- graders
- helicopter and associated support plant/equipment
- mulchers
- piling rig
- pneumatic jackhammers
- rigid tippers
- rollers (10-15 and 12-15 tonne)
- semi-trailers
- tilt tray trucks
- trenchers
- transport trucks
- watercarts
- winches.

2.2.5 Construction traffic

Construction vehicle movements would comprise vehicles transporting equipment, waste, materials and spoil, as well as workers' vehicles. A larger number of heavy vehicles would be required during the main civil construction works associated with the substations. Non-standard or oversized loads would also be required for the substation works (eg for transformer transport) and transportation of transmission line structure materials and conductors.

Hume Highway, Sturt Highway, Snowy Mountains Highway, Batlow Road and Gocup Road are the main national and state roads proposed to provide access to the project footprint. These roads would be supported by regional and local roads throughout the LGAs of Wagga Wagga City, Snowy Valleys, Yass Valley, Cootamundra-Gundagai Regional and Upper Lachlan Shire that connect to the project footprint.

2.2.6 Construction workers

The construction worker numbers would vary depending on the stage of construction and associated activities. During peak construction activities, the project could employ up to 1,200 full time equivalent construction workers across multiple work fronts. It is expected that the maximum number of construction workers at any one location would not exceed 200.

2.2.7 Testing and commissioning

Prior to energisation of the infrastructure, a series of pre-commissioning activities would be conducted. This would include testing the new transmission lines and substation earthing, primary and secondary equipment.

2.2.8 Demobilisation and rehabilitation

Demobilisation and site rehabilitation would be undertaken progressively throughout the project footprint and would include the following typical activities:

- demobilisation of construction compounds and worker accommodation facility

- removal of materials, waste and redundant structures not required during operation of the project
- removal of temporary fencing and environmental controls.

2.3 Operation and maintenance of the project

The design life of the project is 50 years, which can be extended to more than 70 years for some assets.

The substations and transmission lines would be inspected by field staff and contractors on a regular basis, with other operational activities occurring in the event of an emergency (as required). The project would require about five workers (in addition to Transgrid's existing workers) during operation for ongoing maintenance activities. Likely maintenance activities would include:

- regular inspection (ground and aerial) and maintenance of electrical equipment
- general building, asset protection zone and access road/track
- vegetation clearing/trimming within the easement
- fire detection system inspection and maintenance
- stormwater drainage systems maintenance.

It is expected that these activities would only require light vehicles and/or small to medium plant (depending on the work required).

3 Background

3.1 What is the greenhouse effect?

The greenhouse effect is a naturally occurring process that aids in heating the Earth's surface and atmosphere. It results from the fact that certain atmospheric gases, such as carbon dioxide, water vapour and methane, are able to change the energy balance of the planet by absorbing longwave radiation emitted from the Earth's surface. Without the greenhouse effect, life on this planet would probably not exist as the average temperature of Earth would be around -18 degrees Celsius (°C), rather than the present 15°C.

As energy from the sun passes through the atmosphere a number of things take place. A portion of the energy (26 per cent globally) is reflected or scattered back to space by clouds and other atmospheric particles. About 19 per cent of the available energy is absorbed by clouds, gases (like ozone) and particles in the atmosphere. Of the remaining 55 per cent of the solar energy passing through the Earth's atmosphere, about four per cent is reflected from the surface back into space. Thus, on average, about 51 per cent of the sun's radiation reaches the Earth's surface. This energy is then used in a number of processes, including the heating of the ground surface; the melting of ice and snow and the evaporation of water; and plant photosynthesis.

The heating of the ground by sunlight causes the Earth's surface to become a radiator of energy in the longwave band (infrared radiation). This emission of energy is generally directed to space. However, only a small portion of this energy actually makes it back to space. The majority of the outgoing infrared radiation is absorbed by GHGs.

Absorption of longwave radiation by the atmosphere causes additional heat energy to be added to the Earth's atmospheric system. The now warmer atmospheric GHG molecules begin radiating longwave energy in all directions. Over 90 per cent of the emission of longwave energy is directed back to the Earth's surface where it once again is absorbed by the surface. The heating of the ground by the longwave radiation causes the ground surface to once again radiate, repeating the cycle described above, again and again, until no more longwave radiation is available for absorption.

The amount of heat energy added to the atmosphere by the greenhouse effect is controlled by the concentration of GHGs in the Earth's atmosphere.

Emissions of GHGs can result from natural or man-made (anthropogenic) sources. Examples of natural sources include the decomposition or burning of plant material and emissions of methane from animal digestion processes. Emissions also occur as a result of human activities such as the production and burning of fossil fuels, the use and leakage of refrigerants, the clearing of forest and other vegetation, and the use of fertilisers. This separation of natural versus anthropogenic sources is complicated by the fact that natural processes may be manipulated by humans, resulting in increased emissions of GHGs.

On Earth, human activities are changing the natural greenhouse effect. A number of gases are involved in the human-caused enhancement of the greenhouse effect including (NASA, 2019):

- **Carbon dioxide** (CO_2): A minor but very important component of the atmosphere, CO_2 is released through natural processes such as respiration and volcanic eruptions and through human activities such as deforestation, land use changes and burning fossil fuels. Humans have increased the atmospheric CO_2 concentration by more than a third since the Industrial Revolution began. This is the most important long-lived "forcing" of climate change.

- **Methane** (CH_4): A hydrocarbon gas produced both through natural sources and human activities, including the decomposition of waste in landfills, agriculture (especially rice cultivation), as well as ruminant digestion and manure management associated with domestic livestock. On a molecule-for-molecule basis, CH_4 has far more GHG warming potential than CO_2, but it is also much less abundant in the atmosphere.
- **Nitrous oxide** (N_2O): A powerful GHG produced by soil cultivation practices, especially the use of commercial and organic fertilisers, but also (in lesser amounts) from fossil fuel combustion, nitric acid production, and biomass burning.
- **Chlorofluorocarbons**: Synthetic compounds, entirely of industrial origin, used in a number of applications, but now largely regulated in production and release to the atmosphere by international agreement for their ability to contribute to destruction of the ozone layer. They are also GHGs.

Over the last century, the burning of fossil fuels, such as coal and oil, has increased the concentration of atmospheric CO_2. This happens because the coal or oil burning process combines carbon with oxygen in the air to make CO_2. To a lesser extent, the clearing of land for agriculture, industry, and other human activities has also increased concentrations of GHGs. Vegetation and soil typically act as a carbon sink, storing CO_2 that is absorbed through photosynthesis. When the land is disturbed, part of the stored CO_2 is emitted through mechanisms (such as burning or decomposition of vegetation), thereby re-entering the atmosphere. Land disturbance will often also remove the associated carbon sink decreasing the potential for future CO_2 removal.

Quantifying linkages between emissions of GHGs from an individual project to resulting global GHG concentrations and climate warming is not possible due to a host of uncertainties and a lag in the climate system. Action by governments to reduce GHG emissions by sector and national totals will result in mitigation of climate change. Hence, accurate quantification of GHG emissions aids the ongoing assessment of climate impacts and the development of targeted and effective policies and strategies to reduce the impact of global climate warming.

3.2 Greenhouse gas scope definitions

Emissions of GHG can be termed as being Scope 1, Scope 2 or Scope 3, and 'direct' or 'indirect' emissions (refer to **Figure 3-1**).

The definitions below for each scope have been taken from the World Resources Institute (WRI, a US-based environmental non-governmental organisation (NGO)) and World Business Council for Sustainable Development (WBCSD, a Geneva-based coalition of 170 international companies) GHG Protocol (WRI/WBCSD, 2004a). These documents provide detailed information on the activities which should be included in each of the Scope 1, 2 and 3 boundaries. The definition of these boundaries allows the determination of those sources of GHG emissions that can be directly controlled by the project (Scope 1 and Scope 2), or those that the project would have some, but limited control over (Scope 3).

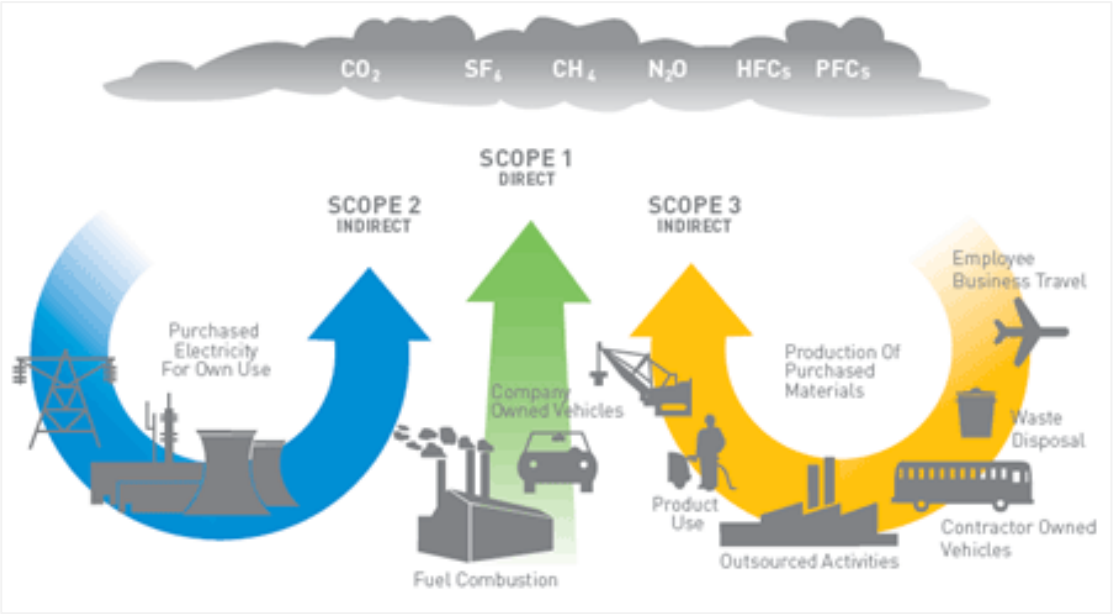


Figure 3-1 Scope 1, 2 and 3 GHG emissions as defined in the GHG Protocol Initiative

Source: Adapted from (WRI/WBCSD, 2004a)

3.2.1 Direct emissions (Scope 1)

Direct emissions of GHG are termed Scope 1 emissions and are those produced from sources within the boundary of the organisation and as a result of the organisation's activities. These direct emissions would arise from the following sources during construction and operation of the project:

- transportation of materials, products, waste or people
- generation of electricity, heat and/or steam
- fugitive emissions, both intentional and unintentional (eg leakage of sulfur hexafluoride (SF_6) from switchgear and land clearing)
- on-site waste management, eg liquid waste management via on-site sewage treatment plant(s).

3.2.2 Indirect emissions (Scope 2 and Scope 3)

Indirect emissions are generated in the wider economy as a consequence of one organisation's activities although they are physically produced by the activities of another organisation.

Scope 2 Emissions

The most important category of indirect emissions for most organisations/projects is from the consumption of purchased electricity (Scope 2 emissions). Scope 2 emissions relate to the GHG emissions from the generation of purchased electricity consumed by an organisation and as a result of the organisation's activities.

3.2.3 Scope 3 emissions

An organisation wishing to undertake a full life-cycle analysis of their product would include all of the following activities within their emissions inventory as Scope 3 emissions:

- extraction and production of purchased materials and fuels
- transport-related activities
  - transportation of purchased materials or goods
  - transportation of purchased fuels
  - employee business travel
  - employees commuting to and from work
  - transportation of sold products
  - transportation of waste
- electricity related activities not included under Scope 2 emissions, including:
  - extraction, production and transportation of fuels consumed in the generation of electricity
  - purchase of electricity that is sold to an end user
  - generation of electricity that is consumed in a transport and distribution system
- leased assets, franchises and outsourced activities.
- use of sold products and services
- waste disposal
  - disposal of waste generated in operations
  - disposal of waste generated in the production of purchased materials and fuels
  - disposal of sold products at the end of their life.

For completeness, and in line with current best practice, this assessment has included consideration of Scope 3 emissions.

3.3 Global warming potentials

For comparative purposes, non-CO_2 GHGs are awarded a "CO_2-equivalence" (CO_2-e) based on their contribution to the greenhouse effect. The CO_2-e of a gas is calculated using an index called the Global Warming Potential (GWP). GWPs are periodically updated by the Intergovernmental Panel on Climate Change (IPCC) in line with improvements to the underlying science. The 100-year GWPs of potential relevance to the project, as taken from the IPCC's Fourth (IPCC, 2007), Fifth (IPCC, 2013) and Sixth (IPCC, 2021) Assessment Reports (AR4, AR5 and AR6 respectively) are presented in **Table 3-1**. The AR5 values (IPCC, 2013) have been used in this assessment, in accordance with Australia's current reporting requirements.

Table 3-1 GHG and 100 year global warming potential

Gas	Chemical Formula	IPCC Global warming potentials (100 year horizon)		
		Fourth Assessment Report [1]	Fifth Assessment Report [2]	Sixth Assessment Report [3]
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	25	28	27.9
Nitrous oxide	N_2O	298	265	273
Sulfur hexafluoride	SF_6	22,800	23,500	25,200

1: (IPCC, 2007); 2: (IPCC, 2013); 3: (IPCC, 2021)

No significant sources of other GHGs (such as hydrofluorocarbons or perfluorocarbons) have been identified as part of the project, therefore they have not been considered further as part of this assessment.

4 Legislative and policy context

4.1 International framework

Several mechanisms are in place to encourage international cooperation in the management and minimisation of GHG emissions, including the IPCC, United Nations Framework Convention on Climate Change (UNFCCC), the Equator Principles, the Kyoto Protocol and the Paris Agreement. The function of each of these is outlined below.

4.1.1 Intergovernmental Panel on Climate Change

The IPCC was established in 1988 and operate to provide decision makers and others interested in climate change with an objective source of information. The IPCC prepares assessment reports based on available scientific evidence and produce guidance documents and recommended methodologies for GHG emission inventories.

4.1.2 United Nations Framework Convention on Climate Change

The UNFCCC was established in 1994 following the release of the first technical report written by the IPCC. It comprises 172 countries (parties) that have ratified the Kyoto Protocol. The UNFCCC sets the overall framework for efforts to manage climate change on an international scale.

4.1.3 The Equator Principles

The Equator Principles is a risk management framework adopted by financial institutions for determining, assessing and managing environmental and social risk in project finance. It is primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making.

Formally launched in Washington DC in June 2003, The Equator Principles were based on existing environmental and social policy frameworks established by the International Finance Corporation (IFC). Since then, the standards have been periodically updated into what is commonly known as the IFC Performance Standards on social and environmental sustainability and the World Bank Group Environmental, Health, and Safety Guidelines. The reviewed fourth iteration of the Equator Principles were published in July 2020 (Equator Principles Association, 2020).

4.1.4 The Kyoto Protocol

The Kyoto Protocol was in force as of 16 February 2005 and commits member states to individual, legally binding targets to limit or reduce GHG emissions. Australia, amongst others, forms part of the Annex I Parties, and was required to meet national targets for GHG emissions between 2008 and 2012. To achieve their targets, Annex I Parties had to implement domestic policies and measures.

A second commitment period was agreed in 2012 for 2013 to 2020, where Australia, as well as 36 other countries, were bound to further reduce GHG emissions by at least 18 per cent below 1990 levels by 2020.

4.1.5 The Paris Agreement

The Paris Agreement was established in 2015 and sets in place a durable and dynamic framework for all countries to take action on climate change from 2020. The key objectives of the Paris Agreement include:

- a goal to limit the increase in global temperatures to well below 2 degrees and pursue efforts to limit the rise to 1.5 degrees
- a commitment to achieve net-zero emissions, globally, by the second half of the century
- differentiated expectations for developed nations, including Australia, that they will reduce their emissions sooner than developing nations
- a five-year review and ratchet process designed to lead to more ambitious commitments from countries in the future.

Australia ratified the Paris Agreement in November 2016 and is committed to reducing GHG emissions by 26 – 28 per cent below 2005 levels by the year 2030. The 2030 target is equivalent to a 50 – 52 per cent reduction in per capita emissions and a 64 – 65 per cent reduction in the emissions intensity of the economy. On 16 June 2022, the Australian Government lodged an updated Nationally Determined Contribution (NDC) with the UNFCCC as part of Australia's obligations under the Paris Agreement, which commits Australia to a more ambitious target of reducing GHG emissions by 43 per cent below 2005 levels by 2030. This is a 15 percentage point increase on the previous 2030 target. It also reaffirmed Australia's commitment to net zero emissions by 2050.

4.1.6 26th UN Climate Change Conference

The United Kingdom hosted the 26th UN Climate Change Conference of the Parties (referred to as COP26) in Glasgow in October-November 2021. This was the first meeting after the initial five-year period, which meant that countries needed to submit or update their plans for reducing emissions.

Nations adopted the Glasgow Climate Pact, aiming to turn the 2020s into a decade of climate action and support. The Glasgow Pact refers to a package of decisions agreed to at COP26 covering a range of items, including strengthened efforts to build resilience to climate change, to curb greenhouse gas emissions and to provide the necessary finance for both. Nations reaffirmed their duty to fulfill the pledge of providing 100 billion dollars annually from developed to developing countries. They collectively agreed to work to reduce the gap between existing emission reduction plans and what is required to reduce emissions, so that the rise in the global average temperature can be limited to 1.5 degrees. For the first time, nations are called upon to phase down unabated coal power and inefficient subsidies for fossil fuels.

4.2 Australia

In Australia, there are several regulatory frameworks for the management and reduction of GHG emissions. This includes the Direct Action Plan, the Emissions Reductions Fund (ERF) and the Safeguard Mechanism.

As part of the recent commitment to a more ambitious emissions reduction target of 43 per cent below 2005 levels by 2030, the Australian government has announced that it will implement new policies across the economy that will be designed to:

- build on existing emissions reduction programs
- give Australian industry a comprehensive and consistent policy framework
- encourage Australian households, businesses and communities to embrace the opportunities presented by the transition to net zero.

The Direct Action Plan is a climate change policy released in 2010 to reduce Australia's greenhouse gas emissions. The stated aim of the original 2010 Direct Action Plan was to reduce Australia's emissions by five per cent by 2020 compared to the 1990 levels. The Direct Action Plan has a number of components. The ERF is the centrepiece of the Direct Action Plan, which states that the ERF will *'directly support CO_2 emissions reduction activities by business and industry'*. The Direct Action Plan also contains a number of other components and commitments, including 'One Million Solar Roofs', 'Solar Towns and Solar Schools', 'Twenty Million Trees', 'Clean Energy Employments Hubs', 'Geothermal and Tidal Towns', 'Renewable Fuels' and 'Greenhouse Friendly Program'.

The ERF is a scheme that aims to provide incentives for a range of organisations and individuals to adopt new practices and technologies to reduce their emissions, and to provide a legal obligation for Australia's top emitters to maintain their emissions below their emissions limit (or baseline) (defined by the Safeguard Mechanism established under the NGER Act). The ERF is enacted through the *Carbon Credits (Carbon Farming Initiative) Act 2011* and allows for the generation of Australian carbon credit units (ACCUs). ACCUs can be sold to the ERF or sold on the secondary market and purchased by emitters who exceed their baseline to offset their emissions.

The Safeguard Mechanism applies to facilities with direct Scope 1 emissions of more than 100,000 tonnes of CO_2-e per year. This framework establishes a baseline against which their emissions reported under the NGER Act are compared. If a facility exceeds its baseline, they have the option to:

- establish a new baseline if the additional emissions related to a change in production variables
- surrender ACCUs to offset emissions
- apply for a multi-year monitoring period to allow additional time to reduce net emissions
- apply for an exemption where emissions are due to exceptional circumstances.

Whilst not a regulatory body, the Climate Change Authority (CCA) provides independent, expert advice on climate change policy. The CCA assists in the development of mitigation policies, undertakes reviews and makes recommendations on the Carbon Farming Initiative (now part of the ERF) and the NGER Act reporting scheme.

4.3 New South Wales

The NSW and Australian Federal Government have a memorandum of understanding that sets out how the governments will work together to increase gas and electricity supply, at the same time as reducing emissions. NSW has also developed a Net Zero Plan and Electricity Strategy within the *Climate Change Policy Framework for NSW* (OEH, 2016). The Climate Change Policy Framework sets out the following seven policy directions:

- create a certain investment environment by working with the Commonwealth to manage transition
- boost energy productivity, put downward pressure on household and business energy bills
- capture co-benefits and manage unintended impacts of external policies
- take advantage of opportunities to grow new industries in NSW

- reduce risks and damage to public and private assets in NSW arising from climate change
- reduce climate change impacts on health and wellbeing
- manage impacts on natural resources, ecosystems and communities.

Net Zero Plan Stage 1: 2020–2030 (State of NSW, 2020) is the foundation for NSW's action on climate change. It outlines the NSW Government's plan to deliver a 50 per cent cut in emissions by 2030 compared with 2005 levels, laying the foundation for progressing towards net zero emissions by 2050. The plan supports various initiatives targeting:

- electricity and energy efficiency
- electric vehicles
- use of hydrogen as a transport fuel and as a replacement for fossil fuels in industry
- opportunities to reduce emissions and sequester carbon from primary industries and land management
- reduced fugitive emissions from coal mining
- reduced organic waste to landfills
- carbon financing.

4.3.1 The Science Based Targets initiative

The Science Based Targets initiative (SBTi) began as a collaboration between CDP (formerly the Carbon Disclosure Project), the United Nations Global Compact, World Resources Institute and the World Wide Fund for Nature. In September 2022, the SBTi's Executive Board voted to incorporate as a formal institution, linked to but separate from its founding partners.

The SBTi's science-based target framework is designed provide a clearly defined pathway for companies to reduce GHG emissions and future-proof business growth. Targets are considered 'science-based' if they are in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement; limiting global warming to well-below 2°C above pre-industrial levels and pursuing efforts to limit warming to 1.5°C. For companies, setting a science-based target is a five-step process:

- **commit**: submit a letter establishing your intent to set a science-based target
- **develop**: work on an emissions reduction target in line with the SBTi's criteria
- **submit**: present your target to the SBTi for official validation
- **communicate**: announce your target and inform your stakeholders
- **disclose**: report company-wide emissions and track target progress annually.

4.4 Transgrid GHG reduction targets

Transgrid has developed both near-term and long-term SBTi-aligned Scope 1, 2 and 3 GHG reduction targets for its operations, as shown in **Table 4-1.** Enabling commitments identified by Transgrid in relation to the Scope 3 targets relevant to the project are outlined in **Table 4-2**.

Table 4-1 Transgrid SBTi-aligned GHG reduction targets

Scope	Near Term Target	Long-Term Target
Scope 1 and Scope 2	Reduce Scope 1* and Scope 2 emissions by 60% by 2030 compared with a base year of 2021	Net zero Scope 1* and Scope 2 emissions by 2050
Scope 3	Reduce Scope 3 emissions from (a) purchased goods and services and (b) capital goods by 48% per one million dollar spend on these two categories by 2030 compared with a base year of 2021	Net zero Scope 3 emissions by 2050

* Note: In accordance with NGER reporting requirements, Scope 1 emissions excludes land clearing

Table 4-2 Enabling commitments relating to Transgrid's Scope 3 GHG reduction targets

Scope 3 emission source	Reduction levers	Commitments
Purchased goods and services - Major projects delivery and other construction	• support market development of lower emission materials – steel, aluminium, zinc, concrete, porcelain insulators • electrify contractor fleet – heavy machinery, transport fleet • local accommodation and local procurement.	• 50% of suppliers by spend for purchased goods and services and capital goods will have science-based targets by 2025 • support market development of lower emission materials – be a foundation customer for locally produced green steel and waterless concrete • set stretch-targets for procuring lower emission services/goods • improve design project specifications – use of low carbon products and services • offer employees flexible work arrangements, provide employees support to purchase electric vehicles.
Other	• product and service decarbonisation • flexible work arrangements • reduce business travel • reduction in waste generation and water use.	

Monitoring and reporting of GHG related activity data to enable tracking of GHG emissions is an ongoing internal process within Transgrid to enable all reporting obligations to be met, and which would encompass both the construction and operation of the project as part of Transgrid's operations across NSW.

4.5 Greenhouse gas emissions estimation guidelines

A GHG emission inventory was compiled for the project based on emission factors and reporting guidelines available in the documents and references described in the following sections.

4.5.1 The Greenhouse Gas Protocol

The GHG Protocol Initiative is a multi-stakeholder partnership of businesses, non-governmental organisations (NGOs), governments and others convened by the WRI and the WBCSD. The objective of the GHG Protocol Initiative is to develop internationally accepted GHG accounting and reporting standards for business.

The GHG Protocol comprises two separate but linked standards:

- **GHG Protocol Corporate Accounting and Reporting Standard** (WRI/WBCSD, 2004a) - This document provides a step-by-step guide for companies to use in quantifying and reporting their GHG emissions.
- **GHG Protocol for Project Accounting** (WRI/WBCSD, 2004b) - A guide for quantifying reductions from GHG mitigation projects.

The first edition of the GHG Protocol *Corporate Accounting and Reporting Standard* was published in September 2001. It covers accounting and reporting of the six greenhouse gases covered by the Kyoto Protocol and has been widely adopted by industry, NGO and government organisations as a basis for GHG accounting and reporting systems.

The latest edition of the *GHG Protocol Corporate Accounting and Reporting Standard* (WRI/WBCSD, 2004a), has been referred to in preparing this assessment.

4.5.2 ISO 14064

ISO 14064 is the group of International Organization for Standardization (ISO) Standards specifying the quantification, reporting, monitoring validation and verification of GHGs.

ISO 14064-1:2018 *Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals* (Part 1) outlines the principles and requirements at organisational level for the quantification and reporting of GHG emissions and its removal and provides guidance on the elements needed to implement an auditable GHG inventory. It offers a framework for designing, developing, managing and reporting organisational or company-level GHG inventories. It includes requirements for determining organizational boundaries, GHG emission boundaries, quantifying an organization's GHG emissions and removals, and identifying specific company actions or activities aimed at improving GHG management. It also includes requirements and guidance on inventory quality management, reporting, internal auditing and the organization's responsibilities in verification activities.

ISO 14064-2:2019 *Greenhouse gases — Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements* (Part 2) provides guidance for quantifying, monitoring and reporting of activities intended to cause emission reductions and removal enhancements from GHG projects. It includes requirements for planning a GHG project, identifying and selecting GHG sources, sinks and reservoirs relevant to the project and baseline scenario, monitoring, quantifying, documenting and reporting GHG project performance and managing data quality.

ISO 14064-3:2019 *Greenhouse gases — Part 3: Specification with guidance for the verification and validation of greenhouse gas statements* (Part 3) defines the principles and requirements for conducting GHG information validation and verification, and provides guidance for those who are conducting or managing this procedure. This can be applied to organisational or project quantification, monitoring and reporting. It specifies the general requirements for selecting GHG audit team members, establishing the level of assurance, objectives, criteria and scope, determining the auditing approach, assessing GHG data, information, information systems and controls, evaluating GHG assertions, and preparing audit statements.

4.5.3 *National Greenhouse and Energy Reporting Act 2007*

The *National Greenhouse and Energy Reporting Act 2007* (Commonwealth) (NGER Act) established a single national framework for reporting and disseminating company information about GHG emissions, energy production, and energy consumption. A rule made under this Act and enacted in 2015 was to establish the Safeguard Mechanism, which operates in tandem with the ERF. Under the *National Greenhouse and Energy Reporting Scheme* (NGERS), emitters (as defined under the Safeguard Mechanism, discussed below) must report annually all Scope 1 and Scope 2 emissions, and results are presented on the Clean Energy Regulator website.

4.5.4 National Greenhouse Accounts Factors

The National Greenhouse Accounts (NGA) Factors are published annually by the Commonwealth Department of Industry, Science and Resources (DISR) and provide methods to help companies and individuals estimate GHG emissions. The NGA Factors draw on the *National Greenhouse and Energy Reporting (Measurement) Determination* 2008. However, they are not published for the purposes of reporting under the NGER Act; instead they have a more general application to the estimation of a broader range of GHG emissions inventories.

The default emission factors listed in the NGA Factors are estimated by DISR using the Australian Greenhouse Emissions Information System and are determined simultaneously with the production of Australia's National Greenhouse Accounts. This promotes consistency between inventories at company or facility level and the emission estimates presented in the National Greenhouse Accounts.

The 2021 NGA Factors (DISER, 2021) have been referred to in this assessment.

4.5.5 Estimating emissions and energy in the electricity generation, transmission, and distribution sectors guideline

The *Estimating emissions and energy in the electricity generation, transmission, and distribution sectors guideline* (CER, 2021) is intended to promote improved and consistent reporting across electricity sector companies in Australia by providing guidance on how to:

- estimate and report emissions from key electricity sector emissions, particularly from fuel combustion
- report accurately on energy production and consumption.

The guideline identifies sources of Scope 1 emissions common to facilities in the electricity sector as being fuel combustion and emissions of SF_6. In relation to Scope 2 emissions, it identifies transmission or distribution network losses, which are line losses through resistive heating within an electricity transmission or distribution facility, as usually being the most significant emissions from electricity transmission and distribution networks.

5 Methodology

5.1 Overview of approach

This assessment was performed as a desktop study. The calculation of GHG emissions from the construction and operation of the project has been performed in a five stage process:

1. definition of the project boundary (ie the project footprint)
2. identification of GHG emission sources within the project footprint during construction and operation
3. identification of emission calculation methods and emission factors for each source
4. identification of the activity data for each emission source required for the calculations
5. calculation of estimated GHG emissions.

The GHG emissions estimated for the project were compared against the most recent publicly available State and national GHG emissions to assess their potential contribution to Australia's emissions inventory and thus their potential impact on Australia's ability to meet GHG reduction targets and policies. This also included consideration of the project's role in facilitating the distribution of power generated by new renewable energy projects into the State and national electricity grid.

Recommendations were then provided for the mitigation and monitoring of key GHG emission sources associated with the project.

The key tasks involved in performing the GHG assessment were as follows:

- perform a desktop review to:
  - identify the key project-related Scope 1, 2 and 3 GHG sources associated with the proposed project construction and operational activities
  - collate relevant published emission factors and the associated activity data required to estimate emissions from key sources
  - source data on the most recent (2019) GHG emissions inventories for Australia and NSW
  - calculate the estimated GHG emissions generated from these sources over the life of the project to compile an annual GHG emissions inventory in terms of tonnes of CO_2-e for the project
- based on the above information, assess the project's contribution to current NSW and national GHG emissions, as well as reviewing its potential impact on the expansion of renewable energy projects in the State
- for key emission sources, identify potential mitigation measures that may be implemented during construction and operation of the project to mitigate and manage GHG emissions.

5.2 General assessment approach

5.2.1 Study area

This section defines the boundaries adopted for the GHG emission inventory compiled for the project as part of this GHG assessment.

The assessment has considered Scope 1, Scope 2 and Scope 3 emissions associated with the construction and operation of the project.

The geographical boundary set for the emissions considered in the GHG assessment covers the project footprint, comprising the proposed transmission line corridor, construction compounds, worker accommodation locations, the telecommunications hut and substations. Scope 1 and Scope 2 GHG emissions associated with the construction and operation of the project are considered to be within the geographical boundary of this assessment. GHG emissions associated with activities at the Transgrid offices outside the project footprint during the design, construction and operation of the project were deemed to be outside the geographical boundary of the assessment.

GHG emissions would also occur during decommissioning of project infrastructure at the end of its design life. Future options for the project infrastructure would vary between life extension, upgrading or decommissioning. Due to the uncertainty regarding the fate of the plant at that time, the GHG emissions associated with the end of life phase of the project and associated infrastructure have not been estimated as part of this study. These emissions would need to be evaluated in detail in the future, once the potential options are understood, and should be factored into the decisions regarding the ongoing operation or decommissioning of the facilities.

5.2.2 Key assumptions

A number of assumptions have been relied upon in compiling the GHG emission inventory for the project. GHG emissions from the key sources identified for the construction and operation of the project have been estimated based on the most current available emission factors published for use in reporting GHG emissions, which rely on estimates of the level of intensity of each activity (referred to as activity data). This includes parameters such as projected fuel consumption rates and potential transmission losses once the project is operational. The activity data used in the calculations has been compiled based on the current available project design information and in consultation with the design team. The basis of the emission estimates and activity data are detailed in the relevant subsections in **Section 5.3.3.**

5.3 Key tasks

This section presents a summary of the GHG emission sources associated with the construction and operation of the project that were identified for inclusion in the GHG inventory, and the emission factors and emission calculation methods used to estimate the GHG emissions.

5.3.1 Identification of emission sources

Construction and operation emission sources were identified through a review of the project description. The potential emissions associated with the construction and operation of the project that were considered in preparing this GHG assessment were:

Scope 1:

- land clearing during construction
- fossil fuel combustion in mobile and fixed plant during construction and operation
- consumption of oils and greases during construction
- on-site treatment and disposal of solid and liquid waste during construction
- emissions associated with the leakage of SF_6 during operations.

Scope 2:

- electricity consumption during construction (substation work, construction compounds and the workers accommodation facility)
- transmission losses during operation.

Scope 3:

- emissions associated with the production and supply of fuels consumed during construction and operation
- emissions associated with fuel consumption by contractors during construction and operation
- emissions associated with embodied energy in construction materials and the transport of these materials to the project footprint
- off-site treatment and disposal of solid and liquid waste generated during construction and operation
- emissions associated with travel/commuting by the workforce during construction and operation.

Of the above, GHG emissions associated with the following activities/sources were deemed to not be material to the assessment and were excluded from the emission estimation process:

- Refrigerant leakage from cooling systems during construction and operation has been assumed to be negligible and excluded from the inventory.
- Electricity consumption at the Bannaby 500 kV substation and Wagga 330 kV substation during operation has been excluded as this would not be significantly increased from existing operations and are therefore not material to the assessment. Electricity consumption at the proposed Gugaa 500 kV substation during operation would be additional to the existing network but it is also anticipated to be negligible and not material to the assessment.
- Use of oils and greases during operations would be minimal, hence any associated GHG emissions are not material to the assessment.
- The workers accommodation facility at Tumbarumba would be connected to sewer with no on-site wastewater treatment plant, hence there would be no Scope 1 emissions from the treatment of liquid waste during construction. Scope 3 emissions have been assumed to be negligible.
- Wastewater treatment facilities may be used to treat wastewater from amenities at the Bannaby 500 kV substation compound (C12) and Gregadoo Road compound (C06) in lieu of trucking offsite for processing. If required, the wastewater treatment facilities at the Bannaby 500 kV substation compound (C12) and Gregadoo Road compound (C06) would be designed for peak staff numbers of 110 persons and 190 persons respectively. GHG emissions associated with these very small-scale treatment plants would not be material to the estimated Scope 1 emissions from the construction of the project and have not been considered further.
- Emissions from the treatment and disposal of solid and liquid waste during operation was assumed negligible and excluded from the inventory.

With respect to land clearing, the project would result in direct (Scope 1) emissions associated with the loss of carbon stock in areas that will be cleared along the transmission line. As land use change is not included as part of Scope 1 reporting under the NGER Scheme, and given that there were no SEARs for the project relating to GHG emissions, land clearing emissions have not been included in the emission inventory presented in this assessment. A robust estimate of these emissions would require detailed information on the areas to be cleared including details on the types and condition of vegetation within those areas. Such information was not available at the time of preparing this report and any estimates based on the high level information that is available would have a very high level of uncertainty. Commitments regarding the minimisation of land clearing performed as part of the project are considered by the biodiversity assessment included in *Technical Report 1 – Biodiversity Development Assessment Report*.

The emission sources that were included in the emission calculations are summarised in **Table 5-1**.

Table 5-1 GHG emission sources included in the inventory for the project

Project activity	Scope 1	Scope 2	Scope 3
CONSTRUCTION			
Land clearing	• Emissions from diesel combustion in mobile plant used for land clearing.	-	Emissions associated with extraction and production of diesel consumed
Construction of project infrastructure	• Emissions from diesel combustion in construction equipment, including cranes, dozers, excavators, haul trucks, portable power generators (gensets) etc.	-	• Emissions associated with extraction and production of fuels consumed. • Emissions associated with the extraction and production of purchased materials.
Vehicle movements transporting staff and equipment	• Emissions from diesel combustion in light vehicles, trucks, etc within the study area.	-	• Emissions associated with extraction and production of fuels consumed. • Emissions from diesel/gasoline combustion in private vehicles during employee travel to and from worksites.
Use of oils and greases	• Consumption of oils and greases not combusted.	-	-
Electricity consumption	-	• Electricity use from the grid.	-
Management of solid waste	-	-	• Emissions from organic material decomposition in landfill.
OPERATION			
Vehicle movements transporting staff and equipment	• Emissions from diesel, petrol and avgas combustion in light and heavy vehicles for maintenance activities etc.	-	• Emissions associated with extraction and production of fuels consumed.
Use of SF_6 in switchgear	• Leakage of SF_6.	-	-
Electricity consumption	-	• Transmission losses.	-

5.3.2 Calculation methods and emission factors used

Summaries of the calculation methods used to estimate GHG emissions from the identified emission sources are provided below. As noted in the following subsections, each emission factor requires information on anticipated activity levels, such as the projected quantities of electricity or fuels to be consumed, which is summarised in **Section 5.3.3**.

5.3.2.1 Scope 1 Emissions

Fuel combustion

Estimates of emissions from the combustion of fossil fuels were made by multiplying the estimated quantities of fuel to be combusted by a fuel-specific energy content factor and fuel-specific CO_2-e Scope 1 emission factors. The emission factors used in the calculations are summarised in **Table 5-2**.

Table 5-2 Emission factors used in the GHG emission calculations – Scope 1

Emission source	Energy content factor (GJ/kL)	Scope 1 emission factors				
		CO_2	CH_4	N_2O	Total	Units
Fuel Use – Stationary and off-road [1]						
Diesel	38.6	69.9	0.1	0.2	70.2	kg CO_2-e/GJ
Gasoline	34.2	67.4	0.2	0.2	67.8	kg CO_2-e/GJ
Kerosene (Aviation turbine fuel)	36.8	69.6	0.02	0.2	69.8	kg CO_2-e/GJ
Fuel Use - Transport (on-road vehicles, rail, marine, air) [2]						
Diesel	38.6	69.9	0.01	0.4	70.31	kg CO_2-e/GJ
Gasoline	34.2	67.4	0.6	1.6	69.6	kg CO_2-e/GJ
Kerosene	36.8	69.6	0.01	0.6	70.21	kg CO_2-e/GJ
Oils and greases [1]						
Petroleum based oils	38.8	13.9	0	0	13.9	kg CO_2-e/GJ
Petroleum based greases	38.8	3.5	0	0	3.5	kg CO_2-e/GJ
SF_6 leakage [3]						
From gas-insulated switchgear and circuit breaker applications	-	-	-	-	0.0089	kg SF_6/kg SF_6
Solid waste [4]						
Municipal Solid Waste	-	-	-	-	1.6	tCO_2-e/t of waste
Construction and demolition	-	-	-	-	0.2	tCO_2-e/t of waste

Note:

[1] SOURCE: Table 3, NGA Factors 2021

[2] SOURCE: Table 4, NGA Factors 2021

[3] SOURCE: Table 30, NGA Factors 2021

[4] SOURCE: Table 49, NGA Factors 2021

Oils and greases (consumed and not combusted)

Estimates of emissions from the use of petroleum-based oils and greases were made by multiplying the quantities estimated to be used by the relevant energy content factor and CO_2-e Scope 1 emission factor. The emission factors used in the calculations are summarised in **Table 5-2**.

SF_6 leakage

The emissions from gas insulated electrical components were determined by multiplying the stock of SF_6 by the default leakage rate shown in **Table 5-2** and the GWP for SF_6 shown in **Table 3-1**. Emissions relating to the use of this gas are estimated using an established leakage rate for gas-insulated electrical compounds, which assumes that the original quantity of gas would be replenished throughout operation.

5.3.2.2 Scope 2 emissions

Electricity consumption

Estimates of Scope 2 emissions associated with the consumption of purchased electricity during construction of the proposed Gugaa 500 kV substation, modification of the Bannaby 500 kV and Wagga 330 kV substations, and by the worker accommodation facility were obtained by multiplying the electricity consumed in kilowatt-hour (kWh)/month estimated by Transgrid by the Scope 2 emission factor for electricity consumption in NSW shown in **Table 5-3**.

Transmission losses

Annual transmission losses from the infrastructure during operation of the project were estimated by Transgrid. The Scope 2 emissions associated with these transmission losses were estimated by multiplying the losses in kilowatt-hours per year (kWh/year) estimated by Transgrid by the NSW Scope 2 emission factor as shown in **Table 5-3**.

Table 5-3 Emission factors used in the GHG emission calculations – Scope 2

Emission source	Scope 2 emission Factors	Units
Consumption from grid - NSW	0.79	$kgCO_2$-e/kWh used
Transmission losses - NSW	0.79	$kgCO_2$-e/kWh lost

SOURCE: Table 5 NGA Factors, 2021

5.3.2.3 Scope 3 emissions

Construction materials - Embodied energy

The construction of infrastructure associated with the project would involve the use of large volumes of steel, concrete, copper and aluminium, the production and transport of which would result in the emission of GHGs. To account for these Scope 3 emissions, the baseline (2021) embodied energy emission factors adopted by Transgrid in developing its SBTi-aligned GHG reduction targets, as shown in **Table 5-4**, were adopted. These factors were identified by Transgrid based on a detailed literature review. As Transgrid has set targets to reduce the embodied energy in purchased goods and services from 2022 onwards, use of the 2021 baseline emission factors will provide a conservative estimate of these Scope 3 emissions.

Fuel consumption – Production and supply of fuels used

Also shown in **Table 5-4** are the Scope 3 emission factors used to estimate the CO_2-e emissions associated with the production and supply of fuels, oils and greases used by the project.

Table 5-4 Emission factors used in the GHG emission calculations – Scope 3

Fuel, oil and grease			
Fuel type	**Energy content factor (GJ/kL) [1]**	**Scope 3 emission factor [2]**	**Unit**
Diesel	38.6	3.6	kg CO_2-e/GJ
Gasoline	34.2	3.6	kg CO_2-e/GJ
Kerosene (aviation turbine fuel)	36.8	3.6	kg CO_2-e/GJ
Petroleum based oils	38.8	3.6	kg CO_2-e/GJ
Petroleum based greases	38.8	3.6	kg CO_2-e/GJ
Embodied energy of construction materials [3]			
Material		**Embodied carbon**	**Unit**
Steel		1.61	g CO_2-e/t
Concrete		0.95	g CO_2-e/t
Copper		4.04	g CO_2-e/t
Aluminium		10.00	g CO_2-e/t

Note:

[1] SOURCE: Table 3, NGA Factors 2021

[2] SOURCE: Table 45, NGA Factors 2021

[3] SOURCE: Transgrid SBTi GHG reduction targets – Baseline (2021) emission factors

5.3.3 Activity data used in calculations

5.3.3.1 Construction activities

The activity data and assumptions used to estimate GHG emissions during construction are summarised in **Table 5-5** and described in the following sections.

Table 5-5 Summary of assumptions used to estimate GHG emissions during construction of the project

Emission source	Activity data	Total value	Notes
Consumption of diesel	Transmission line land clearing and construction, including transport of construction materials	3,315 kL	9,208 L/km of line route 360 km of transmission line
	Bannaby 500 kV substation work	4,182 kL	5,500 L/day for 25 months
	Gugaa 500 kV substation construction	8,240 kL	9,341 L/day for 29 months
	Wagga 330 kV substation work	3,446 kL	4,196 L/day for 27 months
	Transmission line construction compounds	205 kL	5,694 L/month/site Assume 1.5 sites active for 24 months
	Light vehicle use for survey work, supervision, engineering and management support	545 kL	18,173 L/ month 30 month construction period

Emission source	Activity data	Total value	Notes
	Staff commuting	23 kL	Based on an estimated average 900 staff commuting once per week with a nominal 150 km round trip. 20% vehicles being diesel fuelled and a fuel efficiency of 10 L/100 km
Consumption of unleaded petrol	Bannaby 500 kV substation work	279 kL	367 L/day for 25 months
	Gugaa 500 kV substation construction	542 kL	615 L/day for 29 months
	Wagga 330 kV substation work	249 kL	303 L/day for 27 months
	Staff commuting	99 kL	Based on an estimated average 900 staff commuting once per week with a nominal 150 km round trip. 80% vehicles being petrol fuelled and a fuel efficiency of 11 L/100 km
Consumption of oil	Transmission line land clearing and construction	8.3 kL	23 L/km of line route 360 km of transmission line
	Transmission line construction compounds	0.51 kL	14.24 L/month/site Assume 1.5 sites active for 24 months
	Bannaby 500 kV substation work	11.4 kL	15 L/day for 25 months
	Gugaa 500 kV substation construction	22.1 kL	25 L/day for 29 months
	Wagga 330 kV substation work	9.0 kL	11 L/day for 27 months
Consumption of greases	Transmission line land clearing and construction, including transport of construction materials	6,120 kg	17 kg/km of line route 360 km of transmission line
	Bannaby 500 kV substation work	3,802 kg	5 kg /day for 25 months
	Gugaa 500 kV substation construction	7,939 kg	9 kg/day for 29 months
	Wagga 330 kV substation work	3,285 kg	4 kg/day for 27 months
Electricity consumption	Bannaby 500 kV substation work	563 MWh	720 kWh per day for 25 months
	Gugaa 500 kV substation construction	653 MWh	720 kWh per day for 29 months
	Wagga 330 kV substation work	608 MWh	720 kWh per day for 27 months
	Tumbarumba worker accommodation facility	2,400 MWh	3,200kWh per day for 24 months
	Transmission line construction compounds	1,080 MWh	720 kWh per site, per day Assumes 1.6 sites active for 30 months.
Management of solid waste	Municipal Solid Waste - Bannaby 500 kV substation work - Gugaa 500 kV substation construction - Wagga 330 kV substation work - Transmission line	 180 t 209 t 194 t 400 t	Municipal solid waste estimates comprise domestic waste from site personnel at the worker accommodation facility and construction compounds

Emission source	Activity data	Total value	Notes
	Construction and Demolition - Bannaby 500 kV substation work - Gugaa 500 kV substation construction - Wagga 330 kV substation work - Transmission line	 300 t 348 t 324 t 400 t	Construction waste estimates comprise general construction waste such as off-cuts, packaging and excess construction material (such as concrete, timber, plastic and metal).
Embedded energy in construction materials	Concrete Steel Aluminium Copper	71,066 m^3 42,897 t 8,275 t 246 t	

Fuel, oil and grease consumption

The fuel, oil and grease consumption rates were used to estimate both the direct Scope 1 emissions associated with combustion of the fuels within the project footprint, as well as the Scope 3 emissions emitted during the extraction and production of these products used as a result of the project.

Transmission line

For construction of the transmission line, fuel usage was estimated by Transgrid based on the construction equipment expected to be used and the associated fuel consumption rates, considering a variety of distances and transmission structure types. Allowance was also included for clearing of the easement, as well as new and upgraded access tracks. The total fuel use estimate was then averaged over the route length and a representative mix of transmission structure types to provide an estimated average diesel consumption rate of 9,208 litres per kilometre of transmission line, and an estimated average oil consumption rate of 23 litres per kilometre of transmission line. The oil usage rate is based on 0.25 per cent of the diesel consumption rate. The estimated grease consumption rate of 17 kilograms per kilometre of transmission line route is based on various rates of consumption for different activities and is related to the estimated diesel consumption.

The transmission line fuel consumption estimate includes all fuel associated with delivery of materials from warehouses or ports in Sydney to a staging point, and then to the final site location for installation or construction. This includes fuel used in the delivery of all concrete to site but does not include delivery of cement to the regional centres or batching plants. No allowance was included for rehabilitation, such as the removal of access tracks, if required.

Unleaded fuel may also be used in some light vehicles and minor equipment. This usage would be a very minor component of the total fuel use for a project of this type and is expected to be less than one per cent of the fuel used on the project. On this basis, the transmission line construction GHG emission estimates assume all construction-related fuel use is diesel. It has also been assumed that fly-in-fly-out would not be a large contributor to GHG emissions and the consumption of any avgas during construction was not accounted for.

Substation work

Estimated daily diesel, oil and grease consumption rates of 5,500 litres per day, 15 litres per day and 5 kilograms per day respectively, were provided by Transgrid for the construction work at the Bannaby 500 kV substation with an estimated duration of 25 months. An estimated unleaded fuel consumption rate of 367 L/day was also provided for this work.

The estimated daily consumption rates for the construction work at the Wagga 330 kV substation were slightly lower at 4,196 litres per day of diesel, 11 litres per day of oil, 4 kilograms per day of greases and 303 kL per day of unleaded petrol. The estimated duration of the work is slightly longer at 27 months.

Construction of the proposed Gugaa 500 kV substation is anticipated to involve the largest fuel consumption of the three sites, with estimated daily consumption rates of 9,341 litres per day of diesel, 25 litres per day of oil, 9 kilograms per day of greases and 615 kL per day of unleaded petrol. The estimated duration of the work is 29 months.

Construction compounds

An average diesel fuel usage for a typical construction compound or site office was estimated by Transgrid to be 5,694 litres per month, with 14.24 litres of oil per month also estimated. Transgrid estimates that six construction compounds may be required to operate concurrently for 16 months or more, with fewer than that at other times. Not all construction compounds considered by this assessment are expected to be used by the contractors. Based on information provided by Transgrid, it was assumed that on average, 1.5 construction compounds would operate concurrently over a 24 month period.

An average fuel per month for light vehicles associated with survey work, supervision, engineering and management support has been assessed at 18,173 litres per month.

Worker commuting

There is limited information available at the time of preparing this report on the anticipated vehicle movements associated with workers travelling from home to the worker accommodation facility or directly to work sites. For the purposes of this report, and to provide a conservative estimate of associated Scope 3 GHG emissions, it was assumed that over the 2.5 year construction period there would be an average of 900 workers travelling four times a month on a 150 km round trip from their home to accommodation. It was assumed 80 per cent of the vehicles would run on petrol and 20 per cent would run on diesel.

Electricity use

The electricity use at the worker accommodation facility was estimated by Transgrid to be 720 kWh/day (72 kW for 10 hours per day), while the electricity use at each construction compound connected to the grid was estimated to be 3,200 kWh/day (133 kW for 24 hours per day). The following eight construction compounds were assumed to be connected to the grid:

- Wagga 330 kV substation compound (C01)
- Snowy Mountains Highway compound (C02)
- Maragle 500 kV substation compound (C05)
- Gregadoo Road compound (C06)
- Yass substation compound (C10)
- Bannaby 500 kV substation compound (C12)
- Memorial Avenue compound (C14)
- Bowmans Lane compound (C15).

As not all construction compounds would operate continuously throughout the construction period, for the purposes of the GHG emission inventory, it was assumed that only 1.6 construction compounds would consume electricity from the grid concurrently over the construction period.

The construction works at the Bannaby 500 kV substation, the proposed Gugaa 500 kV substation and the Wagga 330 kV substation were estimated to consume 720 kWh/day.

Construction schedule

Construction of the project is targeted to commence in mid-2024, and is estimated to take about 2.5 years to complete. Construction of the proposed Gugaa 500 kV substation could take up to 2.5 years. Construction at each transmission line structure would be intermittent and construction activities would not occur for the full duration at any one location. Durations of any particular construction activity, and inactive/respite periods, can be expected to vary for a number of reasons. For this reason, detailed monthly emission profiles have not been developed.

In order to provide an estimate of annual GHG emissions from the project suitable for comparison against the most recent State and national GHG emission inventories, the total estimated construction GHG emissions have been divided by 2.5 years.

5.3.3.2 Operational activities

A summary of the activity data used in the GHG emission estimation calculations for operation of the project is presented in **Table 5-6**.

Table 5-6 Activity data used to estimate GHG emissions during operation of the project

Emission Source	Activity Data	Value	Notes
Diesel consumption	Bannaby 500 kV substation	4.85 kL/annum	404 L/month
	Gugaa 500 kV substation	11.63 kL/annum	969 L/month
	Wagga 330 kV substation	4.85 kL/annum	404 L/month
	Transmission line/tracks	1.44 kl/annum	120 L/month
Petrol consumption	Bannaby 500 kV substation	2.03 kL/annum	169L/month
	Gugaa 500 kV substation	4.57 kL/annum	381 L/month
	Wagga 330 kV substation	2.03 kL/annum	169 L/month
Avgas consumption	Helicopter and LiDAR inspections	2.40 kL/annum	200 L/month
Use of SF_6	SF_6 charge in switchgear - Bannaby 500 kV substation	2,731 kg	Estimated by Transgrid
	SF_6 charge in switchgear - Gugaa 500 kV substation	4,679 kg	Estimated by Transgrid
	SF_6 charge in switchgear - Wagga 330 kV substation	1,778 kg	Estimated by Transgrid
Transmission losses	Maragle – Bannaby	78 GWh/annum	Estimated by Transgrid
	Maragle – Wagga	28 GWh/annum	Estimated by Transgrid
	Wagga – Bannaby	56 GWh/annum	Estimated by Transgrid

5.4 Limitations and uncertainty

The GHG Protocol states that uncertainties associated with greenhouse gas inventories can be broadly categorised into *scientific uncertainty* and *estimation uncertainty*.

Scientific uncertainty arises when the science of the actual emission and/or removal process is not sufficiently understood. For example, many of the direct and indirect emissions factors associated with GWP values, that are used to combine emission estimates of different GHGs, involve significant scientific uncertainty.

Estimation uncertainty arises any time GHG emissions are quantified, and can be further classified into two types: model uncertainty and parameter uncertainty:

- **Model uncertainty** refers to the uncertainty associated with the mathematical equations (ie models) used to characterise the relationships between various parameters and emission processes (eg emission factors).
- **Parameter uncertainty** refers to the uncertainty associated with quantifying the parameters (eg activity data) used as inputs in the estimation calculations.

Of the above, only parameter uncertainty is within the scope of most companies' control when preparing GHG emission estimates.

The activity data used in the emission calculations are based on estimations and projections of likely consumption rates and activity levels during construction and operation of the project. In many cases, these parameters would be influenced by the detailed design of the proposed infrastructure, materials specifications and sourcing decisions, and the final construction methodology and schedule. The values used in the calculations are therefore subject to a high level of uncertainty, which would flow through into the estimated annual GHG emission rates. To address this, conservative values have been used in the calculations to reduce the likelihood that emissions are underestimated.

Two key objectives of this report are to:

1. identify the most significant sources of GHG emissions associated with the project to inform the detailed design process so that these emissions can be minimised where possible
2. provide the basis for the development of a GHG Management Plan to be implemented during the project, to facilitate the collection of relevant activity data so that GHG emissions can be monitored and managed on an ongoing basis.

While the limitations of the emission estimates should be acknowledged, they are not expected to limit the assessment in achieving the above objectives.

6 Existing environment

This section presents a summary of the most recent GHG emissions inventory data available for Australia and NSW to provide context for the GHG emissions estimated to occur as a result of the project.

6.1 Australia's current GHG emissions

The National Greenhouse Gas Inventory (DISER, 2022) and *National Greenhouse Gas Inventory Quarterly Update: September 2021* was used to present project emissions in comparison to Australian and NSW emissions.

The National GHG inventory for 2019 (DISER, 2022) is the latest available Paris Agreement Inventory for Australia's GHG emissions. These emission estimates are prepared in accordance with the 2019 Refinement to the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2019) and under the UNFCCC and Kyoto Protocol. The National Inventory reports on both a national basis and per state/territory, and includes individual emission estimates for six main sectors:

1. energy
2. industrial processes
3. agriculture
4. land use, land use change and forestry
5. waste
6. other.

These main sectors are also broken down into sub-sectors, including '*1.A.1.a Public electricity and heat production*' within the energy sector.

More recent national emission data (not broken down by state/territory) is also available from the DISR *National Greenhouse Gas Inventory Quarterly Updates* website (DISER, 2021). The quarterly updates are broken down into the following eight sectors:

1. energy - emissions from the combustion of fuel used to generate electricity for public use
2. stationary energy – excluding electricity
3. transport
4. agriculture
5. fugitive emissions
6. industrial processes
7. waste
8. land use, land use change and forestry.

The available annual national and state emissions data reported by DISR for 2016 to 2021 in million tonnes CO_2-e (Mt CO_2-e) is summarised in **Table 6-1**.

Table 6-1 Annual GHG emissions data – Australia and NSW

Reporting Year	2016 [a]	2017 [a]	2018 [a]	2019 [a]	2020 [b]	2021 [b]
Annual emissions: Australia (Mt CO_2-e)						
All sectors [1,2]	530.0	526.7	538.4	529.3	505.5	501.5
Public electricity and heat production [1]	194.7	189.8	183.6	179.4	N/A	N/A
Electricity sector [2]	194.2	187.3	182.5	177.5	170.4	162.3
Annual emissions: NSW (Mt CO_2-e)						
All sectors [1]	137.5	139.2	144.3	136.6	N/A	N/A
Public electricity and heat production [1]	51.8	51.1	52.1	51.9	N/A	N/A

Note:

[1] SOURCE: (DISER, 2022)

[2] SOURCE: (DISER, 2021)

7 Construction impacts

The estimated GHG emissions for construction of the project are shown in **Table 7-1**.

As shown in **Table 7-1**, the estimated total direct Scope 1 emissions (excluding land clearing) over the 2.5 year construction period equate to 56,593 t CO_2-e. The estimated total Scope 2 emissions over the entire construction period associated with electricity consumption at construction compounds, the worker accommodation facility and substations equate to 4,189 t CO_2-e. This results in a total combined Scope 1 and Scope 2 emission estimate of 60,782 t CO_2-e for construction of the project. The main source of Scope 1 and Scope 2 emissions is diesel consumption, which accounts for 86 per cent of the total emissions.

The estimated Scope 3 emissions from the project predominantly relate to energy embodied in construction materials. Emissions associated with the production and supply of fuels contribute less than one per cent of the Scope 3 emissions.

Table 7-1 Estimated GHG emissions during construction

Scope	Activity/source	Estimated emissions (t CO_2-e)	
		Total 2.5 year construction period	Annual average
1	Diesel consumption - off-road and stationary	52,535	21,014
1	Diesel consumption - mobile/on-road	1,480	592
1	Unleaded fuel consumption	2,584	1,019
1	Consumption of oils (lubricants)	27.7	11.1
1	Consumption of greases	3.2	1.3
Total Scope 1		***56,593***	***22,637***
2	Electricity consumption	4,189	1,676
Total Scope 2		***4,189***	***1,676***
3	Extraction and production of diesel consumed	2,770	1,108
3	Extraction and production of petrol consumed	132	53
3	Extraction and production of purchased materials- steel	68,893	27,557
3	Extraction and production of purchased materials- concrete	155,279	62,112
3	Extraction and production of purchased materials- copper	994	398
3	Extraction and production of purchased materials- aluminium	82,750	33,100
3	Employee commuting	297	119
3	Disposal of solid waste generated	1,847	739
Total Scope 3		***312,961***	***125,184***

8 Operational impacts

The annual GHG emissions estimated for operation of the project are shown in **Table 8-1.** The main source of emissions associated with the ongoing operation of the project are Scope 2 emissions related to transmission losses. For the Scope 1 emissions, the main source is associated with leakage of SF_6, due to its potency as a GHG.

Table 8-1 Estimated GHG emissions - operation

Scope	Activity/Source	Estimated Emissions (t CO_2-e/annum)
1	Diesel consumption	61.8
1	Petrol consumption	20.5
1	Avgas consumption	6.2
1	SF_6 leakage	1,922
Total Scope 1		***2,010***
2	Transmission losses	127,980
Total Scope 2		***127,980***
3	Production and supply of fuels used	4.54
Total Scope 3		***4.54***

9 Comparison against state and national GHG emissions

The estimated annual average construction and operational GHG emissions from the project are compared to the most recent GHG emission estimates for NSW and Australia (refer to **Section 6.1**) in **Table 9-1**. As shown in the table, the impact of the project on the State and national GHG emission loads is estimated to be negligible, with the operational annual emission estimate representing less than 0.1 per cent of NSW's annual emissions. The construction annual average emissions are even lower, and while the actual annual emission may be higher in some years than others depending on the staging of activities, the project would still be a very minor contributor to Australia's GHG emissions. As outlined in **Chapter 4,** the project is in fact part of a vital upgrade of NSW's transmission network that is required for Australia to meet its goal of net-zero emissions by 2050.

Based on the above, it can be concluded that the project would not impact on Australia's ability to meet its emission reduction target.

Table 9-1 Potential contributions to state and national GHG emissions

Year	Estimated annual Scope 1 and Scope 2 project emissions (t CO_2-e/annum)	Percentage of NSW emissions	Percentage of Australia's emissions
Construction	24,313	0.018	0.005
Operation	129,990	0.095	0.026

10 Project benefits

The Australian Energy Market Operator's (AEMO) Integrated System Plan (ISP) provides a comprehensive plan for the efficient development of the National Electricity Market out to 2050. In the 2022 ISP (AEMO, 2022), AEMO found that for Australia to meet its goal of net-zero emissions by 2050, it will need to:

- double the electricity it delivers, including a nine-fold increase in large-scale renewable energy and a five-fold increase in rooftop solar
- treble the current firming capacity in the form of large-scale batteries, hydro storage, virtual power plants and gas generation.

To connect this new generation to consumers, AEMO found that more than 10,000 kilometres of new transmission infrastructure will be required around the country. The majority of this new transmission will be used to connect new renewable energy projects to the grid. As much of the new renewable energy capacity will be concentrated in REZs, this will significantly lower the cost of transmission by enabling optimal development planning from the outset, reducing the amount of infrastructure required, and reducing risk premiums for those constructing the new transmission and for those connecting to the grid.

In addition, as recently discussed in its update to the Energy Statement of Opportunities, AEMO has found that the transmission investment supported by the NSW Energy Roadmap, in conjunction with an influx of private capital from the renewables sector, will be critical to maintaining NSW reliability in the medium term, once the Eraring coal-fired generator retires in 2025.

Consistent with the above, once operational, the project is expected to contribute positively to a reduction in emissions from the NSW electricity grid by enabling the introduction of new renewable generation in the Wagga Wagga and Tumut REZs.

As outlined in the Environmental Scoping Report (Aurecon, 2022) for the project, existing coal-fired generators in NSW will be retiring progressively from 2022 and there is a need for new sources of supply to meet growing energy demand. The existing network would continue to play an important role. However, it does not currently have enough capacity to connect these new projects, and the full benefits of new renewable generation (including upgrades to the Snowy Hydro Scheme) would not be realised without an associated increase in transmission capacity. The project would support the transfer of energy from existing renewable generation as well as facilitate development of new renewable generation in the Wagga Wagga and Tumut REZs, which would result in reductions in the GHG emissions intensity of the electricity network.

Future renewable projects identified nearby, which would be supported by the project, include:

- Gregadoo Solar Farm – A 47 megawatt photovoltaic solar farm to be located on land adjacent the existing Wagga 330 kV substation.
- Jeremiah Wind Farm - Development of a 65 turbine wind farm, battery energy storage system and associated ancillary infrastructure with a total capacity of around 400 megawatt. Transmission lines between the proposed Gugaa 500 kV substation and Bannaby 500 kV substation, and future Maragle 500 kV substation and Bannaby 500 kV substation would go through the Jeremiah Wind Farm development area.
- Yass Solar Farm – A proposed solar farm with a proposed output capacity of approximately 80 megawatt to be located on land directly adjacent to the Transgrid Yass substation.

- Rye Park Wind Farm – A proposed 126 turbine wind farm with the ability to produce around 1,192,000 megawatt-hours of renewable energy every year. Transmission lines between the proposed Gugaa 500 kV substation and Bannaby 500 kV substation, and the future Maragle 500 kV substation and Bannaby 500 kV substation would go through the southern end of the wind farm project boundary at Bango.

The project would also improve the efficiency and reliability of the current energy transfer in this part of the network, in conjunction with other proposed transmission system upgrades in the area such as the EnergyConnect (NSW – Eastern Section) project, Victoria to NSW Interconnector West and the Snowy 2.0 - Transmission Connection. The existing congested transmission network gives rise to potentially higher transmission losses, which increase the costs to generators as well as contributing to Scope 2 GHG emissions. Easing the congestion would therefore also facilitate reductions in the GHG emissions intensity of the electricity network as the new projects come online.

11 Management of impacts

11.1 Overview of approach

Electricity generators and electricity transmission or distribution companies have reporting obligations under the NGER legislation. All reportable emissions (ie excluding emissions associated with land clearing) and energy within the operational control of the reporter should be accounted for. This includes fuel combustion emissions that occur through contractor activities (CER, 2021).

The monitoring and reporting of greenhouse gas emissions also provides information that can be used to identify the main emission sources and related activities so that mitigation measures can be identified to minimise key emissions where possible. To assist in this process, a GHG management plan would be prepared for the project to develop strategies to reduce GHG emissions as part of the sustainability strategy and Infrastructure Sustainability Rating Scheme pathway, and in line with Transgrid's SBTi GHG emission reduction targets as well as Australia's international commitments and the State and Commonwealth aspirations.

The objectives of the plan would be to:

- reduce greenhouse gas emissions associated with the project and all relevant emissions sources
- incorporate energy efficiency initiatives into project design, procurement, engineering, construction and operation
- integrate greenhouse gas management and energy efficiency initiatives into business decision making at all stages of the project
- provide consistent and accurate reports on greenhouse gas emission levels in compliance with relevant legislation.

In identifying GHG mitigation measures to be adopted by the project, consideration has been given to the hierarchy of controls, being:

- elimination – for example:
  - minimising the stock of SF_6 required in the network to minimise SF_6 leakage related emissions
  - minimising transmission losses and the area of vegetation clearing required by optimising the transmission line route and construction methodology
- substitution – for example:
  - using lower greenhouse gas intensity fuels such as biodiesel in equipment if possible
- engineering controls – for example:
  - minimising electricity demand by considering energy efficient and passive design features as part of the detailed design and construction of workforce accommodation and office buildings, including air conditioning, lighting, low-flow fittings and solar power
  - selecting appropriately sized equipment for construction activities to maximise fuel efficiency
  - maintaining construction equipment and vehicles in good working order to maximise fuel efficiency
- administrative controls – for example:
  - considering options to minimise transport distances between construction compounds and work sites and schedule activities to minimise vehicle kilometres travelled during construction and operation, where possible, to minimise fuel use
  - implementing a SF_6 leakage detection monitoring during operation

- behaviour – for example:
  - raising awareness in construction workers and operational staff across Transgrid regarding GHG minimisation practices through training and education programs (eg minimising idling of vehicles, ensuring appropriate maintenance and tuning of equipment for fuel efficiency, minimising waste, carpooling, active transport)
  - reclaiming recyclable materials by providing drop-off points throughout the project footprint.

GHG emissions from the project would potentially be offset to some extent by enabling the introduction of new renewable generation in the Wagga Wagga and Tumut REZs. Additional offset strategies may also be considered for the project where in line with the current State and Commonwealth legislation and policy.

11.2 Summary of mitigation measures

Mitigation measures for the project relating to greenhouse gas emissions are outlined in **Table 11-1.**

Table 11-1 Summary of mitigation measures

Impact	Mitigation measures	Timing	Relevant location
GHG emissions	The use of SF_6 will be minimised where possible, including through the investigation of alternatives.	Detailed design and operation	Substations
GHG emissions	Options that will be considered during ISC rating design review include energy efficient and passive design features for substation and worker accommodation facility buildings including air conditioning, lighting, low-flow fittings and solar power.	Detailed design	Substations and worker accommodation facility
GHG emissions	Options to minimise transport distances between construction compounds, accommodation facilities and work sites will be considered, for example utilising vehicle pooling / mini buses and sourcing equipment and materials locally where practicable.	Detailed design	All locations
GHG emissions	GHG emissions and associated activity data will be tracked and recorded to assist in identifying key emission sources and appropriate targeting of mitigation measures, as well as to provide learnings for other projects and demonstration of IS Rating compliance.	Construction and operation	All locations
GHG emissions	SF_6 emissions will be minimised through leakage detection monitoring programs, maintenance and end of life dismantling procedures.	Operation	Substations

12 Conclusion

Potential GHG emissions from construction and operation of the project have been quantified so that the significance in relation to state and national emissions can be assessed. The emission estimates will also provide a basis for the development of a GHG Management Plan for the project. The Planning Secretary's Environmental Assessment Requirements issued for the project do not mention greenhouse gas or carbon emissions and assessment therefore has been prepared in accordance with current industry practice for such assessments and with reference to relevant policies and guidelines.

The estimated GHG emissions associated with the project for both construction (total estimated emissions over the 2.5 year construction program) and operation (ongoing annual emissions once commissioned) are shown in **Table 12-1**.

Table 12-1 Summary of estimated GHG emissions for the project

Scope	Activity/source	Estimated emissions (t CO_2-e)	
		Construction (2.5 years)	Operations (per annum)
1	Consumption of fuels	56,563	89
	Consumption of oils	28	negligible
	Consumption of greases	3	negligible
	SF_6 leakage	not applicable	1,922
Total Scope 1		***56,593***	***2,010***
2	Electricity consumption	4,189	negligible
	Transmission losses	not applicable	127,980
Total Scope 2		***4,189***	***127,980***
3	Extraction and production of fuels consumed	2,902	4.5
	Extraction and production of purchased materials	307,916	negligible
	Employee commuting	297	negligible
	Disposal of waste	1,847	negligible
Total Scope 3		***312,961***	***4.5***

For the construction of the project, the total direct Scope 1 emissions over the 2.5 years are estimated at 56,593 t CO_2-e, which averages out to 6,754 t CO_2-e. The total Scope 2 emissions associated with electricity consumption by the construction compounds, worker accommodation facility and substations are estimated at 4,189 t CO_2-e. This gives a total combined Scope 1 and Scope 2 emission estimate of 60,782 t CO_2- e for construction of the project. The main source of Scope 1 and Scope 2 emissions is diesel consumption, accounting for 86 per cent of the total emissions.

The main source of emissions associated with the ongoing operation of the project are Scope 2 emissions related to transmission losses, which are estimated at 127,980 t CO_2-e/annum. The annual Scope 1 GHG emissions estimated for the project operation are 2,010 t CO_2-e/annum, with the main Scope 1 emission source being the leakage of SF_6, due to its potency as a GHG.

The impact of the project on the State and national GHG emission loads is estimated to be negligible, with the operational annual emission estimate representing less than 0.1 per cent of NSW's annual emissions. The construction annual average emissions are even lower, and while the actual annual emission may be higher in some years than others, depending on the staging of activities, the project would still be a very minor contributor to Australia's GHG emissions.

Based on the above, it can be concluded that the project would not have any potential to impact on Australia's ability to meet its emission reduction target under the Paris Agreement. Conversely, given that it is part of a vital upgrade of NSW's transmission network that is required for Australia to meet its goal of net-zero emissions by 2050, once operational, the project is expected to contribute positively to a reduction in emissions from the NSW electricity grid by enabling the introduction of new renewable generation in the Wagga Wagga and Tumut REZs.

To assist in the monitoring and reporting of GHG emissions from the project however, a GHG management plan will be prepared for the project that will include strategies to reduce GHG emissions. The project would also support the transfer of energy from existing renewable generation as well as facilitate development of new renewable generation in the Wagga Wagga and Tumut REZs, which would result in reductions in the GHG emissions intensity of the electricity network. The existing congested transmission network gives rise to potentially higher transmission losses, which increase the costs to generators as well as contributing to Scope 2 GHG emissions. The project would assist in easing this congestion by improving the efficiency and reliability of the current energy transfer in this part of the network, and as a result, would also facilitate reductions in the GHG emissions intensity of the electricity network as the renewable energy projects come online.

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