Appendix J

Greenhouse Gas Assessment

Blast Furnace No. 6 Reline Project

Greenhouse Gas Report

BlueScope Steel (AIS) Pty Ltd

07 March 2022

→ **The Power of Commitment**

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Executive summary

BlueScope Steel (AIS) Pty Ltd's (BlueScope) Port Kembla Steelworks (PKSW) operation in NSW includes two blast furnaces. No. 5 Blast Furnace (5BF) is currently operating, while No. 6 Blast Furnace (6BF) is currently in care and maintenance. 5BF is expected to continue to produce (molten) iron on a continuous basis until it reaches the end of its operational life at some stage between 2026 and 2030. BlueScope is proposing a move of iron manufacture from 5BF to 6BF, after 5BF ceases operation. 6BF last produced iron in 2011, at which point it was taken out of service and placed into care and maintenance. To prepare 6BF to become operational again, major maintenance works are required (the project). The project aims to return 6BF to service through a reline process that will be carried out while 5BF continues to operate.

GHD Pty Ltd (GHD) was commissioned by BlueScope to prepare a Greenhouse Gas (GHG) assessment for the project. GHD has carried out this GHG assessment in accordance with relevant international, national, state, and local policies, using methodologies which are representative of good GHG accounting in Australia.

Construction emissions from the project rely upon data from other sections of the Environmental Impact Statement, as well as data supplied by BlueScope. Construction emissions are estimated to be 30,000 tCO_2-e, or approximately 9,800 tCO_2-e per annum over the three-year construction period. Emissions during construction are minor and approximately 0.1% of annual operational emissions.

Operational emissions from the project rely upon Scope 1 and 2 emissions data provided by BlueScope. The quantity of GHG emissions for the operation of PKSW, of which 6BF will be a component, was approximately 6,869,000 tCO_2-e per annum in FY2021. The assessment of Scope 1 and 2 operational emissions concluded that 6BF will have a similar GHG emissions profile to 5BF with improvements (reductions) in GHG emissions intensity from the commencement of operations of 6BF. Over $100 million of project scope is directed at environmental improvements, including $80 million of improvements which are designed to deliver reductions in GHG emissions. This will mean that the project will make a near-term positive environmental impact, relative to current 5BF operations. The scope of the project is intended to address the dual aims of the project: to secure BlueScope's domestic ironmaking needs from 2026, as well as provide a bridge to transition from current blast furnace technology to new and emerging low emissions technologies once available at commercial, viable scale.

Construction emissions from the project rely upon data from other sections of the Environmental Impact Statement, as well as data supplied by BlueScope. Construction emissions are estimated to be 30,000 tCO_2-e, or approximately 9,800 tCO_2-e per annum over the three-year construction period. Emissions during construction are minor and approximately 0.1% of annual operational emissions.

This GHG assessment is supported by qualitative information taken from the Climate Action Report published in 2021 (Climate Action Report) by BlueScope's parent company, BlueScope Steel Limited (BSL). GHD considers this to be an appropriate assessment approach in the context of the complex operations of an integrated iron and steelmaking facility such as PKSW. In adopting this approach, GHD has also had regard to the fact that the project is essentially a like for like replacement of current ironmaking operations at 5BF.

Current steelmaking technology is a GHG intensive activity. For example, in 2020, the average GHG emissions intensity of steelmakers reporting to Worldsteel using BF-BOF technology was 2.33 tCO_2-e per tonne of crude steel produced. During this period, the GHG emissions intensity of steelmaking at PKSW was 2.21 tCO_2-e per tonne of crude steel produced, comparing favourably to the average reported by Worldsteel. This means that for 2020, PKSW was within the top quartile of reporters in terms of lowest GHG emissions intensity for integrated steel plants globally, using the Worldsteel calculation methodology (based on ISO 14404 series).

BSL's publication of its Climate Action Report acknowledges the role the steel industry can play in the transition to a net zero emissions future, including its use as a critical component of renewable energy and transport infrastructure. To achieve net zero emissions in steelmaking, commercialisation of breakthrough technologies and supporting infrastructure will be needed.

The availability of breakthrough low GHG emissions ironmaking technologies was considered by BlueScope in assessing options for the future configuration of PKSW. However, as technologies that are suitable for use at PKSW are unlikely to be available and commercially viable at scale until a time well after that required to replace 5BF, the only technically feasible and commercially viable option for BlueScope to continue steelmaking at Port

Kembla in the short to medium term is to progress with the existing configuration and reline 6BF. The reline of 6BF provides a ‘bridge’ to transition from the current blast furnace technology to new and emerging low emissions technologies when they are commercially available.

The GHG reduction measures incorporated in the project design are outlined in section 6 of this report. These measures include the installation of a Top Gas Recovery Turbine to generate electricity, installation of a Waste Gas Heat Recovery system to reduce fuel consumption at the stoves, installation of dual lances at the tuyeres to enable the use of alternative reductants such as hydrogen-rich Coke Ovens Gas and renewable hydrogen, and optimisation of raw material inputs. These measures are part of a broader suite of climate-related projects at Port Kembla that have the potential to further reduce GHG emissions intensity.

In addition to these measures and outside of the scope of the project, BlueScope and BSL are currently investigating emerging technologies such as the use of sustainably sourced biochar as a replacement for pulverised coal used in the blast furnace and, in partnership with Shell Energy Operations Pty Ltd, the design, build and operation of a 10 MW renewable energy hydrogen electrolyser to test the use of renewable hydrogen in the blast furnace at PKSW. BSL has also signed a Memorandum of Understanding with Rio Tinto Group to explore using renewable hydrogen to replace coking coal to directly reduce iron ore sourced from the Pilbara region. Other GHG emission reduction investments made by BSL external to the project are outlined in section 3.

This GHG assessment has been informed by GHG emission data reported for existing operations and the targets and goals set by BSL in the Climate Action Report (noting the enablers essential to those targets being met are explained in the Climate Action Report), including those relating to BlueScope’s operations at PKSW. The aims and objectives of the Climate Action Report are considered to be consistent with international, national, state, and local GHG policies which are outlined in section 3 of this report.

Similarly, the commitment of BlueScope over the campaign life of 6BF to continue research and investment in emerging technologies for PKSW, including 6BF, to more substantially reduce GHG emissions, are considered by GHD to be consistent with international, national, state and local GHG policies aimed at achieving a net zero future.

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Terms and abbreviations

Abbreviation	Description
ABS	Australian Bureau of Statistics
AR	Assessment Report
BF	Blast Furnace
BFG	Blast Furnace Gas
BlueScope	BlueScope Steel (AIS) Pty Ltd
BOF	Basic Oxygen Furnace
BSL	BlueScope Steel Limited
°C	Degrees Celsius
C	Carbon
C&D	Construction and Demolition
CBAM	Carbon Border Adjustment Mechanism
CCUS	Carbon Capture Usage and Storage
CH_4	Methane
COG	Coke Ovens Gas
CO_2	Carbon dioxide
CO2CRC	CO_2 Cooperative Research Centre
CSSI	Critical State Significant Infrastructure
DPIE	Department of Planning, Industry and Environment
DRI	Direct Reduced Iron
DISER	Department of Industry, Science, Energy and Resources
EAF	Electric Arc Furnace
EF	Emission Factor
EIS	Environmental Impact Statement
EP&A	Environmental Planning and Assessment 1979
EU	European Union
FY	Financial year
GHD	GHD Pty Ltd
GHG	Greenhouse gas
GHG Protocol	Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard
GWP	Global Warming Potential
H_2	Hydrogen
HBI	Hot Briquetted Iron
HPCOG	High Pressure Coke Ovens Gas
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Association
kg	Kilograms
kL	Kilolitre
km	Kilometres

Abbreviation	Description
kPa	Kilopascal
kW/m^2	Kilowatts per square metre
LGA	Local Government Area
LPG	Liquefied Petroleum Gas
m	Metres
MSW	Municipal Solid Waste
Mtpa	Million tonnes per annum
MW	Megawatt
MWh	Megawatt hour
N_2O	Nitrous oxide
NG	Natural Gas
NGA	National Greenhouse Accounts
NGER	National Greenhouse and Energy Reporting
NGER Act	National Greenhouse and Energy Reporting Act 2007
NSW	New South Wales
PCI	Pulverized Coal Injection
PKSW	Port Kembla Steelworks
RCPs	Representation Concentration Pathways
SEARs	Secretary's Environmental Assessment Requirements
SF_6	Sulphur hexafluoride
scrap	scrap steel
SRD	State and Regional Development
t	Tonnes
tCO_2-e	Tonnes of carbon dioxide equivalent
TCFD	Task Force on Climate-related Financial Disclosures
TRL	Technology Readiness Level
TRT	Top Gas Recovery Unit
UN	United Nations
USD	United States Dollar

1. Introduction

1.1 Background and project overview

BlueScope Steel (AIS) Pty Ltd's (BlueScope) Port Kembla Steelworks (PKSW) operation in NSW includes two blast furnaces. No. 5 Blast Furnace (5BF) is currently operating, while No. 6 Blast Furnace (6BF) is in care and maintenance.

5BF is expected to continue to produce (molten) iron on a continuous basis until it reaches the end of its operational life at some stage between 2026 and 2030. BlueScope is proposing a move of iron manufacture from 5BF to 6BF, after 5BF ceases operation.

6BF last produced iron in 2011, at which point it was taken out of service and placed into care and maintenance. To prepare 6BF to become operational again, major maintenance works are required (the project). The project aims to return 6BF to service through a reline process that will be carried out while 5BF continues to operate.

The project has been declared Critical State Significant Infrastructure (CSSI) in accordance with section 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and Schedule 5 of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

1.2 Purpose of this report

GHD Pty Ltd (GHD) was commissioned by BlueScope to prepare a greenhouse gas (GHG) assessment for the project. This report will support the preparation of an Environmental Impact Statement (EIS) under the EP&A Act for the project.

This report addresses the relevant criteria in the NSW Secretary's Environmental Assessment Requirements (SEARs) for the project issued in July 2021 (as outlined in Section 3.7).

As such, this report focuses on the impact of GHG emissions associated with the ongoing iron making from 6BF once 5BF comes to the end of its current campaign.

1.3 Proponent details

BlueScope Steel (AIS) Pty Ltd (BlueScope) (ABN 19 000 019 625) is a wholly owned subsidiary of BlueScope Steel Limited (BSL) (ABN 16 000 011 058). BlueScope is the owner and operator of PKSW and is the proponent for the project. BlueScope is one of Australia's leading manufacturers, and one of only two primary producers of iron and steel in Australia, and together with BSL, is a global leader in finished and semi-finished steel products.

1.4 Limitations

This report has been prepared by GHD for BlueScope Steel (AIS) Pty Ltd and may only be used and relied on by BlueScope Steel (AIS) Pty Ltd for the purpose agreed between GHD and BlueScope Steel (AIS) Pty Ltd as set out in Section 1.2.

GHD otherwise disclaims responsibility to any person other than BlueScope Steel (AIS) Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

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

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

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

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

2. Methodology

2.1 Overview

The SEARS (refer Section 3.1) require an assessment of GHG emissions associated with the project, but do not mandate a specific standard, protocol, or methodology for the GHG assessment. This assessment has been undertaken in accordance with the principles of ISO 14064-2 and National Greenhouse and Energy Reporting (NGER) (Measurement) Determination 2008 for measuring emissions, in the following steps:

– Review relevant legislation, guidelines and policy documents to establish the regulatory context for the GHG assessment. Refer Section 3.
– Describe the existing environment, PKSW, and the proposed project. Refer Section 4.
– Establish baseline GHG emissions for PKSW inclusive of the existing operation of 5BF and assess the likely GHG emissions from 6BF. Refer Section 5.
– Assess potential GHG emissions reduction measures that may be applicable to the operation of 6BF and review their viability for incorporation into the project. Refer Section 6.

2.2 Greenhouse gases and global warming potentials

The GHGs considered in this assessment and the corresponding global warming potential (GWP) for each GHG are listed in Table 2.1. GWP is a metric used to quantify and communicate the relative contributions of different substances to climate change over a given time horizon. GWP accounts for the radiative efficiencies of various gases and their lifetimes in the atmosphere, allowing for the impacts of individual gases on global climate change to be compared relative to those for the reference gas carbon dioxide (CO_2).

The GWPs from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment report and section 2.02 of the National Greenhouse and Energy Reporting (NGER) Regulations 2008, updated July 2021, were used in this assessment.

Table 2.1 Greenhouse gases and 100-year global warming potentials

Greenhouse gas	Global warming potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous oxide (N_2O)	265
Sulphur hexafluoride (SF_6)	23,500

2.3 Assessment approach

Relevant sections of the following documents were used for the purposes of defining appropriate methods for quantification of emissions from individual sources from existing operations:

– NGER (Measurement) Determination 2008 (as amended) and NGER Act 2007, Commonwealth Department of Environment and Energy
– Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol) (World Business Council for Sustainable Development and World Resources Institute, 2015)

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

The methodology undertaken for this GHG assessment is semi-quantitative using the data provided by BlueScope and BlueScope reports for the operational emissions of the project. Therefore, the assessment will use existing GHG emissions calculated by BlueScope.

2.3.1 Construction phase emission sources

The following emission sources were included in the assessment boundary for the construction stage:

- Diesel used in plant and equipment
- Transport of plant, materials and equipment to the site, and removal of waste from the site
- Worker commuting, including private transport to/from the site, and buses used around the site
- Electricity from the NSW grid
- Disposal of waste
- Acetylene for welding
- Natural gas use during commissioning of the 6BF.

2.3.2 Operations phase emission sources

The following emission sources were included in the assessment boundary for the operations stage:

- Scope 1 and 2 emissions from iron and steelmaking activities.

2.4 Assumptions and exclusions

The following were excluded from the GHG assessment:

- The scope of this assessment did not include detailed analysis of Scope 3 emissions. Scope 3 emissions associated with construction of the project will be comparable to when BlueScope undertakes periodic maintenance shutdowns and are considered relatively minor. The Scope 3 emissions associated with the operation of 6BF will not materially differ from existing operations, given 5BF and 6BF use the same technology to make iron, and only one furnace will be operating at a time. The Scope 3 emissions from the production of iron ore and coal will therefore remain relatively consistent and as such, a detailed analysis of Scope 3 emissions has not been undertaken.
- No significant vegetation clearing is required by the project with the exception of some weeds on established hardstand areas. Therefore, emissions associated with vegetation clearing are negligible and do not require further consideration.
- Emissions during the operation of the project which are likely to be negligible compared with other emissions from the proposal, include:
  - Emissions associated with combustion of fuels used in minor quantities such as LPG, gasoline, solvents, oils and greases during maintenance and inspection activities.
  - Emissions associated with the leakage of hydrofluorocarbons. The project may use negligible quantities of hydrofluorocarbons for refrigeration and air conditioning during operation of the proposal, and therefore have not been included in this assessment.
- Emissions during the operation of the project which will be the same as current operations, including:
  - Transport of workers to site
  - Transport of raw materials to the site
  - Transport of products and co-products from the site

3. Industry, legislative and policy context

3.1 Secretary's environmental assessment requirements

Table 3.1 outlines the SEARs relevant to GHG.

Table 3.1 Greenhouse gas SEARs

Requirements	Where addressed
An assessment of the greenhouse gas emissions of the project and any measures to minimise emissions intensity, improve energy efficiency and adopt new technologies to reduce emissions in the medium to long term	– Section 5 impact assessment – Section 6 GHG reduction measures and technologies – Section 7 mitigation measures

3.2 Steel industry context

The traditional blast furnace methodology for iron and steel production is carbon intensive: the process relies on the stripping of oxygen from ferrous ores using carbon (in the form of coke) as the reductant. Currently, approximately 73% of the world's iron production is via the blast furnace pathway. Every tonne of steel globally produced across all steel manufacturing technologies in 2020 emitted, on average, 1.85 tonnes of CO_2, equating to 7 to 9 percent of global CO_2 emissions in that year (Worldsteel Association, 2021). Consequently, steel manufacturers across the globe are increasingly facing a decarbonisation challenge. This challenge is driven by three key developments that go beyond the Paris Agreement (McKinsey & Company, 2020):

– *Further tightening of carbon emission regulations.* This is manifested in CO_2 reduction targets, as well as rising CO_2 emission prices as outlined in the European Green Deal.

– *Growing investor and public interest in sustainability*. For example, the Institutional Investors Group on Climate Change, a global network with 250-plus investors and over USD 30 trillion in assets under management, has raised expectations for the steel industry to safeguard its future in the face of climate change. At the same time, global investment firm BlackRock has confirmed its commitment to environmentally responsible business development and sustainable investing.

– *Changing customer requirements and growing demand for carbon-friendly steel products*. A trend that has already been observed in various industries, including the auto industry, where manufacturers have the aim of eliminating carbon emissions completely from their entire value chains (including their suppliers) and taking on a full life cycle perspective in future.

A recent study of 20 global steelmakers estimates that the global steel industry may find approximately 14 percent of steel companies' potential value is at risk if they are unable to decrease their environmental impact under a 2°C scenario (refer to Section 3.3.1 for more information regarding Intergovernmental Panel on Climate Change, climate scenario), where global carbon prices rise to USD 100 per tonne of CO_2 (McKinsey & Company, 2020). Results range from 2 percent to 30 percent for individual companies.

To reduce its GHG emissions, the steel industry has identified a range of measures to be implemented. These are reflected in BSL's first Climate Action Report published in 2021 (Climate Action report), and include:

– Reducing emissions in response to climate science, technology availability and the timing of key investment decisions

– Creating carbon efficient and climate resilient solutions for customers

– Increasing the use of affordable and reliable renewable energy

– Using quality, cost-effective carbon offsets only where direct abatement is not feasible

– Making the case for local, sustainable steel use

– Monitoring and appropriately managing climate risks and engaging with external stakeholders and partners.

BlueScope and BSL acknowledge the part they can play in the steel industry's transition to net zero. The Climate Action Report, the contents of which are discussed further in section 3.7, describes the strategies which will underpin this transition for BSL, including the transition which has already commenced and which will continue at BlueScope's PKSW.

It should also be acknowledged that steel is a fundamental part of any future renewable economy. Steel will be required for all alternative energy systems used to power the economy in the future. Further, steel is a fundamental part of the circular economy, being infinitely recyclable. In playing its part in supplying materials to drive the renewable economy BlueScope and BSL acknowledge that this needs to be undertaken with reduced CO_2 intensity.

3.3 Global policy context

Australia is one of 191 countries plus the European Union that have committed to keeping global temperature rises to well below 2°C through the Paris Agreement under the United Nations Framework Convention on Climate Change (Paris Agreement). Over 73 of these countries, including Australia, have set a goal of reaching net zero GHG emissions by 2050. Some countries may also start acting beyond the commitments of the Paris Agreement. Action on climate change at the diplomatic and national levels is mirrored in many parts of the global community. Details of Australia's commitment to meeting globally agreed targets are outlined in Section 3.4.

More than 175 of the world's largest companies have committed to reducing their emissions to net zero by 2050, and local governments and community groups are increasingly looking for opportunities to invest in emissions reduction initiatives. The Intergovernmental Panel on Climate Change (IPCC) provides scientific information on anthropogenic climate change which is relied upon in global agreements (such as the Paris Agreement) on how to mitigate and adapt to future climatic conditions.

3.3.1 Intergovernmental Panel on Climate Change

The IPCC strongly recommends limiting the global temperature increase to 1.5°C, to prevent the impacts of climate change significantly increasing. These impacts amplify rapidly between just 1.5°C and 2°C of temperature increase. The IPCC has reported that limiting global warming to 1.5°C will require "rapid and far-reaching" transitions in land, energy, industry, buildings, transport, and cities. Global net human-caused emissions of CO_2 will need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050. This means that any remaining emissions will need to be balanced by removing CO_2 from the air (IPCC, 2021). The ideal scenario to slow warming would be Representation Concentration Pathways (RCPs)[1] 2.6, however, according to the IPCC the world is on track for RCP 6.0 or RCP 8.5 if no measures are implemented in the next decade (IPCC, 2021). Table 3.2 details the IPCC's RCPs.

Table 3.2 Climate Change Emission Scenarios

Global climate response	Climate scenario	Projected increase in global surface temperature	IPCC report source
Strong immediate response, emissions peak by 2020, with rapid decline in emissions thereafter from global participation and application of technologies	**RCP 2.6**, atmospheric concentration of CO_2 projected at approximately 420 ppm by 2100	Mean projected increase **1.0°C** Anomaly range +0.3 to 1.7°C (by 2081 – 2100)	Assessment Report (AR)5 (IPCC, 2014)
Slower response, emissions peak around 2040, then decline	**RCP 4.5**, atmospheric concentration of CO_2 projected at approximately 540 ppm by 2100	Mean projected increase **1.8°C** Anomaly range +1.1 to 2.6°C (by 2081 – 2100)	AR5 (IPCC, 2014)

[1] RCPs are concentration pathways used in the IPCC which show different greenhouse gas concentration (not emissions) trajectories to illustrate possible climate futures (e.g. a high emissions future meaning increased temperatures or a low emissions future with less temperature increase) which are dependent on the volume of GHG emissions in the future.

Global climate response	Climate scenario	Projected increase in global surface temperature	IPCC report source
Slow response, application of mitigation strategies and technologies	**RCP 6.0**, atmospheric concentration of CO_2 projected at approximately 660 ppm by 2100	Mean projected increase **2.2°C** Anomaly range +1.4 to 3.1°C (by 2081 – 2100)	AR5 (IPCC, 2014)
Little curbing of emissions, continuing rapid rise throughout the 21st century	**RCP 8.5**, atmospheric concentration of CO_2 projected at approximately 940 ppm by 2100 and continuing to increase	Mean projected increase **3.7°C** Anomaly range +2.6 to 4.8°C (by 2081 – 2100)	AR5 (IPCC, 2014)

3.4 National policy context

The Australian government is taking a technology led approach, implemented via a whole-of-economy plan, to achieve a net zero emissions target by 2050. This plan is outlined in *Australia's Long-Term Emissions Reduction Plan* (Australian Government, 2021).

3.4.1 Australia's Long-Term Emissions Reduction Plan

Australia's Long-Term Emissions Reduction Plan (the Plan), published in 2021, is a whole-of-economy plan that aims to achieve net-zero emissions by 2050. The Plan emphasises the Australian Government's commitment to promoting employment, particularly in regional Australia, whilst also continuing to pursue opportunities for economic growth through international partnerships.

The Plan relies on lowering technology costs as opposed to raising taxes to reduce emissions. Examples of technology that will be promoted under the Plan include clean hydrogen, low-cost solar, energy storage, low emissions steel and aluminium, carbon capture and storage and soil carbon. The Plan aims to not only lower the costs of these existing technologies, but also to investigate emerging technologies such as livestock feed to reduce methane emissions. Approximately $20 billion of Government funding will underpin this Technology Investment Roadmap by 2030.

By maintaining a focus on expanding choices for Australian consumers and businesses, the Plan aims to incentivise buy-in and promote interest in developing industry specific decarbonisation plans with realistic targets and an attitude of accountability. By utilising a holistic, all-economy approach, the Plan aims to create clean energy supply chains involving all market sectors. This is based on a four-pronged approach which includes:

- Driving down technology costs
- Enabling development at scale
- Seeking opportunities in new and traditional markets
- Fostering global collaboration

The Plan highlights the crucial role that needs to be played by regional industries, including industries in the traditional energy production and energy intensive sectors which, according to the Plan, have formed the backbone of Australian exports. The Plan advocates for a voluntary decarbonisation approach as it acknowledges the ongoing demand for coal, gas and carbon intensive exports globally. The Plan reflects the view of the Australian Government that transitioning to other energy producing or utilising industries, such as clean hydrogen and renewable energy, requires a delicate balancing act as Australia aims to retain its position as a global exporter of coal and gas in the interim (Australia Government, 2021).

The Plan outlines how the Australian Government plans to achieve net zero GHG emissions by 2050. As discussed later in this report, the project incorporates technologies which will, immediately upon commencement of ironmaking from the relined 6BF, reduce GHG emissions intensity from iron and steelmaking at PKSW relative to emissions from current operations. In addition, the project includes features to facilitate transition to emerging new low emissions technology once proven at commercial scale. The project is therefore consistent with the aims and objectives of the Plan.

3.5 State policy context

3.5.1 NSW 2040 Economic Blueprint

The NSW 2040 Economic Blueprint (NSW Government 2019) (the Blueprint) aims to inform views on what the NSW economy can achieve over the next two decades. The Blueprint has been informed by research on economic, jobs and productivity trends, and through broad consultation with various stakeholders. The Blueprint identifies a range of recommendations to enhance the performance of the NSW economy guided by the following aspirations:

- A two-trillion-dollar economy after 2040
- Healthy, productive people
- Vibrant, well-connected cities
- Productive, vibrant regions
- Innovative, world-class businesses
- Sustainable environmental and resources management
- Better government performance

A key aspect of the Blueprint in achieving the above aspirations is a focus on economic growth, advanced manufacturing and new industries. The project will contribute to these areas through the significant capital investment being made, and the jobs and revenue it will deliver to the NSW economy, once operational and also during construction. Additionally, the continued production of steel at PKSW will benefit downstream manufacturing industries, helping to promote the development of advanced GHG reduction mechanisms, for example, by supplying steel for renewable energy infrastructure and projects.

In relation to the aspiration of innovative, world-class businesses, the Blueprint recommends encouraging high growth future industries, more advanced manufacturing, and growing the local defence industry supply chain. The project will help realise these recommendations by maintaining the domestic supply of steel products to manufacturing businesses within these sectors. This will contribute to the State's capacity to secure defence procurements and facilitate the growth of new businesses and industries, as well as reduce the transport of materials from overseas, thereby decreasing transport-related GHG emissions. The Blueprint identifies that sustainable environmental and resource management is required to have an innovative industrial base, liveable cities, productive jobs, and high living standards.

The potential impacts of the GHGs from the project and associated reduction measures have been assessed throughout this report. BlueScope has incorporated commercially proven GHG reduction technologies into the project, as well as measures which will facilitate the transition to emerging new low emissions technology once proven at commercial scale. The project is therefore considered to be consistent with the aspiration of sustainable environmental and resource management.

3.5.2 NSW Climate Change Policy Framework

The NSW Government has released the NSW Climate Change Policy Framework, which commits NSW to the aspirational objectives of achieving net zero emissions by 2050, helping NSW to become more resilient to a changing climate.

The policy framework defines the NSW Government's role in reducing GHG emissions and adapting to the impacts of climate change. The Net Zero Plan Stage 1: 2020-2030 (Net Zero Plan) is the first stage implemented under the NSW Climate Change Policy Framework. It outlines how the NSW Government's climate change objectives will be achieved over the current decade. Plans for the following two decades will be released in stages to enable incorporation of evolving technologies, and to allow for continual improvement over time with the aim of achieving net zero emissions by 2050.

Net Zero Plan Stage 1: 2020–2030

The Net Zero Plan Stage 1: 2020–2030 outlines four key priorities for reducing emissions in the period 2020 to 2030. These are:

– Drive uptake of proven emission reduction technologies
– Empower consumers and businesses to make sustainable choices
– Invest in the next wave of emissions reduction innovation
– Ensure that NSW leads by example

As discussed in section 6, BlueScope has incorporated commercially proven GHG emission reduction technologies into the project, as well as measures which will facilitate the transition to emerging new low emissions technology once proven at commercial scale. The project is therefore consistent with the NSW Climate Change Policy Framework and Net Zero Plan Stage 1: 2020–2030.

3.6 Local policy context

Wollongong City Council (Council) has developed and implemented the following plans and strategies of relevance to GHG:

– Wollongong City Council Climate Change Mitigation Plan 2020
– Sustainable Wollongong 2030

3.6.1 Climate Change Mitigation Plan 2020

The objectives of Wollongong City Council's Climate Change Mitigation Plan 2020 are to:

1. Lead the community in emissions reduction and climate change action.
2. Reduce Council's GHG emissions through effective energy management and improving energy efficiency.
3. Reduce Council's GHG emissions through the increased use of renewable energy and alternative fuels.
4. Reduce Council's GHG emissions from landfill through resource recovery and gas capture.
5. Support the community and businesses to reduce their GHG emissions.

3.6.2 Sustainable Wollongong 2030

The Sustainable Wollongong 2030 strategy outlines how the City of Wollongong will work together with key stakeholders to create a sustainable future and a more liveable city. The strategy provides the overarching framework and goals to create a sustainable Wollongong. It identifies six priority areas and six related goals relevant to fostering increased sustainability in Wollongong. Of relevance to the project are:

– Priority area 1 goal: Environmental and climate leadership underpins Council decision-making and service delivery which inspires the same in others.
– Priority area 2 goal: Together protect our environment, reduce emissions and increase resilience to climate change.
– Priority area 3 goal: We will achieve net zero emissions by 2030 for Council operations and together achieve net zero emissions by 2050 for the city.

As a significant employer and contributor to the local community, BlueScope is cognisant of the role it plays in assisting the Council in achieving its goals. As demonstrated by BSL's Climate Action Report, BlueScope, as the largest Australian company within the BSL group of companies, is committed to showing leadership in reducing emissions from its operations. The project, through the incorporation of GHG reduction technologies which have been proven to be viable at commercial scale, as well as measures which will allow for the transition to emerging new low emissions technology once proven at commercial scale, is consistent with the goals of both the Council's Climate Change Mitigation Plan 2030 and the Sustainable Wollongong 2030 strategy.

3.7 BlueScope context

BlueScope's parent company, BSL, has embedded climate strategy into its corporate strategy and has set a goal of pursuing net zero GHG emissions across its global operations by 2050. Achieving the 2050 net zero goal is highly dependent on several enablers, including the commerciality of emerging and breakthrough technologies, the availability of affordable and reliable renewable energy and hydrogen, the availability of quality raw materials, and the appropriate policy settings. BSL has also established medium term targets of a 12% improvement in Scope 1 and 2 GHG emissions intensity by 2030 for its steelmaking activities, and a 30% improvement GHG emissions intensity by 2030 for its non-steelmaking activities[2].

The company has taken a range of measures to enhance its management of climate change risks and opportunities, including reporting annually in line with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). The importance of the climate change strategy is evidenced by the refocus of the Board Committee previously known as the Audit and Risk Committee to issues around sustainability, including climate change, and the corresponding change of name to the Risk and Sustainability Committee of the Board. The company has also established a Climate Change Council, introduced shadow carbon pricing for the evaluation of major capital projects, and invested in a solar power purchasing agreement equivalent to 20 per cent of its Australian electricity consumption. In February 2021, BSL appointed a Chief Executive Climate Change to lead its global climate change response and help drive the company's decarbonisation pathway.

BlueScope and BSL are also participating in and leading several collaborations with industry and research organisations, including ResponsibleSteel, the Net Zero Steel Pathway Methodology Project, the Australian Industry Energy Transition Initiative project, and with the University of Wollongong.

To achieve net zero emissions in steelmaking, commercialisation of breakthrough technologies and supporting infrastructure will be needed. The availability of breakthrough low carbon ironmaking technologies has been an important consideration in assessing options for the future configuration of PKSW. As these technologies require significant development, and are unlikely to be commercially viable at industrial-scale for use in the specific circumstances at Port Kembla Steelworks prior to the end of the current 5BF campaign, the most technically feasible and economically viable option for BlueScope at this time is to progress with the project. As emerging and breakthrough technologies are developed over time to full commercial scale, the strong cash-flows and earnings capability of the Australian Steel Products business, of which BlueScope is a part, is expected to provide significant capacity to transition to these technologies as and when they become technically and commercially viable for use in the Australian context. While breakthrough technologies continue to be developed, there is scope to optimise production processes to reduce GHG emissions through existing and emerging technologies.

Raw material availability will be crucial to secure steel production capability in the near and longer term and to support the transition to net zero. Securing access to the raw materials that are currently used in the blast furnace process, such as metallurgical coal, will be critical in the early transition period, as will be securing future raw material requirements, such as Direct Reduced Iron (DRI) and renewable hydrogen.

BSL and BlueScope are working with partners across the industry, including research and academic bodies to explore emerging and breakthrough technologies to support their decarbonisation pathway. In October 2021 BSL and Rio Tinto signed a Memorandum of Understanding (MOU) to research and design low-emissions processes and technologies for the steel value chain across iron ore processing, iron and steelmaking and related technologies. The two priority action areas for immediate exploration are:

– **Hydrogen Direct Reduction and Iron Melter**

  This concept will involve producing a low emissions iron feed for consumption at Port Kembla and will explore the direct reduction of Rio Tinto's Pilbara iron ores, with the intent of using renewable hydrogen produced from renewable electricity. The direct reduced iron (DRI) from this process will be melted in an electrical furnace, powered with renewable electricity, to produce iron suitable for the steelmaking process.

– **Enhancing existing processes**

  BSL and Rio Tinto will cooperate to explore the development of projects involving iron ore processing and technologies directed at reducing carbon emissions from existing iron and steelmaking processes.

[2] The Climate Action Report contains further details on the Climate Change strategy and the scope and boundaries of the net zero goal and medium term targets

In December 2021, BSL signed a Memorandum of Understanding with Shell Energy Operations Pty Ltd to collaborate on two projects:

– **Pilot renewable hydrogen electrolyser plant at the Port Kembla Steelworks**
  This initial project will investigate designing, building and operating a 10 MW renewable hydrogen electrolyser to explore and test the use of renewable hydrogen in the blast furnace at BlueScope's Port Kembla Steelworks. The ambition is to demonstrate hydrogen as a pathway towards low emissions steelmaking. The hydrogen could also potentially be used for other purposes, such as to feed a pilot direct reduced iron (DRI) plant.
– **Ilawarra hydrogen hub concept**
  The MoU also provides for BlueScope and Shell to collaborate with other organisations to explore a "hydrogen hub" in the Illawarra. This project will explore options for hydrogen supply and offtake, renewable energy supply and hydrogen and electricity infrastructure. The project will also examine the logistics infrastructure required for a commercially viable hydrogen supply chain in the Illawarra.

Along with its Finley Solar Farm Power Purchase Agreement in NSW, in late 2020 BSL announced a $20 million investment to develop a Renewable Manufacturing Zone at PKSW. Half of this investment will be allocated to companies aspiring to build manufacturing capability, particularly in the renewable energy sector in NSW, with an immediate focus on supporting the manufacture of wind tower, solar farm, and pumped hydro electricity transmission facilities. The remaining half of the investment will be directly investing into PKSW to support the development of technology solutions in steelmaking, such as the development of renewable hydrogen projects.

3.7.1 BlueScope Steel Limited's Climate Action Report

In 2021, BSL published its first Climate Action Report (BSL, 2021). The Climate Action Report builds on BSL's earlier reporting on climate change issues over several years in its annual Sustainability Reports and, prior to that, in its annual Community, Safety and Environment reports.

The Climate Action Report outlines its goal of pursuing net zero scope 1 and 2 GHG emissions across all BSL operations by 2050. The Climate Action Report acknowledges that achieving this goal is dependent on several enablers including:

– Evolution of emerging and breakthrough technologies to viable, commercial scale.
– Access to affordable and reliable renewable energy.
– Availability of appropriate volumes of competitively priced hydrogen from renewable sources.
– Access to appropriate quality and quantity of raw materials in both the near and longer-term.
– Public policy that supports investment in decarbonisation and avoids risk of carbon leakage.

For its steelmaking sites, including PKSW as well as its sites in North America and New Zealand, BSL's mid-term goal is to achieve a 12 per cent Scope 1 and 2 GHG emissions intensity reduction target by 2030, relative to FY2018. This translates into a target of 1 per cent year-on-year emission intensity reduction (from the 2018 baseline) across steelmaking activities. In addition, for its non-steelmaking activities, BSL has set a target of a 30 percent reduction in Scope 1 and 2 emissions by 2030, also relative to FY2018.

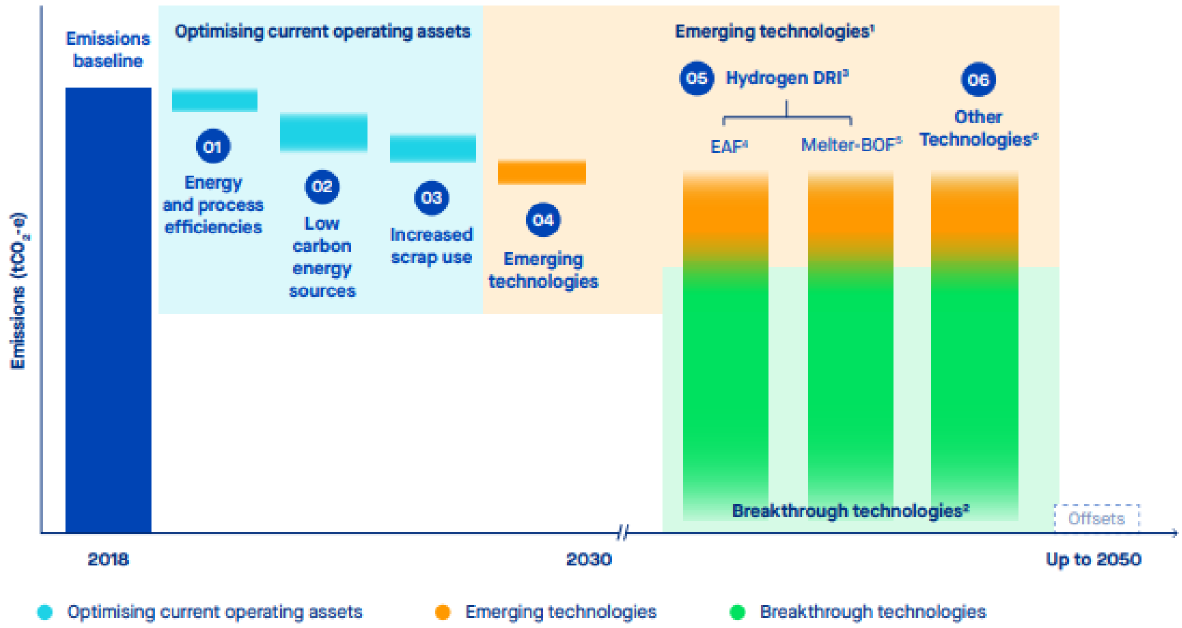
The decarbonisation pathway for steelmaking is represented visually in the Climate Action Report and is shown in Figure 3.1.

While the opportunities described in the Climate Action Report remain under assessment and development, BlueScope and BSL have taken a range of measures to enhance their management of climate change risks and opportunities, including reporting annually in line with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). The importance of the climate change strategy is evidenced by the refocus of the Board Committee, previously known as the Audit and Risk Committee, to issues around sustainability, including climate change, and the corresponding change of name to the Risk and Sustainability Committee. BSL has also established a Climate Change Council and introduced shadow carbon pricing for the evaluation of major capital projects. In February 2021, BSL appointed a Chief Executive Climate Change to lead its global climate change response and help drive the company's decarbonisation pathway.

BlueScope and BSL are also actively participating in and leading several collaborations with industry and research organisations, including World Steel, Responsible Steel, the Net Zero Steel Pathway Methodology Project, the Australian Industry Energy Transition Initiative project, and with the University of Wollongong.

INDICATIVE IRON- AND STEELMAKING DECARBONISATION PATHWAY

Details of each technology option that corresponds to the below Figure[7] is outlined in the following section.



1 Emerging technologies refers to demonstrated technology that is commercially available but requires further application to integrated steelworks, e.g. biochar, hydrogen tuyere injection, etc.
2 Breakthrough technologies refers to technology not yet commercialised, currently at concept or pilot stage, or not yet applied to integrated steelworks (e.g low Technology Readiness Level (TRL)).
3 Contingent upon feasible supply of hydrogen from renewable sources.
4 Requires suitable high-grade ores, estimated at less than 15% of available ores and access to cost-effective energy sources.
5 For Melter-BOF, DRI-melter replaces the blast furnace. Maintains existing BOF and caster infrastructure, and allows a wider range of ores to be used.
6 Other technologies include CCUS, electrolytic reduction, etc.
7 Each technology option is allocated a number which corresponds to information outlined in this section.

Figure above: BlueScope's indicative decarbonisation pathway for our iron- and steelmaking activities.

Note: this diagram is not intended to present a checklist of sequential projects that will be implemented by BlueScope; pursuit of one project may preclude or impact the economics for other projects. This is especially true for options that require significant reconfiguration of existing facilities/process routes, or would result in duplicative production routes such as those included in 05 and 06.

Figure 3.1 ***Indicative iron and steelmaking decarbonisation pathway (BSL Climate Action Report, 2020)***

BSL and BlueScope GHG reductions progress

Since FY2018 BSL has reduced its steelmaking GHG emissions intensity by 1.8 per cent (that is, across the three steelmaking sites in PKSW, North America and New Zealand), and has also reduced the GHG emissions intensity of its midstream non-steelmaking activities by 6.3 per cent.

Taking a longer-term perspective, since 2005, absolute GHG emissions from BSL's steelmaking operations have decreased by 28 per cent, while GHG emissions intensity has reduced by 21 per cent.

Greenhouse gas reduction measures are further outlined in Chapter **Error! Reference source not found.**. The commitment of BlueScope and BSL to meeting the GHG objectives set out in the Climate Action Report is demonstrated by the GHG reductions achieved to date as well as the significant investment which continues to be made in reducing the GHG intensity of operations at Port Kembla and across BSL's global footprint.

3.7.2 BlueScope Steel Limited Sustainability Report FY2021

The FY2021 BSL Sustainability Report outlines BSL's strategy for achieving its sustainability goals, including the Climate Change goals for BSL and BlueScope described in Section 3.7.1. BSL's strategy emphasises the need for strong returns and sustainable outcomes over the next five years and beyond, with investment in carbon reduction technologies a core element of the strategy, alongside product and service innovation and delivery of safe, inclusive and diverse workplaces.

3.8 GHG applicable legislation and guidelines

Legislation and guidelines applicable to the GHG assessment include:

- National Greenhouse and Energy Reporting Act 2007 (NGER Act)
- National Greenhouse and Energy Reporting Regulations 2008
- National Greenhouse and Energy Reporting (Measurement) Determination 2008
- National Greenhouse and Energy Reporting Regulations 2008
- National Greenhouse Accounts Factors 2021
- AS ISO 14064-1:2006 Greenhouse gases – Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals
- Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol) (World Business Council for Sustainable Development and World Resources Institute, 2015)
- Intergovernmental Panel on Climate Change Sixth Assessment Report (2021)

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

NSW State legislation does not currently include any specific requirements in relation to GHG assessments for industrial projects. As detailed in Section 3.1, the SEARs do not mandate a specific standard, protocol, or methodology for the GHG assessment. As a subset of the requirements for assessment of air quality impacts, the SEARs require an assessment of the GHG emissions of the project and any measures to minimise emissions intensity, improve energy efficiency and adopt new technologies to reduce emissions in the medium to long term.

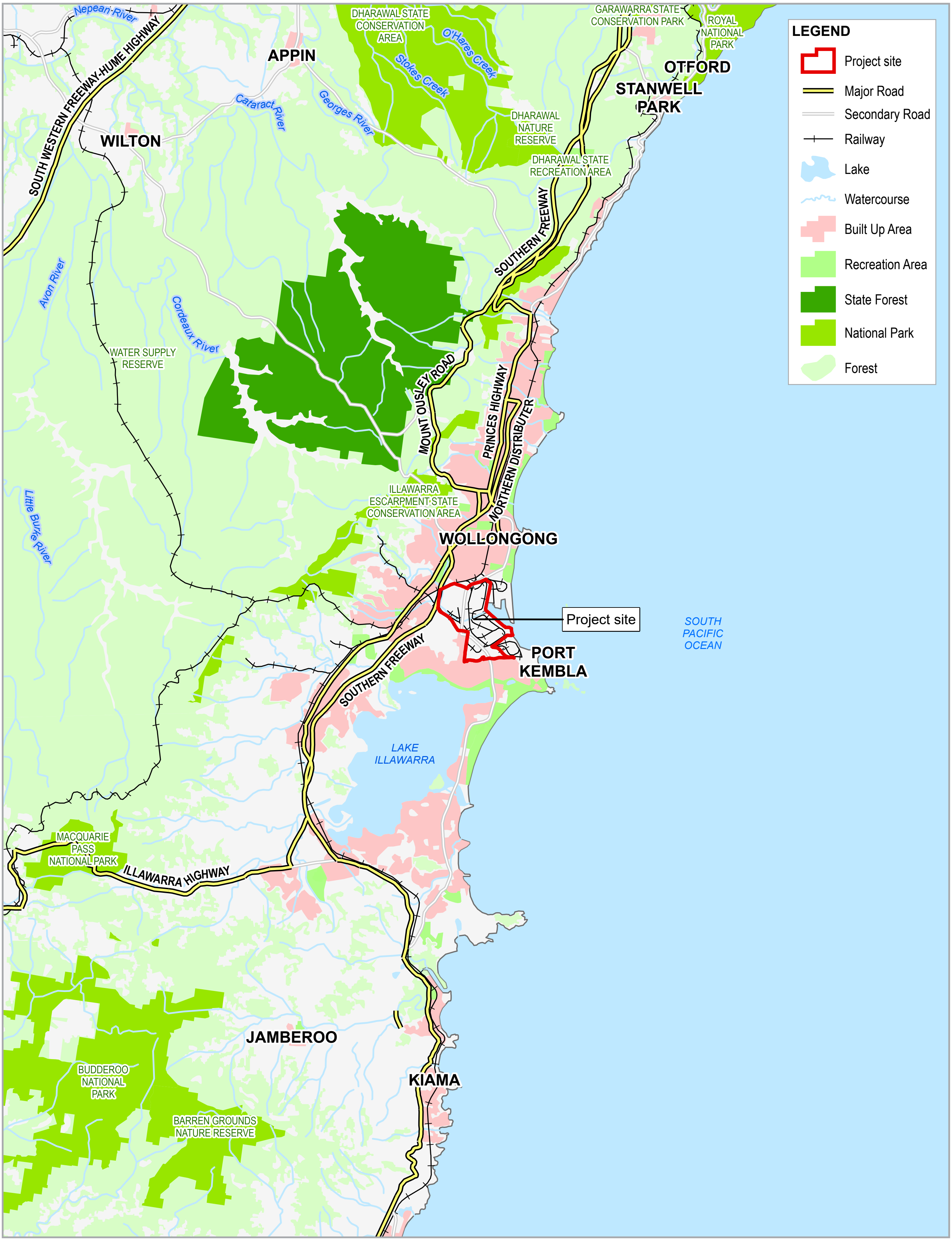
4. Existing environment

4.1 Overview

The project is located within an industrial site of approximately 750 hectares (ha) at Port Kembla in the Wollongong LGA and Illawarra region of NSW. Sydney is approximately 80 kilometres (km) to the north of Port Kembla, while the Wollongong central business district is approximately 2.5 km to the north and Lake Illawarra is approximately 3 km to the south. Port Kembla is the main industrial centre of the Illawarra region.

Key features of Port Kembla are the heavy industrial area and the port, including industrial developments such as PKSW, fertiliser production facilities and petroleum hydrocarbon storage and wholesaling. PKSW is zoned IN3 Heavy Industrial and the port of Port Kembla is zoned SP1 – Special Activities. The Inner Harbour, specifically developed as an all-weather shipping port, covers approximately 60 ha with around 2.9 km of commercial shipping berths. BlueScope operates five berths in the Inner Harbour that supply materials for PKSW.

The area surrounding Port Kembla industrial area is primarily occupied by residential development. These urban areas provide small and large-scale retail outlets, community services (e.g. medical facilities, hospital, schools and sporting facilities) and commercial facilities (e.g. banking and post office). The closest urban developments to PKSW are the suburbs of Cringila, Berkeley, Lake Heights, Warrawong and Port Kembla to the south, and Unanderra, Cobblers Hill, Mount St Thomas, Coniston and Figtree to the north and west. The urban areas of Cringila are located adjacent to the No. 1 Works and No. 2 Works areas and are the nearest to the project area, being approximately 1.2 km to the southwest as shown on Figure 4.1 and Figure 4.2.



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Map Projection: Transverse Mercator
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BlueScope Steel Ltd
No.6 Blast Furnace Reline and Operations
Greenhouse Gas Report

Regional Location

Project No. **12541101**
Revision No. **0**
Date **04/02/2022**

FIGURE 4-1

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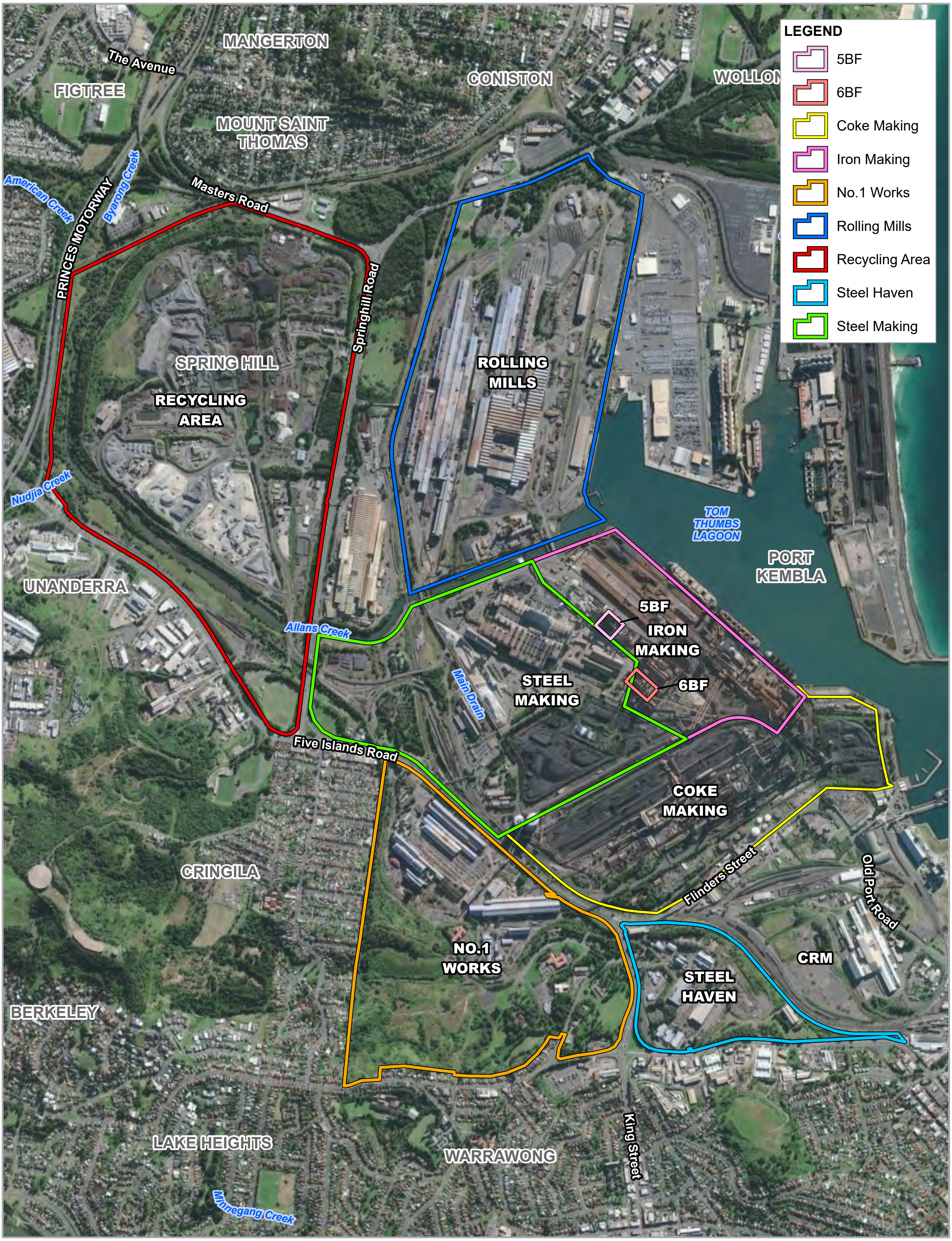

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Kilometres

Map Projection: Transverse Mercator
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GHD

BlueScope Steel Ltd
No.6 Blast Furnace Reline and Operations
Greenhouse Gas Report

Port Kembla Steelworks site layout and locality

Project No. 12541101
Revision No. 0
Date 04/02/2022

FIGURE 4-2

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4.2 Port Kembla Steelworks

PKSW currently operates as an integrated iron and steel plant utilising Blast Furnace ironmaking and Basic Oxygen Furnace steelmaking (BF-BOF operating model). The plant is co-located with hot rolling mills for plate and coil and has adjacent manufacturing facilities for cold rolling, coated products, flat products and welded beams. The plant's current output is approximately 3.1 million metric tonnes of steel per year (Mtpa). Of the steel produced, around 2.5 Mtpa services the domestic market with the remainder being exported. PKSW is Australia's only manufacturer of upstream flat steel products. Together, PKSW and the other facilities owned by BSL around Australia employ approximately 6,200 people.

Iron and steelmaking via BF-BOF technology, as is used at PKSW, results in the production of GHGs as a by-product of the reduction reaction used to convert the iron ore into iron. GHGs produced by current operations at PKSW are predominantly CO_2, with low levels of methane (CH_4) and sulphur hexafluoride (SF_6).

BSL reports annually on its total Australian net energy consumption and GHG emissions under the National Greenhouse and Energy Reporting Scheme (NGERS) in accordance with the methodology prescribed by the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Measurement Determination). The GHG emissions from PKSW, as well as its energy use and consumption, are included in BSL's report.

The Measurement Determination recognises the complexity of measuring GHG emissions from an integrated steelworks in which the BF is not operated independently from other steelmaking processes. The Measurement Determination provides a specific methodology to determine emissions arising from the use of coke as a carbon reductant (called a carbon mass balance approach) which involves:

- Calculating the carbon content of fuels and other carbonaceous inputs.
- Calculating the carbon content in products leaving the activity (that is, of an integrated steelworks) during the relevant year.
- Calculating the carbon content in waste by-products leaving the activity during the relevant year, other than as an emission of greenhouse gas.
- Calculating the carbon content in the amount of the change in stocks of inputs, products and waste products held within the boundary of the activity during the relevant year.

This approach is used to determine the majority of GHG emissions from PKSW, which arise from the use of metallurgical coal in the iron and steelmaking process, comprising approximately 92 per cent of total GHG emissions from PKSW in any one year. The Measurement Determination does not require an allocation of GHG emissions to different plant areas within the integrated steelworks. Of particular relevance to the project, the gas generated by the blast furnace (Blast Furnace Gas or BFG) is captured and circulated around PKSW for use as an energy source, with the location of gas usage determined on a daily basis by operational need.

The integrated nature of the steelworks which makes it impracticable to assess GHG emissions from a single BF is demonstrated by the PKSW integrated operation diagram shown in Figure 4.3. The diagram illustrates the process flow from the material inputs, various operational facilities and respective output pathways, through to the Hot Strip Mill and Plate Mill where the steel is made into flat rolled products. It shows how Coke Ovens Gas (COG), generated during the cokemaking process, and BFG, are captured and circulated for use as an energy source across multiple operational facilities at PKSW from which emissions will ultimately occur.

BlueScope uses other methodologies provided under the Measurement Determination as required to capture other sources of GHG emissions from PKSW, such as those arising from fuel consumption (in particular, natural gas). Emissions from the use of electricity at PKSW are accounted for separately as required by the reporting requirements.

In financial year 2021, PKSW emitted a total of 6,868,848 tonnes of carbon dioxide equivalent (tCO_2-e), comprised of:

- Scope 1 emissions: 6,260,763 tCO_2-e
- Scope 2 emissions: 608,085 tCO_2-e.

The GHG emission intensity of steelmaking at PKSW (tonnes of CO_2-e per tonne of crude steel produced) reported for FY2021 was 2.14 tCO_2-e per tonne of crude steel produced.

BSL is a member of the World Steel Association (Worldsteel) and also participates in Worldsteel's climate action data collection program. In FY2020, the average GHG emissions intensity of steelmakers reporting to Worldsteel using BF-BOF technology was 2.33 tCO_2-e per tonne of crude steel produced. During this period, the GHG emissions intensity of steelmaking at PKSW was 2.21 tCO_2-e per tonne of crude steel produced, comparing favourably to the average reported by Worldsteel. For FY2020, PKSW was within the top quartile of reporters for integrated steel plants (i.e. lowest emitters), using the Worldsteel calculation methodology (based on ISO 14404 series).

Scope 3 emissions have been recently included in BSL's Sustainability and Climate Action Reports. The Climate Action Report refers to BSL's FY2021 commencement of reporting of its Scope 3 GHG emissions profile with its broader climate and sustainability disclosures. Based on the review of Scope 3 GHG emissions from existing operations and the fact that the majority of Scope 3 emission sources would be unchanged by the project, the move of ironmaking from 5BF to 6BF is unlikely to result in material change to Scope 3 emissions. While such Scope 3 emissions are not directly related to the project, as detailed in Section 3.7, BlueScope and BSL are committed to working with stakeholders and partners to reduce Scope 3 GHG emissions.

The co-products from steel manufacturing have many uses, including road base, cement manufacture, pigments and fertiliser. A key co-product produced at the blast furnace is Granulated Blast Furnace Slag which is used as a general cementitious replacement for Portland Cement in concrete construction to lower GHG emissions. The use of blast furnace slag from PKSW in this way supports the avoidance of more than 400,000 tCO_2-e of GHG emissions every year relative to traditional cement making processes. BlueScope will continue to investigate further opportunities to implement circular economy principles as a key component of waste management and reduction initiatives.

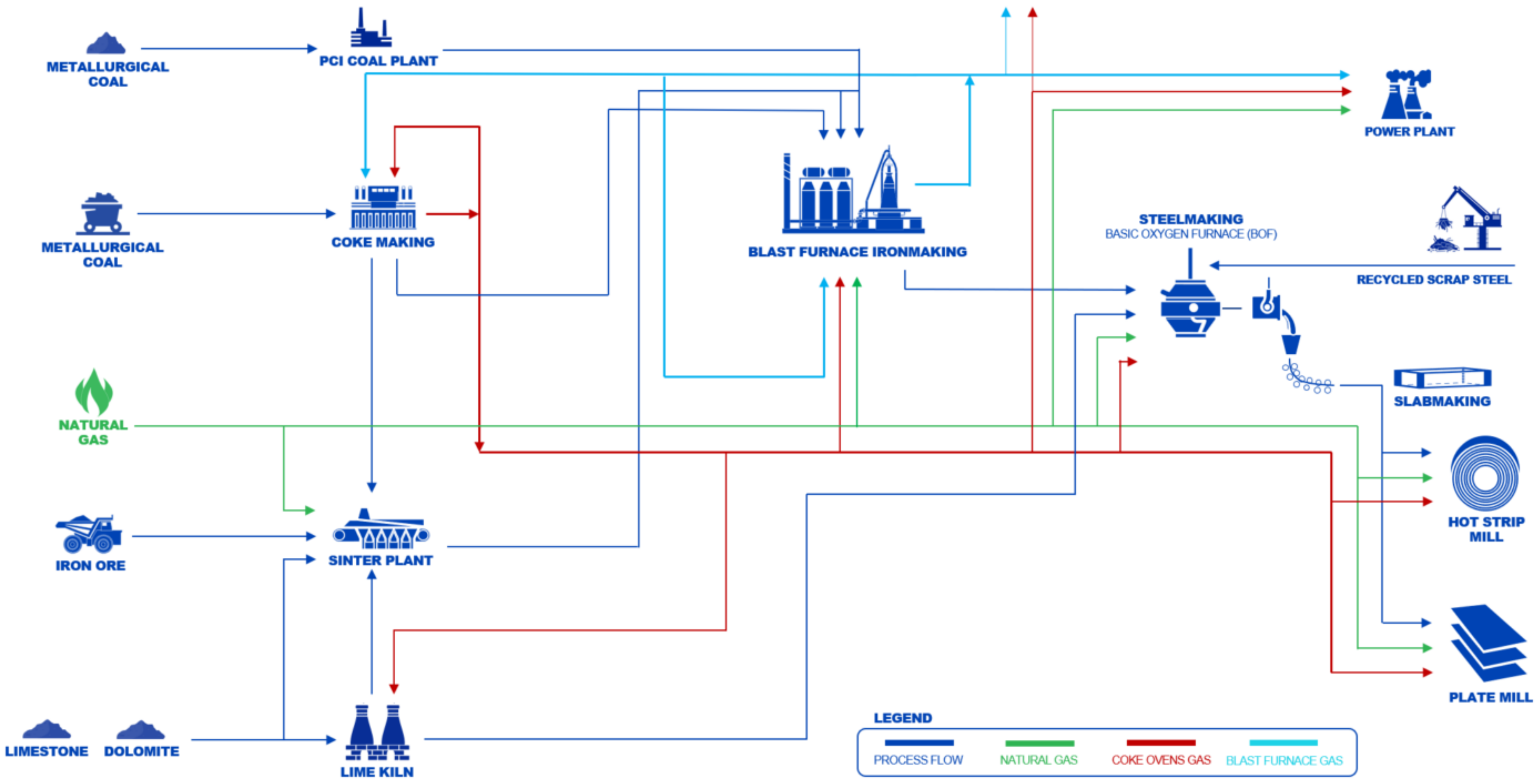


Figure 4.3 Integrated steelworks schematic

4.3 Project summary

The current operational campaign of 5BF is expected to extend to as late as 2030. Whilst the current furnace is operating well, as time moves closer to the campaign end date, the risk of unplanned shutdown will progressively increase as its condition deteriorates with age and use. By the mid-2020s, this risk is predicted to increase. For this reason, to prevent operational discontinuity and safeguard supply, it is considered prudent risk management to have 6BF ready for operation from mid to late 2026.

The project involves the relining of 6BF over a period of approximately 3 years to return it to service and commence ironmaking after 5BF ceases operation. For the purpose of the EIS and GHG assessment, the project area includes 6BF and the operational emissions. The project area is shown in Figure 4.4.

The reline of the furnace initially involves removal of remaining burden material and iron skull, followed by stripping of the staves, refractories and hearth from inside the shell. In places, repairs to the furnace shell will be required. Once stripped, installation of the new hearth, sidewall refractories and staves will be completed, together with repairs/replacement of the tuyeres, tapholes, furnace cooling systems and instrumentation. Significant work will also be required to prepare each of the 6BF ancillary systems for continuous operation across the length of the new campaign. Following construction, 6BF will be commissioned and ramped up for operation. Cold commissioning of 6BF will occur while 5BF remains operational, however ironmaking at 5BF will conclude prior to ironmaking commencing at 6BF. The project will see advances in technology being used including several improvements in 6BF compared to the currently operating 5BF, resulting in lower overall emissions from the site.

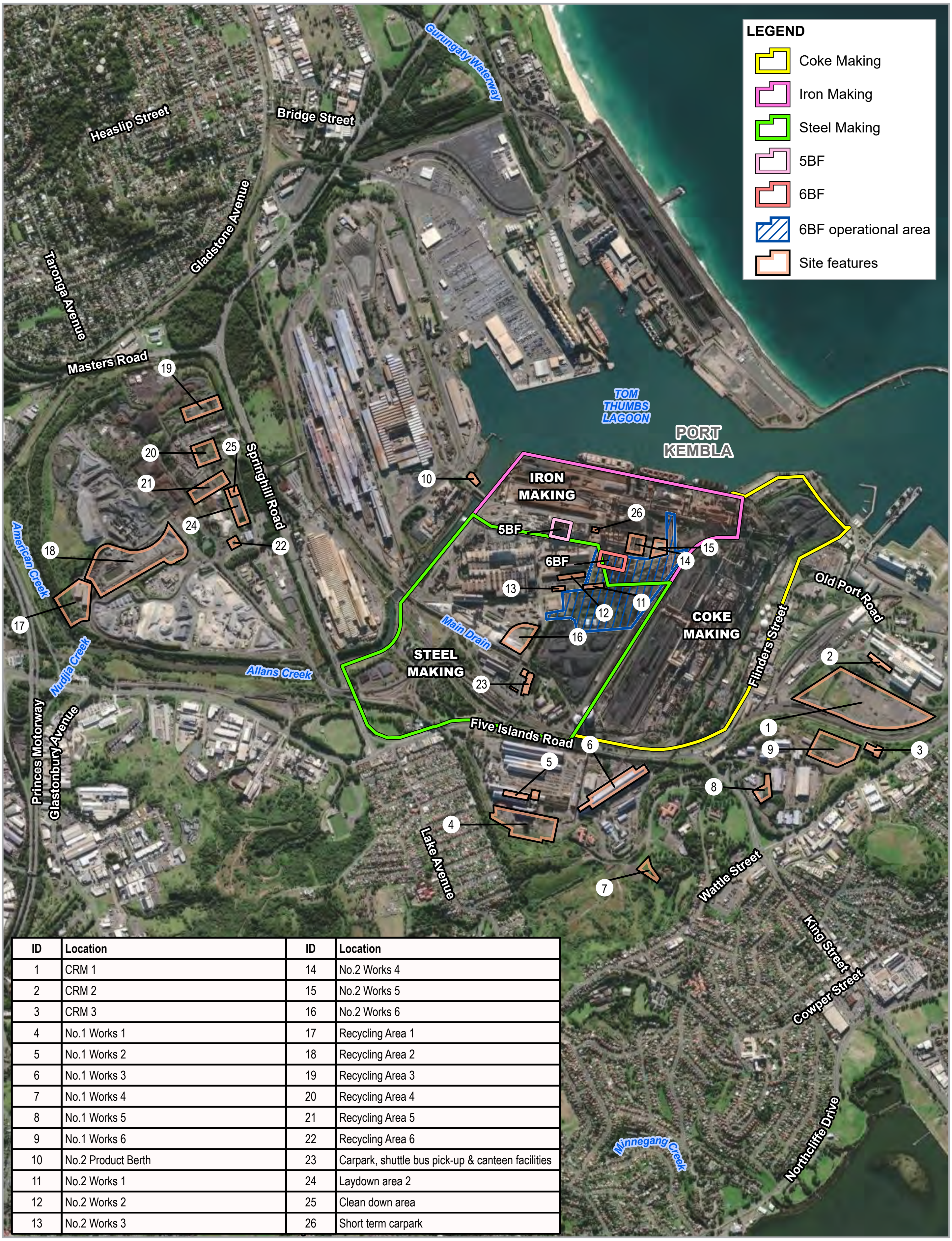
A summary of the key project elements and characteristics is provided in Table 4.1.

Table 4.1 Project summary

Project element	Summary
Construction	Major construction work will be required within the blast furnace and surrounding facilities and will involve removing the remaining burden materials, refractory bricks and blocks and staves within the interior of the blast furnace for replacement. Any required repairs or replacement of ancillary equipment or structures will also be carried out.
Access	The majority of the construction traffic will access the site via the major roads that service the Port Kembla industrial area, including the Princes Motorway and Princes Highway, Shellharbour Road, Springhill Road, Five Islands Road and Masters Road. No changes to existing access arrangements are proposed.
Overhaul of Ironmaking components and systems	– Raw materials handling – Sinter plant – Blast furnace – Stockhouse and charging system – Blast furnace vessel – Cooling system – Casthouse – Hot blast system – Off gas system – Slag handling
Blast furnace slag	Slag produced from the blast furnace is processed into two products, granulated slag and rock slag. Slag is sold for use in the manufacture of other products, such as cement and road base. Ground granulated blast furnace slag can be used to significantly reduce the CO_2 emissions associated with the manufacture and use of concrete.[3]
Commissioning	Commissioning involves the following: – All services brought back into live condition. – Various parts of plant re heated. – Pressure and leak tests conducted. – Cooling systems filled and flushed. – Furnace dried out and charged with kindling and burden material. – Gas system purged and furnace 'blown in'. – Furnace progressively heated until regular casting of iron and slag commences. – Full production reached within one to two months.

[3] A 60% slag mix reduces the CO_2 emissions for a typical 32 MPa concrete mix by 53%. This is significant given concrete is the 2nd most used substance in the world after water (from "A Guide to the Use of Iron Blast Furnace Slag in Cement and Concrete" - ASA Data Sheet 5).

Project element	Summary
Operations	Operation of 6BF will be generally the same as existing operations utilised at 5BF, including: – Processing and transport of raw materials (iron ore, metallurgical coal, coke, fluxes). – Production of sinter (agglomeration of iron ore, coke and limestone dust) for use within the blast furnace. – Production of approximately 2.7 Mtpa of iron from 6BF. – Processing of approximately 0.88 Mtpa of blast furnace slag for use as construction products.
Construction work hours	Where practical, and subject to the final construction program, construction will be carried out during the following construction hours: – Monday to Friday: 7.00 am to 6.00 pm. – Saturday: 7.00 am to 6.00 pm. – Sundays and public holidays: no work. A number of construction activities will be scheduled to be undertaken as night works. Final construction phase will require 24-hour construction (estimated to be a period of 5 months). Further, 24-hour construction may be required for an extended period if 6BF is required online earlier than 2026.
Construction duration	Approximately 3 years
Operational duration	Approximately 20 years



ID	Location	ID	Location
1	CRM 1	14	No.2 Works 4
2	CRM 2	15	No.2 Works 5
3	CRM 3	16	No.2 Works 6
4	No.1 Works 1	17	Recycling Area 1
5	No.1 Works 2	18	Recycling Area 2
6	No.1 Works 3	19	Recycling Area 3
7	No.1 Works 4	20	Recycling Area 4
8	No.1 Works 5	21	Recycling Area 5
9	No.1 Works 6	22	Recycling Area 6
10	No.2 Product Berth	23	Carpark, shuttle bus pick-up & canteen facilities
11	No.2 Works 1	24	Laydown area 2
12	No.2 Works 2	25	Clean down area
13	No.2 Works 3	26	Short term carpark

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Kilometres

Map Projection: Transverse Mercator
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No.6 Blast Furnace Reline and Operations
Greenhouse Gas Report

Project No. 12541101
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Key project features

FIGURE 4-4

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Data source: LPI: DTDB/DCDB, 2017. World Imagery: Maxar.
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5. Impact assessment

5.1 Construction

Emissions during construction have been estimated based on the assumptions listed in Table 5.1. The estimated emissions are shown in Table 5.2. Emission factors have been sourced from the NGER (Measurement) Determination and the National Greenhouse Accounts (NGA, 2021)

Table 5.1 Construction emission assumptions

Emission source	Assumptions
Construction equipment diesel use	Fuel use for construction equipment was estimated based on the type and number of equipment, weeks of use, daily hours of operation and fuel use per hour (sourced from equipment manufacturers data). Equipment includes cranes, excavators, rollers, graders, piling rigs, forklifts, concrete trucks and other trucks.
Electricity from grid (NSW)	The quantity of electricity used was estimated by BlueScope based on the type of equipment/ building, the estimated number of days during the construction program and the consumption per day. Electricity is used in site sheds and lighting, and for small power tools, electric welders, compressors, etc. (Note: large equipment and machinery is normally diesel-driven and is included in the ‘construction equipment diesel use’ above).
Worker commute	There would be up to 300 car trips per day over the construction period, for contractors and construction workers. All vehicles were conservatively assumed to be diesel. Fuel use for passenger vehicles is from the Australian Bureau of Statistics (ABS) Survey of Motor Vehicle Use in Australia (ABS, 2020).
Transport Buses	Buses transport workers around the site. There would be approximately 50 bus trips per day over the construction period. Fuel use for buses is from ABS, 2020.
Transport major equipment and materials	There would be approximately 100 trucks accessing the site per day over the construction period (delivery of equipment and materials to the site and removal of waste from the site). Fuel use from trucks is from ABS, 2020.
Waste (MSW and C&D)	Approximately 100 t of Municipal Solid Waste (MSW) and 7,500 t of Construction and Demolition (C&D) waste would be generated during the construction period. Disposal of this waste to landfill generates GHG.
Welding	Acetylene gas would be used for welding and cutting during demolition, modifications and construction of new structures. The quantity of acetylene used was estimated by BlueScope based on the estimated number of welding days and the consumption per day.
Commissioning	Natural gas will be used during commissioning for drying and heating. The quantity of natural gas used was estimated by BlueScope based on commissioning of previous BFs.

Table 5.2 Construction and commissioning emissions

Emission source	Value		Fuel Type/ parameter	Emissions
	Quantity	Units		tCO_2-e
Total diesel consumption	6,803	kL	Diesel (Stationary)	18,435
Electricity from grid (NSW)	5,688	MWh	Electricity from grid (NSW)	4,494
Worker commute	726	kL	Diesel (Transport)	1,974
Transport Buses	287	kL	Diesel (Transport)	781
Transport major equipment and materials	650	kL	Diesel (Transport)	1,767
Waste (MSW & C&D)	7,600	t waste	Waste (C&D)	1,660
Welding	105,350	m^3	Acetylene	213
Commissioning	56,000	m^3	Natural gas	113
Total emissions				29,437

The quantity of GHG emissions estimated to occur during the full construction period is approximately 30,000 tCO_2-e, or approximately 9,800 tCO_2-e per annum over the three-year construction period. Emissions during construction are minor and only 0.1% of annual operational emissions (as detailed in section 5.2 below).

5.2 Operation

As outlined in Section 4.2, due to the complex integrated nature of PKSW, it is not feasible to extract a separate GHG emission rate for blast furnace operation alone. GHD therefore considers it appropriate to take an integrated approach to quantifying and assessing impacts associated with the project. When assessing the potential impact of project emissions, the following needs to be considered:

– The project represents ongoing operations with ironmaking transferring from 5BF to 6BF.
– The operation of 6BF will have a similar emissions profile to 5BF, with the exception of proposed GHG mitigation strategies (refer Section 6) which will either:
    - Provide GHG reduction from the commencement of operation of 6BF, or
    - Enable the introduction of future GHG reduction technologies as they become commercially viable, such as the use of renewable hydrogen to displace fossil fuel-based energy sources that will enable GHG emissions reductions over the medium to longer term.

It is noted that BSL has announced that the opportunities for GHG emissions reductions enabled by the 6BF reline are part of a broader suite of climate-related projects at Port Kembla that have further potential to reduce GHG emissions intensity.

A summary of Scope 1 and 2 GHG emissions, calculated in accordance with the NGER methodology, from the operation of PKSW for FY2020 and FY2021 is presented in Table 5.3. Scope 1 emissions contributed 91% of total GHG emissions in FY2021, while Scope 2 emissions contributed around 9% of the total GHG emissions from the site. The total GHG emissions presented in Table 5.3 include emissions from the current operation of 5BF.

Table 5.3 Summary of PKSW annual emissions

GHG Emissions (tCO_2-e)	2020	2021
Scope 1	6,103,129	6,260,763
Scope 2	558,237	608,085
Scope 3 (not included in total)	Not reported	1,125,456
Total	6,661,366	6,868,848
Steel production (tonnes)	3,012,548	3,209,637
Intensity (tonnes CO_2-e/tonne steel)	2.211	2.140

Source: Climate Action Report 2021

Overall, the project will have a net improvement (reduction) in GHG emissions intensity per tonne of steel produced, with significant potential for further improvements to be made as new and emerging low emissions technologies become viable. A review of currently available and future technologies along with those selected for implementation by the project is provided in Section 6.

5.3 Impact of emissions

Australia's national GHG emissions, by sector for the year to June 2021 and year 2019 (the most recent year available) are presented in Table 5.4 Total emissions for the year to June 2021 are 498.9 $MtCO_2$-e, and 518.9 $MtCO_2$-e for year 2019.

The most recently published state-based emissions inventory is for 2019. NSW GHG emissions, by sector, for the 2019 year are also presented in Table 5.4. Total annual emissions for NSW are 136.6 $MtCO_2$-e.

Table 5.4 National and NSW GHG emissions

Emissions Source	Australia Emissions Year to June 2021 ($MtCO_2$-e) [1]	2019 Australia Emissions ($MtCO_2$-e) [2]	2019 NSW Emissions ($MtCO_2$-e) [3]
Energy – Electricity	163.9	278.9	94.7
Energy – Stationary Energy (excluding electricity)	99.4		
Energy – Transport	91.2	100.5	27.6
Energy – Fugitive Emissions	48.7	51.0	12.7
Industrial Processes and Product Use	31.1	32.6	12.8
Agriculture	75.0	69.8	16.3
Waste	14.0	12.4	4.8
Land Use, Land Use Change and Forestry	-24.4	-26.3	-12.5
Overall Total	**498.9**	**518.9**	**136.6**

Source:

1. Table 3, Department of Industry, Science, Energy and Resources (DISER) "Quarterly Update of Australia's National Greenhouse Gas Inventory: June 2021" December 2021

2. Table 2.1, DISER, "National Inventory Report 2019", April 2021

3. DISER "State and Territory Greenhouse Gas Inventories 2019", 2021

The quantity of Scope 1 and 2 emissions from PKSW operations reported for FY2021 were 6,868,848 tCO_2-e (approximately 6.9 $MtCO_2$-e) per annum. These emissions represent less than 1.4% of the total Australia emissions, and approximately 5% of NSW emissions, based on the available data presented in Table 5.4.

Scope 1 and 2 emissions associated with the operations of the PKSW are above the threshold of 25,000 tCO_2-e per annum for facility level reporting under the NGER Act so require annual reporting under the NGER scheme. Scope 1 emissions associated with the operations of the proposed project are also above the threshold of 100,000 tCO_2-e per annum for the NGER Safeguard Mechanism – therefore the site has a safeguard baseline emissions number which if exceeded would require offsetting of emissions above the baseline, for example by the purchase of Australian carbon credit units.

Scope 1 and 2 emissions associated with the operations of the PKSW before and after the project are well above both NGER facility and Safeguard thresholds. PKSW will continue to be reported as a separate facility under the NGER Act. As a result of the project (subject to planning approval), the estimated emissions from PKSW are not expected to exceed the PKSW safeguard baseline.

6. Greenhouse gas reduction measures

6.1 Overview

To achieve net zero emissions in steelmaking, commercialisation of breakthrough technologies and supporting infrastructure will be needed. The availability of breakthrough low GHG emissions ironmaking technologies has been an important consideration for BlueScope in assessing options for the future configuration of PKSW. For this reason, the scope of the project is intended to address the dual aims of securing BlueScope's domestic ironmaking needs from 2026, as well as providing a bridge to transition from current blast furnace technology to new and emerging low emissions technologies once available at commercial, viable scale.

While breakthrough technologies are still being developed, there is scope to optimise production processes to reduce GHG emissions through existing and emerging technologies.

As discussed by McKinsey & Company (2020), BF-BOF initiatives can improve efficiency and/or decrease production losses in different ways, for example:

1. Optimising the BF burden mix by maximising the iron content in raw materials to decrease the usage of coal as a reductant.
2. Increasing the use of alternative fuels to pulverized coal injection (PCI), for example, biochar (refer Section 6.4.1), biomass, or hydrogen (either as Coke Ovens Gas or renewable hydrogen).
3. Increasing use of Blast Furnace Gas and Coke Ovens Gas as an energy source.

These processes may have the potential to decrease GHG emissions without eliminating them, but do not offer fully carbon-neutral steel production (McKinsey & Company, 2020). PKSW already seeks to maximise the use of process gases as an energy source as displayed in Figure 4.3. As BF-BOF efficiency programs only result in a reduction in GHG emissions without eliminating them entirely, they are not a long-term solution. Biomass reductants and carbon capture and usage are either only feasible in certain regions or are still in the early stages of development (McKinsey & Company, 2020).

While BlueScope and other BF-BOF steel manufacturers continue to research and investigate lower-emissions technologies, steel, as one of the world's most highly recycled materials, has an important place in a low carbon future. Scrap steel (scrap) currently contributes to approximately 32% of steel products and for approximately 25% of the steel produced at PKSW. In FY2021, over 800,000 tonnes of scrap were recycled at PKSW through the BF-BOF route. There are limits, however, on the amount of scrap which can be used in the BF-BOF process: first, scrap supply cannot meet demand either locally or globally and secondly, there is a thermal limit on how much scrap can be used in the steelmaking process[4].

Raw material availability will be crucial to secure steel production capability in the near and longer term and to support the transition to net zero. Securing access to the raw materials that are currently used in the blast furnace process, such as metallurgical coal (or other mixes of different types of 'clean' metallurgical coal), will be one of the options in the early transition period, as will be securing future raw material requirements, such as Direct Reduced Iron (DRI) and renewable hydrogen.

As part of its Climate Action Plan, on 7 December 2021, BSL announced its commitment to establish a 10 MW electrolyser on the PKSW site, as part of a Memorandum of Understanding with Shell Energy. A hydrogen electrolyser is a system that breaks water into hydrogen and oxygen molecules using electricity in a process called electrolysis. The proposed 10 MW electrolyser will be one of the largest electrolysers in Australia, although it is estimated that a 300 MW electrolyser would be required to generate enough hydrogen to replace carbon as a reductant for total volume of crude steel output from the PKSW. Not only will this support the NSW Government's vision for an Illawarra Hydrogen Hub, but for every tonne of renewable hydrogen used in the steelmaking process will result in reductions of CO_2-e emissions.

[4] As discussed earlier, the BF-BOF is an integrated process and scrap is added to the BOF, rather than the BF itself.

6.2 Technology review

As described in Chapter 4 of the EIS, BlueScope's consideration of project alternatives included extensive research into alternative steelmaking technologies with potential to reduce GHG emissions. Figure 3.1 in section 3.7 of this report shows how some of these technologies may form part of BlueScope's decarbonisation pathway. Currently, however, the alternative technologies which are already available are not viable for new steelmaking plants on the east coast of Australia due to of the lack of affordable natural gas and scrap steel. Electric Arc Furnace (EAF) steelmaking also has very high electricity demand with a 2019 report issued by Worldsteel noting that electricity accounts for roughly 50 percent of the energy input costs for EAFs compared to 7 per cent for BF operations (Schumacher, 2021) and therefore cannot be considered a "green steel" making methodology unless renewable electricity is available to meet this demand.

Table 6.1 outlines the potential partial and full decarbonisation pathways proposed by McKinsey & Company (2020) and identified by BlueScope as potentially viable in the future for adoption at PKSW. The viability of the technology is assessed based on how proven the technology is.

Table 6.1 Summary of potential technologies (sourced from McKinsey & Company (2020) report)

Technology	Description	Example	Viability for PKSW
Partial decarbonisation potential			
Blast Furnace (BF)/ Basic Oxygen Furnace (BOF)	Make efficiency improvements to optimise BF-BOF operations	Optimised BOF inputs (DRI, scrap) increased fuel injection in BF (e.g. hydrogen, PCI)	BSL is assessing the use of both hot briquetted iron (HBI) and DRI as furnace charges, but they come with significant Scope 3 penalties. The installation of the dual lances will allow a potential offset of Scope 1 emissions through the reduction of PCI.
Biomass reductants	Use sustainable biomass as an alternative reductant	Tecnored process[5]	Development of an economically sustainable supply of biochar in Australia is a key enabler for this technology. Research has shown the replacement of PCI coal with biochar to be viable. BlueScope is currently preparing to trial biochar as a pulverised coal replacement at 5BF and, if successful and a sustainable supply chain can be established, will be implemented at 6BF.
Carbon capture and usage	Capture fossil fuel emissions and create new products	Bioethanol production from CO_2 emissions	Research has been undertaken with industry partners to determine the viability of Carbon Capture and Usage and Carbon Capture and Storage at PKSW. CCUS was determined to be economically unviable.
Full decarbonisation potential			
Electric Arc Furnace (EAF)	Maximise secondary flows and recycling by melting more scrap in EAF using renewable energy	EAF – usage to melt scrap	Availability of quality scrap is limited and existing electrical infrastructure is not sufficient to operate large enough EAFs to meet current production demands. EAF has a high electricity demand and the technology cannot be considered decarbonised unless sufficient renewable electricity is available.

[5] A patented process using agglomerated iron ore fines, flux and carbon bearing fines in a moving bed shaft furnace with side feeders enabling solid fuel addition to produce iron (Noldin J, 2008)

Technology	Description	Example	Viability for PKSW
Direct Reduced Iron (DRI) plus EAF using natural gas	Increase usage of DRI in the EAF	Current DRI plus EAF plants using natural gas (NG)	Technology not currently commercially viable due to lack of affordable natural gas on the east coast of Australia coupled with electricity limitations of EAF technology described above.
DRI plus EAF using H_2	Replace fossil fuels in DRI process with renewable energy or H_2	MIDREX DRI process running on H_2 HYL DRI process running on H_2	No current hydrogen infrastructure to allow this path to be implemented. Limitations of electricity requirements for EAF technology as described above.

The reline of 6BF provides a 'bridge' to transition from the current blast furnace technology to new and emerging low emissions technologies. BlueScope has identified a program of enhancements and upgrades to improve the emissions intensity of the balance of the existing BF-BOF steelmaking facilities as described in section **Error! Reference source not found.**. The implementation of established technologies and availability of raw materials will be crucial to secure steel production capability in the near and longer term and to support the transition to net zero technologies such as DRI produced with renewable hydrogen. As emerging and breakthrough technologies are developed over time to full commercial scale, the strong cash-flows and earnings capability of BlueScope and BSL provide significant capacity to transition to these technologies as and when they become technically and commercially viable in Australia.

6.3 Proposed technologies for implementation

BlueScope has incorporated improvements into the design of 6BF which will result in reductions in GHG emissions when compared to those from the current operation of 5BF.

Table 6.2 details the technologies or equipment that are proposed to be installed as part of the operation of 6BF that will assist in reducing GHG emissions when compared with the operation of 5BF.

Table 6.2 Technologies or practices proposed as part of the project

Technology	Description	Potential GHG reduction	Viability
Dual lance tuyeres	Allow the use of additional supplementary gaseous fuels such as Coke Ovens Gas (COG) or hydrogen.	No direct reduction, however, enables COG and hydrogen injection which will reduce GHG emissions by offsetting external metallurgical coal purchases. COG injection has the potential to reduce emissions by approximately 150,000 tCO_2 per year.	Dual lance tuyeres are being designed and will be incorporated into the project design.
Top Gas Recovery Turbine	A Top Gas Recovery Turbine utilises the pressure and thermal energy of blast furnace gases as they leave the furnace to generate electricity. The technology reduces GHG emissions by offsetting external power requirements sourced from fossil fuel generation.	Potential reduction of approximately 11,000 tCO_2 per year in comparison to existing operations.	Proven means of recovering energy from the blast furnace which has been previously implemented on 5BF and will be part of the project design, with improvements which will achieve greater energy recovery on 6BF.

Technology	Description	Potential GHG reduction	Viability
Hot Blast Waste Gas Heat Recovery	Gas to gas heat exchangers recover waste heat from the Hot Blast Stoves allowing a reduction in fuel consumption. The higher efficiency combustion liberates Coke Ovens Gas which can be injected into the dual lance tuyeres displacing a proportionate amount of pulverised coal injection into the furnace. Reduction in GHG emissions via reduced fossil fuel energy consumption.	Potential reduction of approximately 11,000 tCO_2 per year, and enables injection of COG into the blast furnace.	Proven technology which will be part of the project design.
Energy Efficiency	Use of variable speed drives on compressors, pumps and fans, high efficiency motors, and correct equipment selection to avoid over sizing electric motors. Reduction in GHG emissions achieved via reduced fossil fuel energy consumption.	N/A	Proven technology that will be implemented as part of the project.

The incorporation of the technologies identified in Table 6.2 is expected to achieve a reduction of GHG emissions of approximately 172,000 tCO_2-e. This reduction is equivalent to removing over 30,000 cars per year from the road[6]. In addition to these technologies, all operational equipment will be operated and maintained to minimise leaks, accidental venting of gases, or other fugitive GHG emissions to the maximum extent practical.

Furthermore, these technologies will be key enablers of medium to longer-term opportunities to reduce Port Kembla Steelworks' greenhouse gas intensity. These opportunities are part of a broader suite of climate-related projects at Port Kembla that have the potential to significantly reduce GHG emissions intensity. Partnerships and collaborations with governments, technology vendors and industry bodies will be crucial to implementing future technologies.

6.3.1 Dual lance tuyeres

Iron ore, coke and flux materials are 'charged' into the top of the furnace. As the materials descend through the furnace, they are subject to and react with an ascending high speed, high pressure gas stream consisting of preheated air, enrichment oxygen and steam at temperatures in excess of 2,000°C. The gas stream is injected into the furnace through tuyeres positioned above the hearth around the circumference of the furnace. The injection of pulverised coal into the blast furnace is an established technology at PKSW where the coal acts as a fuel and reduces the amount of coke required in the process. The pulverised coal is injected into the blast furnace via an injection lance at the tuyeres.

As part of the project, dual lance tuyeres will be installed at 6BF to enable the injection of hydrogen as an alternate reductant, either in the form of COG[7] or renewable hydrogen, into the blast furnace. These reductants will replace a proportionate amount of the coal currently injected into the blast furnace, thereby reducing Scope 1 GHG emissions.

[6] Based on US EPA estimate of 4.6 tonnes CO_2-e per car per year and 220 cars = 1kt.
[7] COG is gas generated from cokemaking processes and is used as a fuel at the blast furnace. It is around 60% hydrogen.

6.3.1.1 Coke Ovens Gas as an intermediate source of hydrogen

COG is composed of approximately 60% hydrogen, making it an available source of hydrogen until electrolysis of hydrogen becomes economically viable. The high concentration of hydrogen contained in COG makes it suitable for use as a reductant in the blast furnace. BlueScope is investigating a number of different ways to make more COG available for use in the Blast Furnace (the primary source being the Hot Blast Waste Gas Heat Recovery mentioned above). Before it is injected into the blast furnace, COG needs to be pressurised to approximately 700 kPa. In addition to the work of the project, BlueScope is investigating the installation of a COG compression plant. While this is not part of the project scope, the plant would further enable the use of COG as a reductant in the blast furnace.

The use of COG as a reductant in the blast furnace has the potential to result in CO_2 emission reductions of up to approximately 150,000 tCO_2-e per year.

6.3.1.2 Hydrogen as a reductant

As discussed in section 3.7, BSL has signed a Memorandum of Understanding with Shell Energy Operations Pty Ltd to investigate designing, building and operating a 10 MW renewable energy hydrogen electrolyser to test the use of hydrogen in the blast furnace at PKSW. To produce renewable hydrogen, the electrolyser must be powered by renewable energy.

The electrolyser does not form part of the project scope however, its operation will potentially enable the use of hydrogen as a reductant at the blast furnace.

If successful, it is estimated the 10 MW electrolyser may achieve emission reductions of up to 12,000 tonnes of CO_2 per year and provide the information necessary to allow subsequent installation of a larger electrolyser for more significant reductions once the cost of hydrogen production is economically viable and sufficient renewable electricity is available.

6.3.2 Top Gas Recovery Turbine

A Top Gas Recovery Turbine (TRT) designed to extract power from the furnace top gases in a similar fashion to a hydroelectric generation system will be installed at the top of the furnace. The TRT will let the furnace top pressure down from 200 kPa to approximately 10 kPa, driving an alternator to generate approximately 13 MW of electricity to be consumed within the works.

This technology is currently utilised at PKSW and the new TRT at 6BF will produce approximately 3MW more than the existing TRT installed at 5BF, thereby reducing the amount of electricity externally sourced for the operation of PKSW.

6.3.3 Waste Gas Heat Recovery

A Waste Gas Heat Recovery unit will be installed on the 6BF stoves. This technology uses heat pipes to transfer energy directly from the flue gas into both the BFG and combustion air supplied to the stoves.

This technology is not currently implemented at PKSW and its installation at 6BF will reduce the need for enrichment gas, COG, to be used at the stoves. This will enable the use of COG as a reducing agent at the blast furnace to decrease the amount of pulverised coal injected into the furnace.

6.4 Emerging and future breakthrough technologies

BlueScope recognises that the decarbonisation of hard-to-abate industries like iron and steelmaking relies on breakthrough technologies, once proven and scalable. Several hydrogen-based ironmaking technologies are currently being explored across the industry. These range from the injection of hydrogen into existing blast furnace operations to the replacement of current ironmaking technologies with DRI manufactured using renewable hydrogen. Concept studies, prototypes and demonstration plants are being developed, but further significant advances will be needed before these technologies are commercialised. Based on current research, technology and commercial readiness, these technologies are expected to continue to develop over the current and following decade, with significant take-up across the steel industry predicted to occur into the 2040s.

A range of innovative “green steel” ideas are starting to be piloted globally and BlueScope, when examining the possible steel production and supply options to be adopted at the conclusion of the current 5BF campaign, considered the potential use of these breakthrough technologies. Following extensive review of the available options and industry analysis of those developments, BlueScope has concluded that these technologies, and the supporting infrastructure required to implement them (such as a cost competitive renewable hydrogen supply chain) will not be commercialised at a viable scale in time to maintain production once the current campaign of 5BF concludes in the mid to late 2020s.

6.4.1 Biochar

Producing biochar captures 50 percent of the CO_2 that would otherwise escape during waste decomposition and retains most of it for up to 100 years. McKinsey & Company (2020) estimate that biochar technology is less than a decade away from the point when it could start having a real impact: by 2030, it could sequester roughly 2 Mtpa of CO_2.

The use of biochar is identified as an emerging technology in BSL’s Climate Action Report (refer Figure 3.1). This process involves the use of sustainably sourced charcoal from forestry or construction industry waste as a coal substitute. Biochar is currently used as a reductant in some iron and steel plants overseas (such as Brazil) however, the availability of sustainable biochar in Australia is currently limited. A key enabler of this technology will be the development of an economically sustainable source of biochar in Australia.

In 2006, BlueScope partnered with CSIRO and OneSteel in a successful Worldsteel CO_2 Breakthrough R&D (CO2BT) program on the potential use of renewable carbon-based (biochar) materials. In the case of renewable carbon-based materials, the objective was to partially replace coal in various processes, particularly for a) pulverised coal injection (PCI) into the BF, b) metallurgical coal in coke ovens, c) anthracite in iron ore sintering and d) calcined anthracite in steel decarburisation. At the conclusion of the CO2BT program in 2012, the suitability of biochar had been demonstrated at a technical and pilot-scale level for all four applications.

BlueScope is currently evaluating options for the use of biochar as PCI into the BF, through potential supply of biomass/biochar, pyrolysis equipment capable of producing large quantities of biochar, and plant trials at 5BF. If trials are successful and a sustainable supply chain can be established, BlueScope will be able to introduce biochar into the relined 6BF.

It is estimated that biochar has the potential to achieve reductions of up to 450,000 tonnes of CO_2 per annum.

6.4.2 Hydrogen-based Direct Reduced Iron (DRI) / Electric Arc Furnace (EAF) steelmaking

Hydrogen-based DRI coupled with steel production using an EAF is technically feasible and already considered to be part of a potential long-term solution for decarbonizing the steel industry on a large scale. The question is not whether but when and to what extent this transformation will happen.

While integrated manufacturers produce steel from iron ore and need coal as a reductant, EAF producers use steel scrap or direct reduced iron (DRI) as their main raw material and sometimes pig iron in billets. The existing commercial production of DRI is achieved by subjecting pelletised iron ore to natural gas or COG. The hydrogen and carbon monoxide in the natural gas or coal gas react with the oxygen in the iron ore reducing it to iron and generating water and/or CO_2.

Significant attention is being given by the media to the potential for the use of renewable hydrogen as a reductant source to reduce the carbon footprint of steelmaking processes using the DRI process. However, this technology remains at pilot stage; in 2019 its technology readiness level (TRL) was assessed by the Australian Renewable Energy Agency as 1 – 6, indicating the requirement for further research, development and demonstration. The recent report of the Australian Industry Energy Transition Initiative predicts that this technology will be commercially available only in 2035 and this prediction may in fact be optimistic having regard to the timeframes in which step changes in iron and steelmaking technologies typically occur.

There are external factors affecting the immediate implementation of renewable hydrogen-based DRI-EAF steelmaking including production technology, limited power supply, and hydrogen supply security (McKinsey & Company, 2020):

– *Production technology*: While transitioning the process to an entirely hydrogen-powered process is technically feasible, the technology has yet to be proven on a large scale (McKinsey & Company, 2020).
– *Limited power supply*: Renewable hydrogen-based steel creates a need for a significant capacity increase in electricity derived from renewables. To put this into perspective, the total energy required to produce two million tonnes of hydrogen-based steel is about 8.8 Terawatt-hour, which equates to the output from 300 to 1,100 wind turbines (depending on the output capacity of current and future turbines) (McKinsey & Company, 2020). The development of a commercial renewable hydrogen industry requires the availability of renewable electricity to increase substantially. A low-cost, large-scale, reliable supply of renewables is critical to reducing the cost of renewable hydrogen production sufficiently to bring it into the range of commercial viability for industrial use in iron and steelmaking.
– *Hydrogen-supply security*: The future shift to hydrogen-based steel production relies heavily on the broad availability of renewable hydrogen on an industrial scale. Producing two million tonnes of hydrogen-based steel requires 144,000 tonnes of hydrogen (McKinsey & Company, 2020).

As reported by the European Parliamentary Research Service (2020), the production of 1 tonne of steel requires 50 kg of hydrogen. Currently, the largest electrolyser in Australia is 1.25 MW, capable of producing 480 kg of hydrogen per day (AGIG, 2021). PKSW produces approximately 8,000 tonnes of iron per day, therefore, to maintain existing production rates, approximately 400,000 kg of hydrogen would be required per day.

BSL and Shell Energy Operations Pty Ltd have signed a Memorandum of Understanding to investigate, design, build and operate a 10 MW renewable energy hydrogen electrolyser to explore and test the use of renewable hydrogen in the blast furnace at PKSW (refer section 3.7). If successful, it is estimated the 10 MW electrolyser may achieve emission reductions of up to 12,000 tonnes of CO_2 per year. While an improvement, BlueScope estimates up to a 300 MW electrolyser would be required to service the blast furnace.

In addition to the limitations posed by the availability of renewable hydrogen, the transition of steelmaking technology from BF-BOF to renewable hydrogen-based DRI-EAF requires changes to raw material inputs. Currently only 15-20% of iron ores available globally are suitable for use as a DRI feed in a DRI/EAF process configuration. A sudden transition to renewable hydrogen-based DRI-EAF technology by the steelmaking sector could result in rising price premiums given an uncertainty of a secure DRI supply, thereby negatively affecting the economic viability of the production method.

One of the priority action areas of the Memorandum of Understanding signed by BSL and Rio Tinto is to explore the direct reduction of Rio Tinto’s Pilbara ores, which are not currently suitable for direct reduction using the commercially available DRI-EAF technology, to overcome this limitation.

6.4.3 Hydrogen-based Direct Reduced Iron (DRI) / Melter / Basic Oxygen Furnace (BOF)

An alternative process for the use of lower-grade ore sources that are unsuitable for DRI-EAF steel production is to add a Melter process after the DRI process. Such technology exists and can be used to remove the metal oxide impurities (‘gangue’) that are present in the Pilbara hematite based ores. This process also enables the existing BOF-Caster configuration that is part of an integrated steelworks to continue to be utilised, without the need to invest in an additional conversion process. The limitations of renewable hydrogen production and availability for DRI discussed above remain applicable to this technology. As with the DRI-EAF technology, the DRI-Melter-BOF process is electricity-intensive.

Hematite ores such as those which are predominant in the Pilbara region of Australia are not currently suitable for direct reduction using the commercially available DRI-EAF technology due to the levels of gangue present in the material but may be suitable for DRI-Melter-BOF technology. One of the priority action areas of the Memorandum of Understanding signed by BSL and Rio Tinto is to explore the direct reduction of Rio Tinto’s Pilbara ores, to determine the suitability of this technology in the future.

6.4.4 Direct electrolysis of iron ore

Direct electrolysis of iron ore is a proposed technology currently undergoing small pilot trials overseas. It involves the reduction of iron ore using electro-chemical processes rather than using chemical reductants.

This electricity intensive process could potentially be a zero emission technology if utilising 100 per cent renewable energy however, the technology is in its early stages and must be further developed to overcome engineering issues, and pilot trials upscaled before it can be considered technically and economically viable at the scale required.

6.4.5 Blast Furnace coupled with Carbon Capture, Utilisation and Storage (CCUS)

Carbon Capture Utilisation and Storage (CCUS) involves capturing CO_2 emissions at the source, removing impurities, compressing the CO_2 for transport, and either utilising it to create other products or permanently storing it in underground geological formations.

In 2018 to 2019, BlueScope partnered with the CO_2 Cooperative Research Centre (CO2CRC) to explore potential pathways for reducing GHG emissions in steel production through CCS and CCU. A high-level evaluation of the economic viability of transport (piping or shipping) and storage location options for captured CO_2 from Port Kembla was carried out by CO2CRC and the Sydney University. In addition, utilisation of CO_2- and CO-rich gases to provide high-quality, value-added products using innovative biochemical and chemical processes have been considered. Further work on the potential to use plant generated gases to produce ethanol was completed, with many different scenarios considered, including hydrogen and methane.

Findings are yet to be released publicly, however, CCUS opportunities will not be progressed at this stage, as they were determined to be economically unviable.

7. Mitigation measures

7.1 Construction

Construction stage emissions are minor. Measures such as the use of appropriately sized equipment, minimising use and turning off engines where practical will minimise GHG emissions during construction.

7.2 Operations

Mitigation measures have been outlined in Sections 3.7 and 6. The mitigation measures for the project form part of BlueScope's GHG reduction and climate targets. Section 6.3 details technologies that will be incorporated into the operation of the project. A reduction in GHG emissions relative to current 5BF operations is anticipated through the implementation, installation or undertaking of the following:

– Dual lance tuyeres.
– Waste Gas Heat Recovery unit installed on 6BF stoves.
– Top Recovery Turbine installed to extract energy from gases vented from the top of the blast furnace.
– Energy efficiency initiatives such as use of high efficiency motors and variable speed drives on auxiliary equipment.
– Maintenance and operation of equipment to minimise leaks, accidental venting of gases or other fugitive GHG emissions to the extent practical.

In addition to the mitigation measures proposed above, BlueScope is committed to identifying and investigating possible measures to be implemented to reduce net GHG emissions from the operation of 6BF. This will include but is not limited to:

– Optimising raw material mixes.
– Replacing a portion of the pulverised coal currently used in the blast furnace process with alternative reductants such as COG, renewable hydrogen and/or biochar.
– Investigation and review of emerging technologies to determine commercial and economic viability.

BlueScope and BSL will continue to undertake regular reporting on total PKSW net energy consumption and GHG emissions under the NGERS in accordance with the methodology prescribed by the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Measurement Determination).

Sustainability and Climate Change strategies will be regularly reviewed against evolving regulatory, corporate or other policy over the life of the 6BF campaign to ensure the GHG management strategies are managed in accordance with evolving stakeholder expectations.

BlueScope will also continue to maximise the use of steel manufacturing co-products to offset carbon intensive material inputs into industrial processes e.g. the use of Granulated Blast Furnace Slag as a cementitious replacement for Portland Cement in concrete construction to lower GHG emissions.

8. Conclusions

The quantity of GHG emissions estimated to occur during the full construction and commissioning period are approximately 30,000 tCO_2-e, or approximately 9,800 tCO_2-e per annum. Emissions during construction are minor and approximately 0.1% of annual operational emissions.

In line with current operations, annual emissions from the project will account for less than 1.4% of Australia's annual GHG emissions and approximately 5% of NSW's annual GHG emissions, based on currently available data.

Over the life of the project GHG emissions are predicted to reduce through the implementation of proven technologies including dual lance tuyeres, top recovery gas turbine, waste gas heat recovery and COG injection. These technologies are anticipated to reduce GHG emissions by approximately 172,000 tCO_2-e or approximately 2.5% based on FY2021 emissions. These technologies also provide scope for further reductions. The scope of the project is intended to address the dual aims of the project: to secure BlueScope's domestic ironmaking needs from 2026, as well as provide a bridge to transition from current blast furnace technology to new and emerging low emissions technologies once available at commercial, viable scale

Emissions reductions would also be achieved through the implementation of various other technologies as they become proven and commercially viable. This includes the use of biochar as a pulverised coal replacement, hydrogen-based DRI following installation of a hydrogen electrolyser at PKSW and installation of a COG compression plant.

Measures will be implemented to minimise and reduce GHG emissions and energy usage in relation to the 6BF reline project. Whilst the project represents a continuation of 'business as usual' as iron production is transferred from 5BF to 6BF, ongoing measures implemented by BlueScope as part of the project will ensure ongoing reductions in GHG emissions are achieved.

Consistent with the commitments made by BSL in their Climate Action Report, BlueScope is committed to continue research and investment in emerging technologies for PKSW over the campaign life of 6BF to more substantially reduce GHG emissions. This approach is considered by GHD to be consistent with international, national, state and local GHG policies aimed at achieving a net zero future.

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