Alba Power Station 5 Block 4
Supplementary ESIA
Updated Climate Change Risk Assessment

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Aluminium
for the world

Environment Arabia

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Table of abbreviations

IEA	International Energy Agency
Alba	Aluminium Bahrain B.S.C.
BAT	Best Available Techniques
BREF	Best Available Techniques Reference Document
CCRA	Climate Change Risk Assessment
CEMS	Continuous Emissions Monitoring System
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
EACS	Environment Arabia Consultancy Services W.L.L.
EP	The Equator Principles
EPFI	Equator Principles Finance Institution
ESDD	Environmental and Social Due Diligence
ESIA	Environmental and Social Impact Assessment
EWA	Electricity and Water Authority
GHG	Greenhouse Gas
GWP	Global Warming Potential
IFC	International Finance Corporation
IFI	International Finance institution
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
mtpa	Metrics Tonnes per Annum
N_2O	Nitrous Oxide
O&M	Operation and Maintenance
PS	Power Station
scf	Standard Cubic Feet
UNFCCC	United Nations Framework Convention on Climate Change
WBCSD	World Business Council on Sustainable Development
WBG	World Bank Group
WRI	World Resources Institute

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Glossary of terms

Absolute GHG emissions	The total aggregate amount of Scope 1 and Scope 2 emissions released over a specified time period.
Activity data	A quantitative measure of the magnitude of an activity that results in greenhouse gas emissions such as a production output or traffic volume.
Air cooled condenser	A direct dry cooling system used to condense turbine exhaust steam inside finned tubes using cool ambient air flow. This is the preferred option over water-cooled condensers for power plants in water scarce regions.
Best available techniques	'Techniques' refer to both the technology used, and the techniques adopted to design, construct, operate, maintain, or decommission an installation. 'Best' refers to the most effective way in achieving a high level of environmental protection. 'Available' refers to options that are developed in scale and accessible for implementation in the relevant industry sector under financially and technically viable conditions.
Black start capability	The capability of a power system to recover from a total or partial shutdown through a dedicated auxiliary power source without any electrical energy supplied by an external power generating facility.
Brayton cycle	A thermodynamic cycle that describes how gas turbines operate.
Carbon dioxide equivalent	A common unit used to compare emissions from various greenhouse gases, accounting for their different global warming potential.
Combined cycle	The combination of multiple thermodynamic cycles to generate power which decreases efficiency losses by converting residual heat into useful energy.
Emissions factor	A conversion factor that describes that rate at which a given activity releases a specific greenhouse gas to the atmosphere.
Gas turbine	A type of turbine that produces electricity by mixing compressed air with fuel at an extremely high temperature. The hot air-fuel mixture moves through the turbines, and the propulsion is used to drive a generator, converting mechanical into electrical energy.
GHG emissions intensity	The absolute greenhouse gas emissions divided by a unit of output such as the tonne of primary aluminium produced or the amount of electricity generated.
The GHG Protocol	A series of guidance documents produced by the World Resources Institute and the World Business Council on Sustainable Development that sets out one of the world's leading standard for organisations to measure and manage their greenhouse emissions.
Global warming potential	A measure of how much heat a greenhouse gas absorbed in the atmosphere in relation to carbon dioxide. Typically used as a conversion factor to obtain the carbon dioxide equivalent emissions.
Heat recovery steam generator	A heat exchanger that recovers heat from the exhaust gases of a gas turbine to produce steam to drive a steam turbine to produce additional electricity.
Mobile source emissions	Any emissions released by vehicles, engines, and equipment that can move from one location to another. Typically categorised into on-road mobile sources and non-road mobile sources
Mothballing	The act of pulling a piece of equipment or building from service but maintaining it in good condition so that it can readily re-deployed.
The Project	Refers to the Power Station 5 Block 4 Expansion Project.

Project scenarios	A description of the possible alternatives to the Power Station 5 Block 4 Expansion Project that were considered during the Project's conceptual development and feasibility study stages. For the purpose of this greenhouse gas alternatives analysis, only two project scenarios are considered: a no project scenario versus a with project scenario.
Rankine cycle	A thermodynamic cycle that describes how steam turbines operate.
Redundancy	A redundant power system is one that has been designed to feature two or more power supplies of a similar nature, with the goal of increasing the system's resilience by providing a backup or fail-safe option.
Scope 1 emissions	Direct greenhouse gas emissions that occur from sources controlled or owned by the organisation/project such as fuel combustion in vehicles and furnaces.
Scope 2 emissions	Indirect greenhouse gas emissions associated with the purchase and consumption of electricity, steam, heat, or cooling.
Simple cycle	Power generation using only a single thermodynamic cycle without heat recovery. Considered to be less efficient than a combined cycle operation.
Stationary source emissions	Any emissions released by fixed points such as factories, power plants, refineries, and buildings.
Steam turbine	A type of turbine that produces electricity by using a heat source to heat a fluid, typically water, to extremely high temperatures until it is converted into a gaseous stream. The stream moves through the turbines, and the propulsion is used to drive a generator, converting mechanical into electrical energy.

Executive Summary

Aluminium Bahrain B.S.C. (Alba) has proposed to add a new block to the existing three blocks at Power Station (PS) 5 to improve the plant's overall operational efficiency. The PS5 Block 4 Expansion Project (hereafter referred to as 'the Project') would be of a similar 1:1:1 gas turbine, steam turbine, and heat recovery steam generator configuration as the existing three blocks and would employ one of the world's most efficient combined cycle turbines available on the market. The addition of Block 4 would increase the power generation capacity of PS5 from 1,800 MW to 2,481 MW and lead to improvements in the energy, greenhouse gas (GHG) emissions, natural gas consumption and resource efficiency of the power generating units. The Project would be in line with Alba's intention of replacing less efficient technologies with their more advanced counterparts to reduce operating costs and secure a continuous power delivery to its aluminium production processes while achieving environmental objectives.

This report provides the updated components to the Project's Climate Change Risk Assessment (CCRA), which were previously noted by the third-party reviewer during their Environmental and Social Due Diligence (ESDD) as non-compliant with international finance institutions' (IFI) requirements. The first component is the GHG alternatives analysis, which compares GHG emissions between a scenario in which the Project proceeds based on the final design and associated decommissioning arrangements versus a scenario in which the Project does not come forward. The second component involves a review of the Project's GHG emissions inventory, which justifies Alba's current emissions estimation methodology and provides a series of recommendations for further consideration.

1 INTRODUCTION

1.1 Project description

Aluminium Bahrain B.S.C. (Alba) is one of the world's largest aluminium smelters who began operating in 1971 with a production capacity of 120,000 metric tonnes per annum (mtpa). Since then, Alba has expanded its capacity to 1,561,222 mtpa of high-quality aluminium products (as of 2021), making its operations critical to Bahrain's downstream aluminium sectors and wider socio-economic development.

Alba owns and operates a smelter plant located adjacent to King Hamad Highway, south of Sitra in the Kingdom of Bahrain. The plant currently features six potlines, with the latest line commissioned in 2018 and achieving full production in Q3 2019. To power production processes, Alba operates a total of five power stations (PS) and generates electricity for use in the facility on-site using natural gas.

As of now, Alba has a captive power generation capacity of 3,665 MW, with PS3, PS4, and PS5 supplying the electricity required by production processes. PS1 has been scheduled for full decommissioning, while PS2 will be kept on standby to provide emergency support and black start capability. Decommissioning works for PS1 and PS2 are currently underway.

PS3 was installed in 1992 and consists of two combined cycle blocks, with six gas turbines and two steam turbines and a total capacity of 800 MW. PS4 was installed in 2005 and consists of two combined cycle blocks, with four gas turbines and two steam turbines and a total capacity of 900 MW. PS5 was newly commissioned in 2019 and consists of three combined cycle blocks, with each block hosting one gas turbine, one steam turbine, and one heat recovery steam generator. PS5 currently has a total capacity of 1,800 MW.

To improve the plant's overall operational efficiency, a fourth block to PS5 with a similar 1:1:1 combined cycle configuration as the existing three blocks was proposed. On completion of the PS5 Block 4 Expansion Project (hereafter referred to as 'the Project'), the capacity of PS5 will increase from 1,800 MW to 2,481 MW.

Block 4 will be integrated with the plant's existing infrastructure with respect to power evacuation, although independent facilities will be constructed for operational controls. PS5 Block 4 is expected to commence its commercial operations in Q4 2024. Given that the Project will expand the capacity and increase the efficiency of PS5 beyond that of PS3 and PS4, Alba intends to shut down and maintain PS3 as emergency standby, while PS4 will be operate on a partial basis.

1.2 Report scope

An Environmental and Social Impact Assessment (ESIA) was undertaken by Envirotech Consultancy W.L.L. on behalf of Alba, and was submitted to Bahrain's Supreme Court for Environment in Q1 2022. The approved ESIA Report was issued to BNP Paribas, the coordinator of project finance, and an Environmental and Social Due Diligence (ESDD) was performed by Citrus, the appointed third-party reviewer. From the review of Climate Change Risk Assessment (CCRA), the following gaps/actions were identified:

- Prepare a stand-alone document,
- Expand analysis of alternatives to include how the project compares with similar assets, assessment of less GHG emissions intensive options and whether the analysis justifies the proposed design, and

- Include justification of GHG emissions data, specifically whether the emissions estimates have received independent validation.

In response to the ESDD outcomes, Alba commissioned Environment Arabia Consultancy Services W.L.L (EACS) to address the gaps in the ESIA and Equator Principle Action Plan (EPAP). This report is prepared by Royal HaskoningDHV UK Ltd., as subcontracted by EACS, and addresses two compliance gaps identified by Citrus. The report does not cover physical and transition risk assessment as it has been addressed the in the report prepared by Envirotech (ENV-RJC-20-00070/ESIA-ADM-001).

Chapter 2 presents comparisons of greenhouse gas (GHG) emissions between a ‘no project’ and ‘with project’ scenario to evaluate GHG emission savings associated with implementing the final project design, as assessed in the ESIA. Chapter 3 reviews the data used to compile and calculate the Project’s GHG emissions inventory by evaluating the data quality and provides recommendations for future improvements. Concluding statements are provided in Chapter 4.

2 GREENHOUSE GAS ALTERNATIVES ANALYSIS

The purpose of the GHG Alternatives Analysis is to demonstrate how the Project has considered GHG emissions from an early stage, resulting in a final design with lower GHG intensity. However, it should be noted that the selection of the final design would also be influenced by other project considerations beyond GHG emissions. Therefore, an alternative with the lowest GHG emissions may not necessarily be the best practicable environmental option.

This chapter includes the following sections:

- Section 2.1 – IFI requirements with respect to evaluating project alternatives and their GHG impacts;
- Section 2.2 – a description of the methodology used to identify different project alternatives, the criteria against which each alternative are evaluated, and how their GHG emissions are determined and compared to the final project design; and
- Section 2.3 – comparisons of GHG emissions between each alternative considered and the final project design.

2.1 International Finance Institutions' requirements

2.1.1 The Equator Principles

The Equator Principles (EP) is one of the leading risk management frameworks within the financial industry that apply to projects globally and across industry sectors (EP (2020) EP4). The framework is composed of ten environmental and social requirements that projects supported by five selected financial products from an Equator Principles Financial Institution (EPFI) need to adhere to. These financial products include:

- Project Finance Advisory Services;
- Project Finance;
- Project-Related Corporate Loans;
- Bridge Loans; and
- Project-Related Refinance and Project-Related Acquisition Finance.

However, an EPFI may choose to apply the EP to additional financial products beyond the scope of the EP at their own discretion. Moreover, although the EP were not designed to be applied retroactively, EPFIs are required to apply the EP when financing expansion or upgrade works to an existing project. The EP are updated periodically, and the latest version (EP4) came into effect on October 1st, 2020, along with a series of supporting guidance notes.

Principle 2: Environmental and Social Assessment requires clients to assess environmental and social risks relevant to the proposed Project, as well as describe appropriate measures to minimise, mitigate, and where residual impacts remain, offset or compensate for such impacts on communities and the environment.

Furthermore, *Principle 2* also require a CCRA for all projects in all locations whose combined annual Scope 1 and Scope 2 emissions[1] are expected to exceed 100,000

[1] As defined in WBCSD and WRI (2004) The GHG Protocol: A Corporate Accounting and Reporting Standard, Scope 1 emissions are defined as direct GHG emissions arising from sources that are owned or controlled by the organisation, while Scope 2 emissions are defined as indirect GHG emissions from the production of electricity and other energy-related utilities purchased and consumed by the organisation.

tonnes of carbon dioxide equivalent (CO_2e). A component of the CCRA is a GHG Alternatives Analysis that evaluates lower GHG intensive alternatives. Given that the Project is likely to exceed *Principle 2*'s threshold of 100,000 tonnes of CO_2e per year, an Alternatives Analysis is required for the Project.

Annex A: Climate Change: Alternatives Analysis, Quantification, and Reporting of Greenhouse Gas Emissions defines the implementation and reporting requirements for the GHG Alternatives Analysis, as summarised below:

- The Alternatives Analysis must evaluate technically and financially feasible and cost-effective options available to reduce project-related GHG emissions during the design, construction, and operation of the project in relation to both Scope 1 and Scope 2 emissions;
- For Scope 1 emissions, the Alternatives Analysis should aim to ascertain the best practicable environmental option and include the consideration of alternative fuel or energy sources if applicable;
- For projects in high carbon intensity sectors (which applies to the Project), the Alternatives Analysis will include comparisons to other viable technologies used in the same industry and in the country or region as the Project, including, as appropriate, the relative energy efficiency or GHG efficiency ratio;
- The Alternatives Analysis should document and justify why the alternative options were not selected. The approach to the analysis should adhere to the relevant regulatory permitting regime if applicable, and any GHG emissions should be calculated in line with the GHG Protocol or national reporting methodologies if they are consistent with the GHG Protocol; and
- It is acknowledged that in some circumstances, public disclosure of the full Alternatives Analysis or project-level emissions may not be appropriate, for instance, where the analysis includes business confidential, commercially sensitive, or proprietary information.

2.1.2 International Finance Corporation's Performance Standards

The International Finance Corporation (IFC) is part of the World Bank Group (WBG) and is an established global development institution focussed on advancing economic development in a sustainable manner. As part of IFC's Sustainability Framework, clients seeking investments must assume full responsibility for managing their environmental and social risks by adhering to IFC Performance Standards (IFC 2012 Performance Standards on Environmental and Social Sustainability). The latest edition came into effect on January 1st, 2012 and expanded its scope to include climate change issues.

Performance Standard 3: Resource Efficiency and Pollution Prevention requires clients to consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project. Examples of possible alternatives provided by the IFC include alternative project locations, the adoption of alternative energy sources, and the use of alternative practices.

2.2 Methodology

The following section provides a description of the methodology designed for the Project's GHG alternatives analysis. It is worth noting that the Project, once operational, will serve the sole function of power generation to serve production processes at Alba's smelter plant. There are relatively few technological and design approaches for the provision of power generator for this sector, therefore the potential for a significant number of alternatives for consideration by Alba were limited since the concept development stage of the Project.

Therefore, due to the limited technological options available, the GHG Alternatives Analysis focused on a comparison of emissions to a scenario in which the Project does not come forward.

2.2.1 Data sources

The GHG Alternatives Analysis was informed by the following data sources:

- Power Station 5 – Block 4 Expansion Addendum to the ESIA Report conducted by Envirotech Consultancy W.L.L., September 2022 (document reference: ENV-RJC-20-00070/ESIA-ADM-01);
- Power Station 5 – Block 4 Expansion Project: Power Station Operating Scenarios produced by Alba;
- Power Station 5 – Block 4 Expansion Project: BAT Assessment Report produced by Alba; and
- Power Station 5 – Block 4: Project Feasibility Report produced by Alba, October 2021 (document reference: PS5.BL4.ALBA.DOCS.0150.

2.2.2 Business objectives

All of Alba's combined cycle power plants operate on natural gas supplied via two gas supply stations covered by a single gas supply agreement. The actual power generation at Alba's PS is constrained by the permissible contractual daily average gas limit of 528 million standard cubic feet (mmscf). Alba's smelter plant operates in an island mode without a direct connection between its internal power distribution system and the Electricity & Water Authority (EWA) national grid, meaning that the facility is self-sufficient. However, there are a total of three existing interconnections that allow the exchange of power between the two systems if required and agreed via a power supply agreement.

The production of primary aluminium requires the efficient generation and steady, reliable delivery of power. Following the Line 6 Expansion Project, the total internal load requirement from the production processes was in excess of 2,600 MW. In the event of power curtailment, it is critical that the supply of steady power is re-established in the shortest time possible to avoid costly, long-term outages at the aluminium potlines. Moreover, due to its extreme energy dependency, the cost of energy is one of the most substantial contributors to the overall cost of production at the facility. Therefore, one of Alba's priorities is to maximise annual power generation efficiency at its PS, whilst ensuring sufficient spinning reserve to stabilise the power distribution system and continue production processes following transient disturbances,

It should also be noted that the original concept for PS5 was based on four blocks. Thus, several of the auxiliary systems in PS5 have been designed and constructed to serve four blocks, and a plot of land had already been allocated for the fourth block. However, construction of Block 4 was deferred because it was determined that Block 1, 2, and 3 at PS5 could meet the additional load requirements of Potline 6 and limit natural gas consumption within the quota allocated by the gas supply agreement.

Alba's decision to now proceed with Block 4, as originally planned, has the objective of achieving higher level of power generation, and thus operational efficiencies, and increasing its global competitiveness. Enhancing efficiency at the facility would also tie in with Alba's other strategic objectives such as driving down production costs and building business resilience against an increasingly volatile energy market, as well as contributing to the sustainable management of natural gas resources and the reduction of GHG emissions.

2.2.3 Alternatives screening

Given the project context described in **Section 2.2.2**, there is limited room for alternatives that would be compatible with Alba's business objectives and considered as technically and financially feasible and cost-effective. The choice of fuel source was determined by Bahrain's energy mix and the nature of operational activities at the facility. Bahrain relies heavily on domestic fossil fuel reserves and generates electricity mainly via natural gas combustion (IEA, 2020). Compared to fuel oil and coal, natural gas produces less GHG emissions and has a higher energy content, making it the most efficient fossil fuel option. Moreover, due to their intermittent availability, renewables would not currently deliver a stable, reliable flow of electricity as needed for the production of primary aluminium.

Alternative locations and layouts were also screened out, given that that Block 4 was originally intended to be sited adjacent to the existing three blocks at PS5, which were previously built as part of the Line 6 Expansion Project. Provisions have already been made for Block 4 at PS5, thus locating the Project per Alba's original plans would utilise the existing infrastructure and integrate its operational and maintenance (O&M) requirements with PS5's existing internal processes.

In terms of alternative technologies, Alba conceptualised the Project with the intention of increasing overall efficiency at the facility by replacing lower efficiency power generating units with the most efficient generating units as far as practicable. Thus, the final design for the Project involves the use of one of the most efficient power generation technologies available on the market within the region, which also satisfies Alba's safety, quality, cost, and technical requirements.

Given the above considerations on what alternatives Alba consider to be viable and reasonable, this analysis will only examine and compare GHG emissions associated with a 'no project' scenario versus a 'with project' scenario.

2.2.4 Alternatives evaluation

To calculate GHG emissions for the two scenarios identified in **Section 2.2.3**, a standard calculation-based methodology was adopted, which involves multiplying measured or estimated activity data with emission factors, and where relevant net calorific factors and global warming potential (GWP) factors. Activity data for the comparisons were obtained from the total natural gas requirement estimated by Alba in units of million scf per day. Natural gas requirements were provided for the no project and with project scenarios, with separate requirements for the winter and summer season due to differences in ambient air temperatures affecting the power generation efficiency of the turbines.

In addition to quantitative data, a best available technique (BAT) assessment report and a breakdown of each operating scenario were also provided, including the number and location of power generating unit in-service under each scenario. Standard conversion factors were used to convert different gas measurement and energy units, while emission factors were obtained from the Intergovernmental Panel on Climate Change's (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories, namely default emission factors for stationary combustion sources in the energy industry. It should be noted that country-specific emission factors for Bahrain were not available at the time the GHG calculations were performed, as noted in Bahrain's Third National Communication under the United Nations Framework Convention on Climate Change (UNFCC).

For the purpose of comparing GHG emissions between the two scenarios, calculations were performed for Scope 1 operation GHG emissions only. Further discussions on the boundaries of the Project's GHG emissions inventory and its key emission sources can be found in **Section 3**. Daily emissions were calculated for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) using their respective emission factors and were converted to carbon dioxide equivalent (CO_2e) emissions[2] using GWP factors from the most recent IPCC Sixth Assessment Report published in 2021.

2.3 Key outcomes

2.3.1 No project scenario

Under the no project scenario, power supply to Alba's smelter plant would continue to be provided by the existing PS, namely PS3, PS4, and PS5.

PS3 was constructed in 1992 as part of Alba's Line 4 Expansion Project with a total capacity of 800 MW. PS3 consists of two combined cycle blocks, with each block comprising three GE (formerly ABB) gas turbines and a GE (formerly ABB) steam turbine. PS4 was constructed in 2005 as part of the Line 5 Expansion Project with a total capacity of 900 MW. PS4 consists of two combined cycle blocks, with each block comprising two GE (formerly Alstom Power) gas turbines and a GE (formerly Alstom Power) steam turbine. PS5 was constructed in 2019 as part of the Line 6 Expansion Project with a current total capacity of 1,800 MW. Without the Project, PS5 consists of three combined cycle blocks, with each block in a multi-shaft 1:1:1 gas turbine, steam turbine, and heat recovery steam generators configuration of GE design.

A breakdown of the no project scenario can be seen in **Table 2.1**.

Table 2.1 No project scenario summary

PS number	Number of units in-service	Total capacity (MW)	Operating load (MW)	Load factor (%)
Winter season				
PS1	No units in-service	80	0	-
PS2	No units in-service	100	0	-
PS3	1 gas turbine, 1 steam turbine	833	145	18
PS4	4 gas turbines, 2 steam turbines	913	867	95
PS5	3 turbines, 3 steam turbines	1,758	1,688	96
Total natural gas requirement in million scf per day		514		
Summer season				

[2] CO_2e is a common unit for comparing different GHG. The unit takes the different GWP of GHG into account. In other words, the CO_2e of a GHG signifies the amount of CO_2 that needs to be emitted to have an equivalent global warming impact.

PS number	Number of units in-service	Total capacity (MW)	Operating load (MW)	Load factor (%)
PS1	No units in-service	68	0	-
PS2	No units in-service	85	0	-
PS3	3 gas turbines, 1 steam turbine	755	283	38
PS4	4 gas turbines, 2 steam turbines	837	795	95
PS5	3 turbines, 3 steam turbines	1,580	1,517	96
Total natural gas requirement in million scf per day		535		

2.3.2 With project scenario

Under the with project scenario, Alba would add Block 4 to the existing PS5, which has the capability of producing 680.8 MW[3]. Block 4 will be constructed in the same 1:1:1 configuration as the existing three blocks at PS5 and will be capable of running both in open and combined cycles.

As described in Alba's BAT Assessment Report, the Project was designed with reference to the EU BAT Reference Document for Large Combustion Plants (hereafter referred to as 'BREF'), which covers the combustion of any solid, liquid, and/or gaseous combustible material as fuels in installations with a total rated thermal input of 50 MW or more. The BREF states that a combination of two thermodynamic cycles, namely the Brayton and Rankine cycle, provides the best use of energy by converting the heat loss from the first cycle to useful energy in the second cycle. The Project will adopt this configuration as part of its combined cycle by pairing a high temperature gas turbine with a relatively low temperature steam turbine. The major Project components consist of:

- A gas turbine rated at 475.4 MW[3];
- A heat recovery steam generator with a rated steam output of 439.8 tonnes/hour;
- A steam turbine rated at 217.3 MW[3];
- An air-cooled condenser; and
- Control systems.

Manufacturers for these components have been selected based on their specifications of the most advanced and efficient technologies available on the market that are also practicable to Alba. Conclusions from the BAT Assessment Report indicate that the Project exceeds the relevant BAT requirements. Some notable findings include:

- The gas turbine specified is an advanced J class turbine of Mitsubishi make with enhanced cooling to maximise performance;
- The gas turbine's open cycle operational efficiency was predicted at 42.56% at 25°C, which would be higher under International Organisation for Standardisation (ISO) conditions[4]. The BREF states that efficiencies for heavy

[3] at an ambient air temperature of 25°C

[4] ISO conditions refer to standard testing conditions used by the gas turbine industry. These conditions are 15°C/59°F ambient air temperature, 60% relative humidity, and 14.7 pound per square inch absolute (psia).

duty gas turbines with power outputs between 150 to 380 MW could reach up to 42% under ISO conditions;
- The gas turbine's combined cycle operational efficiency was predicted at 60.56% at 25°C, which would be around 64% under ISO conditions. This efficiency is representative of the normal operational regime for Block 4;
- According to the BREF, high operational efficiencies are an indication of both an efficient utilisation of fuel and lower GHG intensity for each power unit produced.

A decommissioning schedule for the less efficient power generating units has been prepared by Alba. Gas turbines 1 to 15 at PS1, each with a power rating of around 16 to 18 MW, and the boiler and steam turbine at PS2, which are approximately 60 MW, are no longer available for power generation. The steam turbine at PS1 is currently being dismantled. Gas turbines 16 to 19 at PS1, each with a power rating 18 to 21 MW, and gas turbines 20 to 25, each of which are approximately 22 MW, are currently not in-service but are maintained for emergency support until the commissioning of Block 4 in January 2025. The emergency support capacity is around 180 MW. Beyond the commissioning of Block 4, the remaining gas turbines at PS1 will be fully decommissioned, while those at PS2 will be for black start capability.

A breakdown of the with project scenario can be seen in **Table 2.2**.

Table 2.2 With project scenario summary

PS number	Number of units in-service
Winter season	
PS1	No units in-service
PS2	No units in-service
PS3	No units in-service
PS4	2 gas turbines, 1 steam turbine
PS5	4 gas turbines, 4 steam turbines
Total natural gas requirement in million scf per day	492
Summer season	
PS1	No units in-service
PS2	No units in-service
PS3	No units in-service
PS4	3 gas turbines, 2 steam turbines
PS5	4 gas turbines, 4 steam turbines
Total natural gas requirement in million scf per day	504

2.3.3 Comparisons of greenhouse gas emissions

GHG emissions associated with the no project and with project scenarios are summarised in **Table 2.3**. These GHG emissions cover all power generating units assumed to be in-service under each operating scenario, as described in **Table 2.1** and **Table 2.2**.

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Table 2.3 GHG emissions comparisons

Scenarios	Total CO_2e emissions (tonnes/day)
Winter season	
No project	29,368.8
With project	28,111.5
GHG emission savings	1,257.1
Summer season	
No project	30,568.4
With project	28,797.2
GHG emission savings	1,771.2
Total GHG emission savings	3,028.3

As evidenced, implementation of the Project would lead to a reduction in daily GHG emissions arising from power generation at Alba's smelter plant. This is due to an overall increase in the operational efficiencies of the power generating units, which also have the additional benefit of resource (natural gas) conservation. The power generation efficiency at the facility would increase from 48.07% to 50.99% and 50.02% to 52.25% for the winter and summer seasons respectively with the addition of Block 4. This is associated with an improvement in GHG intensity, with a reduction from 0.394 to 0.372 tonnes of CO_2/MWh. Moreover, with Block 4 in-service and PS5's expanded capacity, there will be no requirement to increase the natural gas quota allocated to Alba, given that the overall gas consumption for the same power generation output will be reduced.

Therefore, it can be concluded that implementation of the Project, based on the final design and associated decommissioning arrangements, would lead to positive impacts from an energy efficiency and GHG emissions perspective.

3 JUSTIFICATION OF GREENHOUSE GAS EMISSIONS DATA

The purpose of this chapter is to review the data and approach used to compile and calculate the GHG emissions inventory for the Project. The evaluation will focus on the data quality, including data representativeness and completeness, and recommendations for future improvements will be provided where relevant. References will also be made to internationally recognised standards and guidelines for GHG emissions accounting and reporting.

This chapter includes the following sections:

- Section 3.1 - IFI requirements with respect to independent verification;
- Section 3.2 – a description of how the GHG emissions inventory has been calculated for the Project; and
- Section 3.3 – key outcomes of the review and recommendations for future improvements.

3.1 International Finance Institutions' requirements

3.1.1 The Equator Principles

Under *Annex A: Climate Change: Alternatives Analysis, Quantification, and Reporting of Greenhouse Gas Emissions* (EP, 2020), EP4 defines how GHG emissions arising from the proposed project should be quantified, as summarised below:

- GHG emissions should be quantified in line with the GHG Protocol to allow for aggregation and comparability across projects, organisations, and jurisdictions;
- The Project may choose to adopt host country regulatory requirements and GHG accounting and reporting methodologies instead if they are consistent with the GHG Protocol; and
- The Project is required to quantify Scope 1 and Scope 2 emissions.

In addition, within EP (2020) Guidance Note on Climate Change Risk Assessment, it is noted under the *Use of Consultants* clause that the CCRA may draw upon the capabilities and outputs from other advisors beyond the Independent Environmental and Social Consultant whose skills and experience may assist in ensuring a higher quality CCRA.

3.1.2 International Finance Corporation's Performance Standards

In conjunction with *Performance Standard 3: Resource Efficiency and Pollution Prevention,* IFC (2020) Guidance Notes under *Guidance Note 3* provides clarifications on how GHG quantification should be implemented, as summarised below:

- Scope 1 and Scope 2 emissions should be quantified for projects that are considered to produce significant GHG emissions. Emissions that arise from within the project site but not from project-related activities (i.e. downstream or upstream emissions) should not be included in the quantification;
- When carbon dioxide (CO_2) emissions result from fossil fuel use, these emissions should be quantified through knowledge of fuel use;
- Scope 2 emissions associated with the production by others of electricity consumed by the project can be estimated using a national average of GHG emissions performance of the electricity grid. Project-specific grid factors should be used where available;

- Scope 2 emissions associated with the production by others of heating and cooling energy consumed by the project should also be quantified; and
- The six GHGs of most concern to the United Nations Framework Convention on Climate Change (UNFCC) are CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulphur hexafluoride (SF_6);

Furthermore, *Annex A: Suggested GHG Quantifying and Monitoring Practice* to *Guidance Note 3* states that the most authoritative and updated methodologies are provided by the Intergovernmental Panel on Climate Change (IPCC) via the National Guidelines for Greenhouse Gas Inventories. Other internationally recognised methodologies are also provided, including the GHG Protocol. IFC acknowledges that projects should select and adopt the methodology that best suits its characteristics such as project type and sector and the objective of estimating and reporting GHG emissions.

3.2 Current greenhouse gas emissions inventory

Calculations for the current inventory was provided by the Project's gas and steam turbine manufacturer, Mitsubishi Power. The methodology and assumptions adopted are shown below:

Total annual CO_2 emissions = (Winter Operating Hours x Winter Emissions Factor x 3600) + (Summer Operating Hours x Summer Emissions Factor x 3600)

- Assuming a total of 8,000 hours per year at 100% load operation, with a 50-50 split between the seasons;
- CO_2 emissions per gas turbine quoted at 71.1 kg/s at 25°C and 64 kg/s at 42°C under a combined cycle configuration, which resemble winter and summer ambient air temperatures respectively; and
- Using 3,600 seconds in an hour and 0.001 tonne in a kilogram.

The total annual CO_2 emissions for the Project was estimated to be 1,945,440 tonnes per year.

3.3 Key outcomes and recommendations

A review of the Project's GHG emissions inventory indicates that the inventory scope and boundary are extremely limited, given that the only operational activity that also qualifies as a key emission source is the natural gas combustion for power generation. Under the GHG Protocol, this is considered as Scope 1 emissions from a stationary combustion source. Alba advised that direct emissions from backup diesel generators would be minimal and difficult to predict, given that its power distribution system has adequate built-in redundancies to ensure continuous power delivery in the event of faults to one part of the power system and scheduled maintenance periods. Therefore, based on past experience, Alba does not anticipate the use of emergency support from mothballed PS or backup generators.

Moreover, due to Block 4's location within PS5, the Project's O&M schedule would be integrated with processes already in place for the existing three blocks. Thus, no Scope 1 emissions from additional O&M vehicles are anticipated. Scope 2 emissions were also advised by Alba to be zero. Although the facility has the infrastructure required to import electricity from EWA, no formal contract has been signed for the continuous import of power. In addition, there is sufficient captive power generation capacity on-site to continuously serve production processes at the smelter plant without the need for power import. This design information justifies Alba's decision to consider natural gas combustion for power generation as the only key emission source in the GHG emissions inventory.

However, it is important to note that the GHG emissions inventory only covers the operational phase. Alba stated that the construction power demand would be extended from its own PS. The expected power demand during construction is estimated to be a maximum of 1.2 MW, which is 0.2% of Block 4's power generation capacity, and will be drawn from the existing PS. Furthermore, Alba also specified that there will be emissions from construction equipment and vehicles on-site, which are not owned by Alba and therefore would be considered by the GHG Protocol as Scope 3 emissions from mobile combustion sources. However, construction phase emissions are likely to comprise a small and temporary component of the overall Project GHG footprint.

Based on the observations described above, the following recommendations are proposed for consideration to supplement the Project's current GHG emissions inventory:

- The quoted emissions factors provided by Mitsubishi Power only cover CO_2. However, the combustion of natural gas also releases residual amounts of CH_4 and N_2O, which are GHGs and contribute to the global warming effect (WBCSD and WRI, 2005). Emission factors for CH_4 and N_2O should also be obtained; and
- It is noted that Alba has a continuous emissions monitoring system (CEMS) and advanced control system in place to manage its air quality impacts, and GHG calculations are currently performed based on the GHG Protocol and the IPCC sector-specific guidelines. Existing internal processes at Alba should also be extended to the Project, so that all sources of operational GHG emissions are measured and/or estimated in line with good international practice and relevant international standards and guidelines.

4 CONCLUSIONS

This document provides the updated components to the Project's CCRA, namely a GHG Alternatives Analysis and a review of the Project's GHG emissions inventory, as requested by the third-party reviewer during ESDD. Due to the limited scope for alternatives that would satisfy Alba's business objectives and be considered as technically and financially feasible and cost-effective, the Alternatives Analysis compared GHG emissions associated with a no project scenario versus a with project scenario. Comparisons were undertaken quantitatively using the daily natural gas requirement specified by Alba under different operating scenarios. These two scenarios were identified and agreed in collaboration with Alba.

Outcomes of the GHG Alternatives Analysis indicate that implementing the Project, based on its final design and associated decommissioning arrangements, would lead to a reduction in operational GHG emissions from the perspective of both absolute emissions and emissions intensity. This is primarily due to an overall increase in the operational efficiencies of the power generating units, with the addition of Block 4's advanced technologies in place of less efficient technologies in the existing PS. Moreover, the Project was determined to exceed BREF BAT requirements for large combustion plants, which signifies high energy and GHG efficiency in relation to comparable assets within the same industry and region.

A review of the Project's current GHG emissions inventory was also conducted. Taking into account the limited nature of its scope and boundary, it was considered justifiable that the inventory only included natural gas combustion for power generation as the key emission source throughout the Project's operational lifetime. Based on the design information provided by Alba, it was also justifiable to exclude Scope 1 mobile source emissions from O&M vehicles and Scope 2 emissions from power import. However, a number of considerations were proposed to supplement the existing GHG calculations.

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