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 contents

Page

1 INTRODUCTION 1
1.1 Project description 1
1.2 Report scope 1

2 APPENDICES 3

Appendix A Physical and Transition Risk Assessment Prepared by Envirotech
Appendix B Updated Climate Change Risk Assessment Prepared by EACS

1 INTRODUCTION

1.1 Project description

Aluminium Bahrain B.S.C. (Alba) is the world’s second largest single site aluminium smelter. Alba 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. (Envirotech) on behalf of Alba, and was submitted to the Supreme Council for Environment (SCE), the national environmental regulator, 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.

Following the review of the ESIA, Citrus issued an Equator Principle Action Plan (EPAP) document which identified the gaps in the ESIA and provided actions to mitigate the gaps. One of the gaps identified in the EPAP was the climate change risk assessment which required updating to align with the EP4 requirements. The following actions were recommended:

- With external consultancy support, update Climate Change Risks Assessment to meet the requirements set out in the EP4 Guidance Note on Climate Change Risk Assessment (CCRA). To include:
    - Assessment of transition risks;
    - alternatives analysis;
    - compatibility with Bahraini climate change commitments; and
    - justification of GHG emissions data.

Following the receipt of EPAP, Envirotech prepared an updated CCRA in the form of an ESIA addendum report and submitted it to Citrus for review. This report is presented in **Appendix A**.

Following the review of updated CCRA, additional 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). The CCRA was prepared by Royal HaskoningDHV UK Ltd., as subcontracted by EACS, and addresses two compliance gaps identified by Citrus. This report is presented in **Appendix B**.

2 APPENDICES

Appendix A

Physical and Transition Risk Assessment Prepared by Envirotech

ADDENDUM TO THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDY – CLIMATE CHANGE RISK ASSESSMENT

PROJECT : ALBA POWER STATION 5 – BLOCK 4

CLIENT : ALUMINIUM BAHRAIN B.S.C

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Table of Contents

1 Introduction 6
2 Climate Change Risk Assessment 7
2.1 Project Description 7
2.1.1 Current Power Generation Scenario 7
2.1.2 Load Flow 8
2.1.3 Block 4 Expansion Project 8
2.2 Climate Change Policies and Plans 9
2.2.1 Kingdom of Bahrain 9
2.2.2 Aluminium Bahrain BSC – The Road to Net Zero by 2060 10
2.3 Risk Assessment Methodology 13
2.3.1 Overall Approach – EP4 Requirements 13
2.3.2 Risk Matrix 15
2.4 Risk Assessment 17
2.4.1 Physical Risks 17
2.4.2 Transition Risks 20
2.5 Alternatives Analysis 21
2.5.1 GHG Emissions 21
2.5.2 Alternatives Analysis 23
3 References 25

List of Figures

Figure 2-1 Stages in Alba Road Map 10
Figure 2-2 Pathway to Net Zero by 2060 (tCO_2e/tAl) 11
Figure 2-3 Reduction Potential by Initiative (tCO_2e/tAl) 12
Figure 2-4 Six (6) ESG Priorities 13
Figure 2-5 Risk Matrix 15

List of Tables

Table 2-1 Baseline Operating Scenario of Alba Power Stations 7
Table 2-2 Alba Power Stations - Load Flow during Summer and Winter Seasons 8
Table 2-3 Qualitative Measures of Likelihood 16
Table 2-4 Qualitative Measures of Consequence 16
Table 2-5 Climate Change Risk Assessment for Physical Risks 18
Table 2-6 Summary of Transition Risks Assessment 21

ABBREVIATIONS

Alba	Aluminium Bahrain BSC
CCGT	Combined Cycle Gas Turbine
COP26	26th United Nations Climate Change Conference of the Parties
CWMP	Construction Waste Management Plan
EPAP	Equator Principle Action Plan
ESIA	Environmental and Social Impact Assessment
GHG	Green House Gases
GWP	Global Warming Potential
IFC	International Finance Corporation
MPW	Mitsubishi Power Ltd.
MW	Megawatt
NEEAP	National Energy Efficiency Action Plan
NG	Natural Gas
NREAP	National Renewable Energy Action Plan
PS	Power Station
SCE	Supreme Council for Environment
SEPCO III	SEPCO III Electric Power Construction Co. Ltd.

1 INTRODUCTION

Aluminium Bahrain B.S.C. (Alba) consistently ranks as one of the largest and most modern Aluminium smelters in the world. Known for its technological strength and innovative policies, Alba enforces strict environmental guidelines, maintains a high track record for safety, and is widely regarded as one of the top performers on a global scale.

Alba PS 5 Block 4 Combined Cycle Power Plant is an expansion of the existing Power Station 5, which was commissioned in 2019 – 2020 and consists of 3 x CCGT Blocks of 1:1:1 configuration, with H class gas turbine technology, GE A650 steam turbine, GE (Alstom legacy) heat recovery steam generator, GE Mark VIe distribute control system. PS5 power is exported to the Alba islanded grid through a recently completed (2019) Siemens 220kV indoor gas insulated switchgear Substation.

PS5 Block 4 Project is the addition of a fourth Block of similar 1:1:1 configuration with J-class gas turbine technology and with minimum nominal ISO rating of a 680.8 MW and it also includes tie into the existing 220kV Substation. A Consortium of Mitsubishi Power Ltd. (MPW) and SEPCO III Electric Power Construction Co. Ltd. (SEPCO III) will execute PS5 Block 4. PS5 capacity will increase from 1,800 MW to 2,481 MW. Block 4 Gas turbine unit will have the capability to operate on 100% Khuff gas, 100% Residual will also have the capability to operate on any proportionate mixture of Khuff-residual gas. Generally, concept for the new Block 4 is like the existing Blocks 1 to 3, and the services will be provided from the common facilities from the existing PS5 or other plants within the Alba complex.

Rationale behind the expansion of PS5 Block 4 is the efficiency of this combined cycle power plant is much higher than combined cycle power plants of PS 3 and PS 4. Power Station 3, which is operating on a low load, will be shut down and will be kept as emergency standby. Power station 4 will be running partially.

Alba commissioned M/s Envirotech Consultancy W.L.L. as environmental consultant to perform and Environmental and Social Impact Assessment (ESIA) Study. An ESIA report was submitted to the Supreme Council for Environment on 06th January 2022 and environmental clearance was issued.

Alba forwarded the approved ESIA report to BNP Paribas – the coordinator of project finance. BNP Paribas appointed Citrus advisors Ltd. (Citrus) to conduct a review on the report for compliance with Equator Principles 4. Citrus then prepared a report that highlighted some gaps and an Equator Principles Action Plan (EPAP) to address them.

This report presents the climate change risk assessment as recommended in the EPAP.

2 CLIMATE CHANGE RISK ASSESSMENT

2.1 Project Description

2.1.1 Current Power Generation Scenario

Alba currently has five (5) Power Stations including the newly built Power Station 5 as part of Potline 6 Expansion within the complex. Further to the completion of Potline 6 expansion, the capacity of PS5 has increased to 1,800 MW. As a result, there is a reduction in the requirement to operate PS 3 and PS 4. On completion of Pot line 6 Expansion project, Power station 1 was largely de-commissioned. As of September 2020, fifteen out of nineteen Gas Turbines, originally installed, has been disconnected electrically and are no longer available for generation.

Further to the completion of Block 4, the capacity of PS5 will increase from 1,800 MW to 2481 MW The baseline operating scenario is shown in Table 2-1.

Table 2-1 Baseline Operating Scenario of Alba Power Stations

Power Station	No. of Units	Total Capacity (MW)	Operating Load (MW)	Load Factor (%)
Winter Without PS 5 – Block 4				
PS1	5 GTs	80	0	-
PS2	5 GTs, 0 ST	100	0	-
PS3	6 GTs, 2 STs	833	145	18
PS4	4 GTs, 2 STs	913	867	95
PS5	3 GTs, 3 STs	1758	1688	96
Total		**3,584**	**2,700**	**75**
Summer without PS 5 – Block 4				
PS1	4 GTs	68	0	-
PS2	5 GTs, 0 ST	85	0	-
PS3	6 GTs, 2 STs	755	283	38
PS4	4 GTs, 2 STs	837	837	95
PS5	3 GTs, 3 STs	1580	1580	96
Total		**3,325**	**2,700**	**81**

2.1.2 Load Flow

Load flow during summer as well as winter seasons considering the existing and future operational scenarios are presented in Table 2-2.

Table 2-2 Alba Power Stations - Load Flow during Summer and Winter Seasons

Power Stations	Operational Units (In-Service)
Winter Base Case (3 PS 5 Units Operational)	
PS 5	GT 71, ST 72, GT 73, ST 74, GT 81, and ST 82
PS 4	GT 51, GT 52, ST 53, GT 61, GT 62, and ST 63
PS 3	1GT and 1ST
PS 2	No Units Operational
Summer Base Case (3 PS 5 Units Operational)	
PS 5	GT 71, ST 72, GT 73, ST 74, GT 81, and ST 82
PS 4	GT 51, GT 52, ST 53, GT 61, GT 62, and ST 63
PS 3	2 GTs and 1 ST
PS 2	No Units Operational
Winter Base Case (4 PS 5 Units Operational)	
PS 5	GT 71, ST 72, GT 73, ST 74, GT 81, ST 82, GT 83, and ST 84
PS 4	2 GTs and 1 ST
PS 3	No Units Operational
PS 2	No Units Operational
Summer Base Case (4 PS 5 Units Operational)	
PS 5	GT 71, ST 72, GT 73, ST 74, GT 81, ST 82, GT 83, and ST 84
PS 4	GT 51, GT 52, ST 53, GT 61, GT 62, and ST 63
PS 3	No Units Operational
PS 2	No Units Operational

2.1.3 Block 4 Expansion Project

On completion of Pot line 6 Expansion project, Power station 1 was largely de-commissioned. As of September 2020, fifteen out of nineteen Gas Turbines, originally installed, were disconnected electrically and are no longer available for generation. Remaining four gas Turbines are connected to the network system and will remain physically available for possible future use as a black start and emergency reserve.

Power Station 2 will remain in a black start and emergency reserve capacity. One of the Gas Turbine is dedicated to start the Power station 5 Gas Turbine during the blackout condition and other Gas Turbines are emergency reserve. Power Station 2 steam generator will be decommissioned and disposed of the following the power requirement review.

Alba PS 5 Block 4 Combined Cycle Power Plant is an expansion of the existing Power Station 5, which was commissioned in 2019 – 2020 and consists of 3 x CCGT Blocks of 1:1:1 configuration, with H class gas turbine technology, GE A650 steam turbine, GE (Alstom legacy) heat recovery steam generator, GE Mark VIe distribute control system. PS5 power is exported to the Alba islanded grid through a recently completed (2019) Siemens 220kV indoor gas insulated switchgear Substation.

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On completion of PS 5 Block 4 Expansion Project, the capacity of PS5 will increase from 1,800 MW to 2,481 MW. Rationale behind the expansion of PS5 Block 4 is the efficiency of this combined cycle power plant is much higher than combined cycle power plants of PS 3 and PS 4. Power Station 3, which is operating on a low load, will be shut down and will be kept as emergency standby. Power station 4 will be running partially.

2.2 Climate Change Policies and Plans

2.2.1 Kingdom of Bahrain

[10] Up to the 26th United Nations Climate Change Conference of the Parties (COP 26), Bahrain had not set an explicit CO_2e emissions reduction target, as CO_2e emissions were addressed implicitly within existing energy targets. These targets include achieving a 6% improvement in energy efficiency by 2025 through the adoption of the National Energy Efficiency Action Plan (NEEAP) and increasing the

share of renewable energy by 5% in 2025 and 10% in 2035 through the adoption of the National Renewable Energy Action Plan (NREAP). CO_2e emissions reduction resulting from the implementation of the NEEAP and the NREAP is projected to amount to 1.9 million tons in 2030, which is less than 5% [7, SCE 2020] of Bahrain's total CO_2e emissions [7, SCE 2020]. While the government has implemented major initiatives, a few initiatives within the private sector are also evident, including installing 880 solar panels in a shopping mall and the planned establishment of a 5-MW solar farm for Aluminium Bahrain [11, 12].

One week before COP 26 took place, Bahrain announced on the 24th of October 2021 its commitment to achieving carbon neutrality by 2060, with an interim goal of a 30% reduction in CO_2e emissions by 2035 [13]. This is Bahrain's first explicit CO2e emission reduction target. Bahrain has almost achieved its renewable energy target for 2025 and is planning to double the penetration of renewables by 2025, thus accomplishing this target 10 years earlier than planned [14]. In the case of the NEEAP, 21 out of 22 energy efficiency initiatives have been achieved in line with the energy efficiency target set for 2025 [14].

2.2.2 Aluminium Bahrain BSC – The Road to Net Zero by 2060

Alba's Net Zero Roadmap is defined in three distinct phases— planning, managing, and monitoring. These phases are designed to illustrate the inherent uncertainty in longer-term objectives, but also to provide clarity on how Alba intends to allocate resources at each stage. The Planned stage is inherently more defined.

Figure 2-1 Stages in Alba Road Map

2.2.2.1 The Path to Net Zero

As shown in Figure 5-2, Alba has made great strides since 2015, effectively reducing scope 1 & 2 emissions intensity from 9.56 to 7.94 tonnes of CO_2e per tonne of

Aluminum produced (tCO_2e/t Al). The graph below showcases the 2020 emissions intensity baseline and the estimated emissions reduction from initiatives identified and defined by Alba. It is important to note that although reduction initiatives have been identified and modeled, Alba is still in the exploratory phase of these efforts and intend to further refine and enhance estimates over the upcoming months and years.

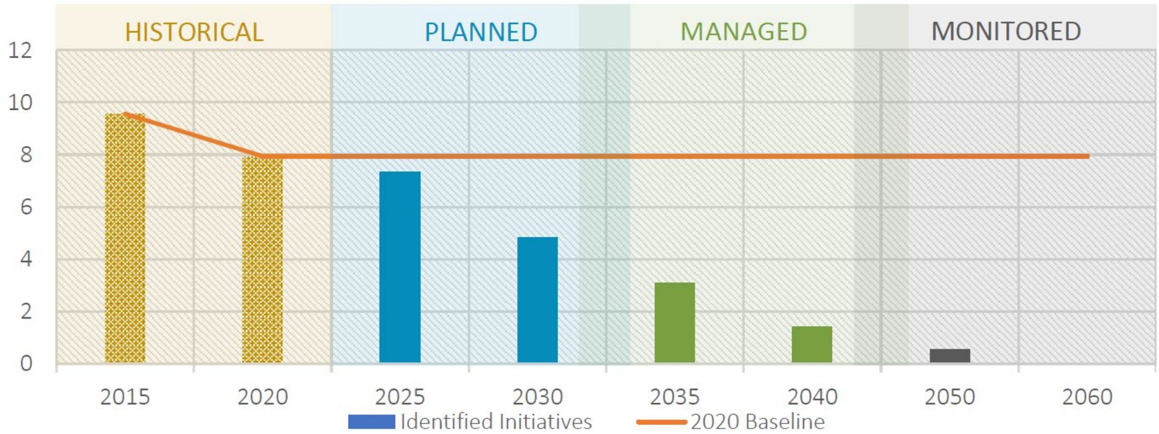
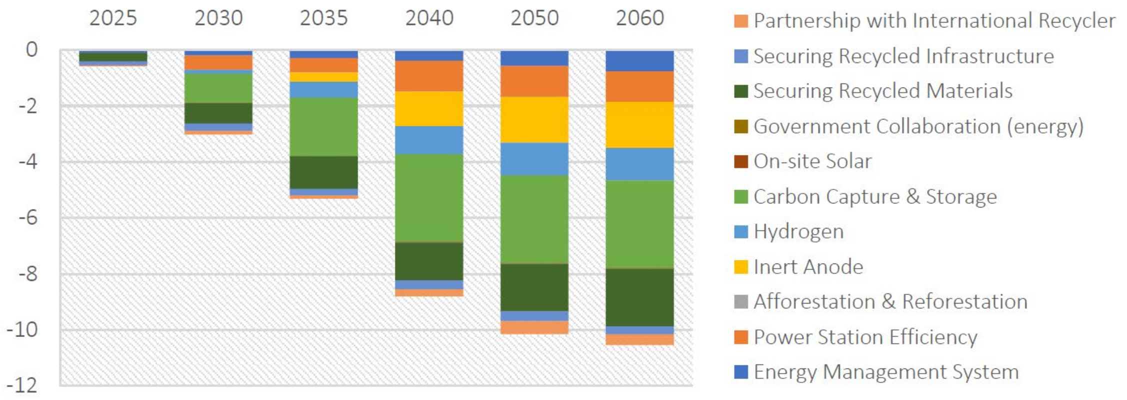


Figure 2-2 Pathway to Net Zero by 2060 (tCO_2e/tAl)

2.2.2.2 Identified Initiatives

In late 2021, Alba underwent a rigorous ESG strategy development process. A key objective of this work was to identify emissions reduction initiatives – some of which are known and others that are still in development – and in an effort reach Net Zero by 2060. The graph below summarizes identified initiatives and showcases Alba's current understanding of the potential emissions reduction resulting from each opportunity. Initiatives are summarized below.



- I.A.1 — **Energy Management System (EMS):** To ensure effective management of energy consumption, Alba will develop a formal Energy Management System aligned with ISO 50001, to be fully implemented in 2023.
- I.A.2 — **Power Station Efficiency:** Alba has plans to decommission inefficient power stations and add additional capacity to a newer, more efficient power station by 2025.
- I.B — **Afforestation & Reforestation:** In alignment with Bahrain's national commitment, Alba will plant trees in new or existing habitats to sequester carbon beginning in 2023.
- I.C — **Inert Anode Technology:** Alba has outlined a multi-phased approach to implement inert anode technology in existing pot lines beginning in 2030, in addition to decommissioning and replacing pot lines with inert anode technology by 2040.
- I.D — **Hydrogen:** Alba intends to steadily explore, incorporate, and replace natural gas with Hydrogen fuel in existing power station when technology becomes mature and cost effective starting from 2025.
- I.E — **Carbon Capture & Storage (CC&S):** Alba will monitor carbon capture & storage technologies, with the intent of implementing in 2035-2040.
- I.F — **Carbon Offsets:** After exhausting all other feasible emissions reduction initiatives, Alba is committed to closing any gaps in emission reduction targets by purchasing carbon offsets.
- II.A — **On-Site Solar:** Through installation of 5MW of on-site solar capacity by 2025, Alba will help reduce scope 2 emissions. Alba intends to explore additional on-site solar opportunities in future years.
- II.C — **Government Collaboration:** Alba is committed to working collaboratively with Bahrain to achieve Net Zero emissions by 2060, effectively eliminating corporate scope 2 emissions.
- III.A — **Securing Recycled Materials:** Alba will increase recycled aluminum sourcing, capitalizing on significant associated energy benefits by 2023 and develop a plan to increase supply over time.
- III.B — **Securing Recycled Infrastructure:** In addition to increasing recycled aluminum supply, Alba is committed to investing in recycled infrastructure in 2023.
- III.C — **Partnership with International Recycler:** To further enhance Alba's efforts to process secondary aluminum, Alba will work to establish international partnership with recyclers, with an initial focus on the EU, beginning in 2022.

Figure 2-3 Reduction Potential by Initiative (tCO_2e/tAl)

2.2.2.3 Way Forward

The Net Zero roadmap and associated reduction initiatives described in this document represent a key part of a broader ESG strategy Alba has been developing in late 2021 and early 2022.

In concert with the Net Zero strategy, Alba has identified six ESG priorities through a comprehensive ESG strategy development process, categorized into two buckets: GHG priorities and Stakeholder priorities. A roadmap was developed for each of the six ESG priorities describing approximately 20 initiatives that may be incorporated into Alba's operations over the next few years. ESG priorities span across environmental and social topics, and initiatives include both value chain and direct operations impacts.

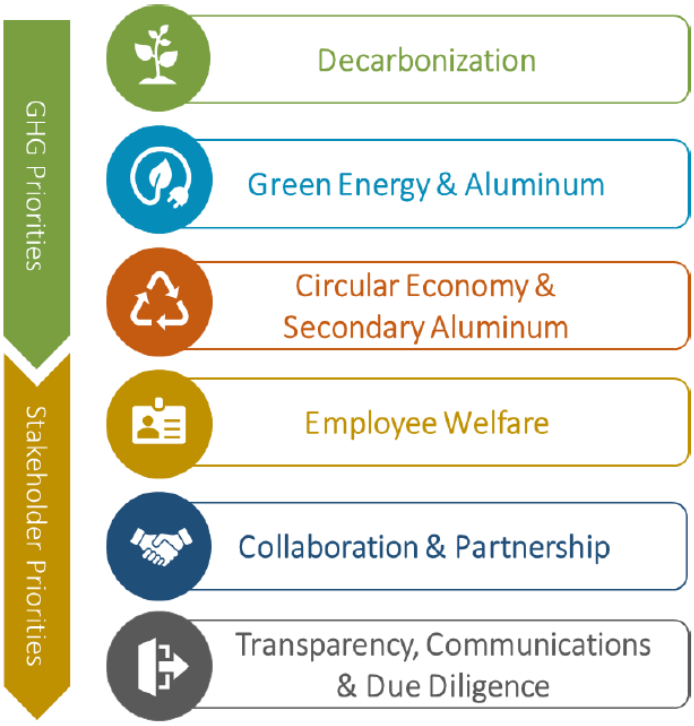


Figure 2-4 Six (6) ESG Priorities

2.3 Risk Assessment Methodology

2.3.1 Overall Approach – EP4 Requirements

2.3.1.1 Climate Change Risk Assessment Requirements

[5] A Climate Change Risk Assessment (CCRA) is required to be undertaken:

- For Category A and, as appropriate, Category B projects. For these projects the CCRA is to include consideration of relevant climate-related 'Physical Risks' as defined by the Task Force on Climate-Related Financial Disclosure (TCFD).
- For all projects, in all locations, when combined Scope 1 and Scope 2 emissions are expected to be more than 100,000 tonnes of CO_2 equivalent annually. For these projects the CCRA is to include consideration of climate-related 'Transition Risks' (as defined by the TCFD). The CCRA must also include a completed alternatives analysis which evaluates lower greenhouse gas (GHG) intensive alternatives.

2.3.1.2 Climate Related Risks

The Recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD Recommendations) divides climate-related risks into two overarching categories. These are:

- Risks which relate to the physical impacts of climate change (Physical Risks); and
- Risks which relate to the transition to a lower-carbon economy (Transition Risks).

2.3.1.2.1 Physical Risks

The TCFD Recommendations state that 'Physical risks resulting from climate change can be event driven (acute) or longer-term shifts (chronic) in climate patterns.

Potential impacts for projects from Physical Risks could include:

- Direct damage to assets, as a result of extreme weather events (e.g., droughts, storms) or rising sea levels.
- Changes in water availability, sourcing and quality, often with consequent social impacts.
- Disruption to operations, ability to transport goods and supplies and impacts on employee/community safety.
- Indirect impacts from supply chain disruption, workforce/community exposure to vector borne diseases (resulting from temperature/precipitation changes), or large movements of people in response to physical impacts of climate change (e.g., sea level rise, desertification, salinization of agricultural land, droughts, storms).

2.3.1.2.2 Transition Risks

The TCFD Recommendations state that 'Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, reputation and market changes to address mitigation and adaptation requirements related to climate change.

The TCFD Recommendations identify the following Transition Risks:

- **Policy and legal risks** – impact of policy and regulatory actions that seek to constrain the adverse effects of climate change or promote adaptation or transition (e.g., carbon pricing, emissions caps, differential capital treatment by regulators, land use changes, water restrictions).
- **Technology risks** – technological improvements that support the transition to a lower emissions economy and lead to demand shifts and market advantage for operators who adapt faster (e.g., battery storage, electric vehicles, carbon capture and storage and technologies that enable improved

operating efficiency, reduce GHG emissions and optimise water and land use).

- **Market risks** – shifts in supply and demand for certain commodities, products and services as climate-related risks and opportunities are acted on (e.g., rise in electric vehicle demand, increased production costs due to changing input prices of energy, water, etc.).
- **Reputation risks** – changing customer or community perceptions of an organization's positive or negative impact on the transition to a lower emissions economy (e.g., public perception of coal-fired power).

2.3.2 Risk Matrix

Figure 2-5 illustrates the risk matrix used in the risk assessment process.

Likelihood Level	Consequence Level				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
5 Almost Certain	L (5)	M (10)	H (15)	E (20)	E (25)
4 Likely	L (4)	M (8)	H (12)	H (16)	E (20)
3 Possible	L (3)	M(6)	M (9)	H (12)	H (15)
2 Unlikely	L (2)	L (4)	M (6)	M (8)	M (10)
1 Rare	L (1)	L (2)	L(3)	L (4)	M (5)

Figure 2-5 Risk Matrix

E = >20	Extreme Risk: potentially threatening the overall viability of the project and requiring priority action
H = >12	High Risk: the most severe risks that can be accepted as part of the design and routine operation of the CPP infrastructure and facilities.
M = >5	Medium Risk: risk that can be expected to influence the design and routine operation of the CPP infrastructure and facilities and where control measures can be applied and will be sufficient.
L = <5	Low Risk: where existing control measures will be sufficient to mitigate any potential impacts and /or where no action will be required to treat them unless they become more severe.

Source: International Standard for Risk Management, ISO 3100 Risk Assessment Matrix' methodology.

This risk assessment process requires a uniform approach to determining the likelihood and consequence of each impact. The qualitative measures of 'likelihood' and 'consequence' for this assessment are described in Table 2-3 and Table 2-4 (Source: Adapted from International Standard for Risk Management, ISO 3100 Risk Assessment Matrix Methodology).

Table 2-3 Qualitative Measures of Likelihood

Level	Descriptor	Likelihood	Annual Exceedance Probability
5	Almost Certain	There is a high possibility the event will occur as there is a history of frequent occurrence. The event is expected to occur in most circumstances	Will probably occur more than once a year
4	Likely	It is likely that the event will occur as there is a history of casual occurrence. The event has occurred several times or more in the past.	Will probably occur once in 1- 10 years
3	Possible	The event has occurred at least in the past and may occur again	May occur once in 10-100 years
2	Unlikely	There is a low possibility that the event will occur, however, there is a history of infrequent and/or isolated occurrence.	May occur once in 100 years
1	Rare	It is highly unlikely that the event will occur except in extreme/exceptional circumstances, which have not been recorded historically.	Unlikely during the next 100 years

Table 2-4 Qualitative Measures of Consequence

Level	Descriptor	Infrastructure Services
1	Insignificant	No infrastructure damages Numerous risk reduction and control measures exist.
2	Minor	Localized infrastructure services disruption. No permanent damage. Some minor restoration work required. Early renewal of infrastructure by 5–10%. Suitable risk reduction and control measures exist.
3	Moderate	Widespread infrastructure damage and loss of service Damage recoverable by maintenance and minor repair. Early renewal of infrastructure by 10–20%. Some suitable risk reduction and control measures exist.
5	Major	Extensive infrastructure damage requiring extensive repair. Permanent loss of regional infrastructure services. Early renewal of Infrastructure by 20-50%.

Level	Descriptor	Infrastructure Services
		Loss or retreat of usable land for power generation, gas supply or transmission of electricity. Few suitable risk reduction and control measures exist.
6	Catastrophic	Permanent damage and/or loss of infrastructure services. Loss or retreat of infrastructure support and translocation of power generation and transmission facilities and services. No suitable risk reduction and control measures exist.

2.4 Risk Assessment

2.4.1 Physical Risks

Higher average temperatures and more frequent and severe extreme temperatures are expected to lower thermoelectric plant efficiency and available generation capacity. However, the plant is designed for higher ambient temperature conditions than that is prevailing currently.

Based on the Kingdom's qualitative assessment of the SLR risks, the predicted loss ranges from 27 percent of the Kingdom's area with a rise of 1.5 meters of sea water to 56 percent of the Kingdom's area with a rise of 5 meters by 2100 (PCPMREW). Block Block4 is located at approximately 30 meters above mean sea level and hence impacts due to sea level rice are not anticipated.

Water requirement for Block 4 expansion will be met through the existing desalinated water supply within Alba. Further, the project uses ACC (Air Cooled Condenser) cooling system. Hence, water usage will be limited to cleaning and domestic usage. Impacts are not anticipated on reduced water availability during the project life cycle.

Risks due to floods or cyclones can be expected as a result of climate change. However, with adequate mitigation measures, the risks can be reduced.

Table 2-5 provides an assessment of physical risks.

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Table 2-5 Climate Change Risk Assessment for Physical Risks

Risk Category	Consequence	Likelihood	Risk Ranking	Control Measures	Residual Risk (After Controls in Place)
Higher Temperatures: Increasing temperatures and increasing magnitude and frequency of extreme heat events may lead to a reduction in energy generation potential, and this will add to operational and maintenance costs	1 – Insignificant	2 – Unlikely	L (2)	**Priority Control Measures:** A reasonable number of control measures are available in terms of infrastructure building design and construction measures to accommodate higher mean temperatures and reduce extreme heat. Following measures shall be included: — Extreme temperature scenarios in infrastructure building design and construction measures to accommodate higher mean temperature and reduce exposure to heat. — Design, engineer, and construction of structures suited for rising temperatures and heat waves. — Develop best operating practices for equipment at higher temperatures.	L (1)
Reduced Water Availability and Draught: Changes in seasonal water availability and increasing salinity can lead to minor disruptions to cooling and increases in treatment costs.	1 – Insignificant	2 - Unlikely	L (1)	— The Project site itself is in an area which has less rain fall. — Power stations in Alba are using water from its own desalination plant located within the complex. — Air cooled condensers are used for cooling process instead of water-based cooling towers.	L (1)

Risk Category	Consequence	Likelihood	Risk Ranking	Control Measures	Residual Risk (After Controls in Place)
Sea Level Rise Sea level rise can contribute to infrastructure damage and loss of service.	1 – Insignificant	2 – Unlikely	L (1)	Power Station 5 Block 4 is located approximately 30 meters above the mean sea level. Based on the Kingdom's qualitative assessment of the SLR risks, the predicted loss ranges from 27 percent of the Kingdom's area with a rise of 1.5 meters of sea water to 56 percent of the Kingdom's area with a rise of 5 meters by 2100 (PCPMREW). Hence, further control measures are not included	L (1)
Flooding, Cyclones and Storm Surge: An increase in the frequency and intensity of flooding may occur and can cause damage to infrastructure and disruptions to power generation	1 - Insignificant	3 – Possible	L (3)	Control measures shall include. — Risk reduction via non-structural adaptation measures, effective planning, and design, and building institutional capacity for risk management and reduction. — Update siting, design, and operational plans to account for sea level rise, flooding, and storm surge. Risk reduction via structural adaptation measures, including elevation of critical infrastructure and equipment, enhance levees and flood control structures. — Incorporate more resilient/robust design specifications and construction standards (cyclone ratings etc.), including waterproofing measures. — Prepare emergency response plans and early warning systems to account for higher frequency of intense storms, flooding and cyclones.	L (3)

2.4.2 Transition Risks

Bahrain announced on the 24th of October 2021 its commitment to achieving carbon neutrality by 2060, with an interim goal of a 30% reduction in CO_2e emissions by 2035 [13]. This is Bahrain's first explicit CO2e emission reduction target. The Kingdom will adopt a circular carbon economy strengthened by various offsetting schemes including carbon-capture technology and afforestation. In concert with the Net Zero strategy, Alba has identified six ESG priorities through a comprehensive ESG strategy development process, categorized into two buckets: GHG priorities and Stakeholder priorities. A roadmap was developed for each of the six ESG priorities describing approximately 20 initiatives that may be incorporated into Alba's operations over the next few years. Hence risks due to government policies are not anticipated.

It is not likely that the government will impose any restrictions on water use and land use. Alba is using water from its own desalination plant. Construction of Block 4 CCP located within the Alba complex. Hence, impacts or not anticipated in these aspects.

One of Alba's initiatives of ESG strategy development is the plan to decommission inefficient power stations and add additional capacity to a newer, more efficient power station by 2025. Block 4 CCP expansion Project is part of that plan. Further, Alba's road map to net zero target on-site solar installation is a major factor. To reduce scope 2 emissions Alba will be installing 5 MW on-site solar systems. Considering the typical life cycle of a combined cycle power plant is 25 to 30 years, technology and market risks will not have significant impact.

Alba acknowledges prioritization of climate mitigation efforts and are proactively responding to pledges from both government and industry. Alba prepared a Road Map to Net Zero and broader ESG strategy in collaboration with a leading sustainability consulting firm, SCS Consulting Services Inc. Through the road map and ESG strategy Alba assessed the transition process and identified initiatives (refer Section 5.2.2.2) to reduce emissions. Construction of Block CCP is part of this initiative. Physical risks are not anticipated during the life cycle of the project. Hence, there are no impacts due to legal risks.

The project is licensed by the Supreme Council for Environment, Kingdom of Bahrain. Stakeholder consultations were held during ESIA stage, and no objections for the construction and operation of the Project were received from the stakeholders responded to consultation invitations. The ESIA study report is disclosed in Alba corporate website. Alba is preparing stakeholder engagement plan specific to the Block 4 Project and further stakeholder engagement programs will be detailed in the plan. Reputation risks related the Project are not anticipated.

Transition risk assessment can be summarized as follows:

Table 2-6 Summary of Transition Risks Assessment

Transition Risk Category	Consequence	Likelihood	Risk Ranking
Policy Risk	1 - Insignificant	2 – Unlikely	L (2)
Technology and Market Risk	1 - Insignificant	3 - Possible	L (3)
Legal Risk	1 - Insignificant	2 – Unlikely	L (2)
Reputation Risk	1 - Insignificant	1 - Rare	L (1)

2.5 Alternatives Analysis

Alba currently has five power stations using natural gas as fuel and supplying electricity to the smelter plant and associated facilities. However, it is important to note that following commissioning of Power Station 5, Power Stations 1 and 2 were decommissioned and disconnected from the Grid.

On completion of PS 5 Block 4 Expansion Project, the capacity of PS5 will increase from 1,800 MW to 2,481 MW. Rationale behind the expansion of PS5 Block 4 is the efficiency of this combined cycle power plant is much higher than combined cycle power plants of PS 3 and PS 4. Power Station 3, which is operating on a low load, will be shut down and will be kept as emergency standby. Power station 4 will be running partially.

Scope 1 emissions are expected from the power station, as there is no import of power required for the functioning of Block 4. Since, existing staff of Power Station 5 will be operating Block 4, additional vehicles are not required during operational phase. Utilities required for the new block will be shared with existing PS 5. Hence, Scope 2 and Scope 3 emissions are not expected.

Methane and N_2O usually constitutes 1% of the CO2e and hence was not further considered in the analysis.

2.5.1 GHG Emissions

Continuous Emission Monitoring Systems (CEMS) are installed on Power Station 4 and Power Station 5 stacks to measure the emissions. Power Station 3 emissions are measured by Environmental Team using portable gas analyzer.

Alba is calculating GHG using the following equation:

$$Natural\ Gas\ (MMSCF)(NG) = \frac{Total\ NG\ to\ Alba(\ GBTU) \times 100}{Gross\ Calorific\ Value\ (GCV) for\ NG}$$

$$Net\ Calorific\ Value\ of\ (NG\ BTU/SCF) = \frac{GCV}{1.1111}$$

$$Emission\ Intensity\ from\ Export\ (E2) = \frac{Exported\ Power\ (MWh) \times 3.41242 \times 1.0551 \left(\frac{GBTU}{TJ}\right) \times NG\ Emission\ Factor\ for\ CO2\ (\frac{Kg}{TJ})}{1{,}000{,}000\ \times Metal\ Production\ \times Efficiency}$$

$$Emission\ Intensity\ from\ Import\ (E3) = \frac{Imported\ Power\ (MWh) \times 3.41242 \times 1.0551 \left(\frac{GBTU}{TJ}\right) \times NG\ Emission\ Factor\ for\ CO2\ (\frac{Kg}{TJ})}{1{,}000{,}000\ \times Metal\ Production\ \times Efficiency}$$

$$Emission\ Intensity\ from\ Power\ Production\ (E1) = \frac{NG\ (MMSCF) \times NCV \times 1.0551\ \left(\frac{GBTU}{TJ}\right) \times NG\ Emission\ Factor\ for\ CO2\ (\frac{Kg}{TJ})}{1{,}000{,}000 \times Metal\ Production}$$

$$Emission\ Intensity\ as\ CH4 = \frac{NG\ (MMSCF) \times NCV \times 1.0551 \left(\frac{GBTU}{TJ}\right) \times NGEmission\ Factor\ for\ CH4 \left(\frac{Kg}{TJ}\right) \times CH4\ GWP}{1{,}000{,}000 \times Metal\ Production}$$

$$Emission\ Intensity\ as\ N2O = \frac{NG\ (MMSCF) \times NCV \times 1.0551 \left(\frac{GBTU}{TJ}\right) \times NGEmission\ Factor\ for\ N2O \left(\frac{Kg}{TJ}\right) \times N2O\ GWP}{1{,}000{,}000 \times Metal\ Production}$$

$$Total\ NG\ Intensity = E1 + E3 - E2$$

$$Total\ Intensity\ from\ Power\ Generation = (E1 + E3 - E2) + CH4\ Intensity + N2O\ Intensity$$

Average Calculated GHG emissions for the existing power stations are as follows:

- Power Station 3 = 0.4933 KgCO_2/KWh
- Power Station 4 = 0.4221 KgCO_2/KWh
- Power Station 5 = 0.3687 KgCO_2/KWh

In accordance with the calculations from MPW, the estimated GHG emissions from Block 4 CCP is 0.382 KgCO2/KWh.

On completion of Block 4 Expansion Project, the capacity of PS5 will increase from 1,800 MW to 2,481 MW. The efficiency of this combined cycle power plant is much higher than combined cycle power plants of PS 3 and PS 4. Power Station 3, which is operating on a low load, will be shut down and will be kept as emergency standby. Power station 4 will be running partially. From the GHG emission calculations it is evident that the emissions from Block 4 is lesser than that from PS3 and PS4. Hence, the implementation of the Project will support Alba's road map to net zero by 2060.

2.5.2 Alternatives Analysis

Combined-cycle power plants are compound gas turbine–steam turbine systems wherein the extreme hot exhaust from a gas turbine is employed to run a boiler, and the steam thus produced is fed into a steam turbine to generate power.

The idea of combined cycles has grown out of the need to improve the simple Joule cycle efficiency by utilizing the waste heat in the turbine/engine exhaust gas. This is a natural solution because the gas turbine/engine is a relatively high-temperature machine and the steam turbine a relatively low-temperature machine. The flue-gas temperature at a gas turbine outlet for example is about 500°C or more. This temperature creates the possibility to apply an additional steam cycle process. Such a system combination optimizes the gas and steam processes to increase the overall electric or mechanical efficiency [15, JRC BREF].

Combined Cycle Power Plants can deliver high power output at efficiencies as high as 50%–60% with low emissions and produce 50% more electricity than a simple-cycle plant consuming the same amount of fuel. Due to their high efficiency and the fact that they usually burn natural gas fuel, gas turbine–based power plants also emit far less carbon dioxide than other types of fossil fuel power plants.

The advantages of Combined Cycle Power Plants include, but not limited to, the following:

- Capital cost is lower than other power plants.
- They have a small footprint and do not require much space when compared to other modes of power generation.
- Less operating and maintenance staff is required.
- Construction time is short compared to other types of power plants.
- Due to its ability to start up quickly and respond to demand changes rapidly, the combined cycle power plant has become the ideal companion for renewable power generation sources such as wind energy and solar energy, whose output is variable.

Alba proposes to use air-cooled condenser (ACC) to condensate the exhaust steam from the steam turbines. Steam from the steam turbine exhaust flows through the bundles of tubes and the cooling airflows across the outer surface of the tubes and cools the steam. The cooling air is supplied by forced draught fans.

The most evident advantages of air-cooled condensers are:

- No problem arising from thermal and chemical pollution of cooling fluids;
- Flexibility for any plant location and plot plan arrangement because equipment requiring cooling need not be near a supply of cooling water;
- Reduction of maintenance costs;

- Easy installation;
- Lower environmental impact than water cooled condenser due to the elimination of an auxiliary water supply resulting in water saving;
- No use of water treatment chemicals and no need for fire protection system.

Hence, the development of CCP has been identified by Alba as the most feasible technology alternative for the electricity generation. Further, one of Alba's initiatives of ESG strategy development is the plan to decommission inefficient power stations and add additional capacity to a newer, more efficient power station by 2025. Block 4 CCP expansion Project is part of that plan. Considering the above, it can be safely concluded that development of Block 4 CCP is in line with the Governments initiatives on the climate commitments.

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Appendix B

Updated Climate Change Risk Assessment Prepared by EACS

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

February 2023
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for the world

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Table of contents

			Page
1	INTRODUCTION		1
	1.1	Project description	1
	1.2	Report scope	1
2	GREENHOUSE GAS ALTERNATIVES ANALYSIS		3
	2.1	International Finance Institutions' requirements	3
	2.1.1	The Equator Principles	3
	2.1.2	International Finance Corporation's Performance Standards	4
	2.2	Methodology	4
	2.2.1	Data sources	5
	2.2.2	Business objectives	5
	2.2.3	Alternatives screening	6
	2.2.4	Alternatives evaluation	6
	2.3	Key outcomes	7
	2.3.1	No project scenario	7
	2.3.2	With project scenario	8
	2.3.3	Comparisons of greenhouse gas emissions	9
3	JUSTIFICATION OF GREENHOUSE GAS EMISSIONS DATA		11
	3.1	International Finance Institutions' requirements	11
	3.1.1	The Equator Principles	11
	3.1.2	International Finance Corporation's Performance Standards	11
	3.2	Current greenhouse gas emissions inventory	12
	3.3	Key outcomes and recommendations	12
4	CONCLUSIONS		14
5	BIBLIOGRAPHY		15

Tables

Table 2.1	No project scenario summary	7
Table 2.2	With project scenario summary	9
Table 2.3	GHG emissions comparisons	10

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

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.

Environment Arabia

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**.

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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