Specialist Climate Change Impact Assessment

Phakwe Richards Bay Gas to Power 3 CCPP

Prepared by Promethium Carbon for:

savannah environmental

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WWW.PROMETHIUM.CO.ZA | TEL: +27 11 706 8185 | FAX: 086 589 3466
THE COURTYARDS, BLOCK 2, 1ST FLOOR, 32 PETER PLACE, BRYANSTON| P.O. BOX 131253, BRYANSTON, 2021
PROMETHIUM CARBON (PTY) LTD | REG NO: 2005/018622/07 | DIRECTORS: RT LOUW, HJ SWANEPOEL

Executive Summary

This report presents the climate change impact assessment conducted by Promethium Carbon (appointed by Savannah Environmental) for the Phakwe Richards Bay Gas Power 3 combined cycle power plant (CCPP) located in the Richards Bay Industrial Development Zone (IDZ) Phase 1F. This assessment was conducted in accordance with the environmental authorisation process, and in the context of the Thabametsi Case judgement.

Promethium's assessment covered the impact of the proposed project on climate change and the project resilience to climate change across both the construction and operational phases of the project.

The assessment of the project's impact on climate change was based on the project's greenhouse gas (GHG) emissions, as calculated according to SANS 14064:2021 Part 1 and the Regulations and Technical Guidelines published by the Department of Forestry, Fisheries, and the Environment (DFFE).

The assessment of the project's resilience to climate change was guided by the DFFE's Framework for Climate Change Vulnerability Assessments and the Equator Principles. The project's vulnerability was assessed across core operations, value chain (upstream and downstream), and the broader social and environmental context.

This report also addresses possible mitigation and adaptation measures that could be considered by the proposed project developer as recommendations to reduce GHG emissions and improve the project's resilience to climate change.

The impact of the project on climate change was assessed in the context of both GHG emissions from the project, as well as the potential positive impact the project can have through the avoidance of emissions. The results are compared to South Africa's carbon budget for the NDC Low Emission Scenario, which was calculated as 7 760 million tons CO_2e.

The project will emit 82 ktCO_2e during the construction phase, 7 870 ktCO_2e/year during the operational phase and 236 000 ktCO_2e over its lifetime when running on LNG. The portion of these emissions emitted inside the borders of South Africa represents 1.9% of the low emission NDC carbon budget calculated, for the lifetime of the project.

When considering the potential positive impact of the proposed project, the expected GHG emissions from the project will avoid emissions through the displacement of coal. In addition to this, the project will enable an increased level of intermittent renewable energy capacity to be placed onto the South African grid. The total avoided emissions are 236 million tCO_2e over the lifetime of the project through the displacement of the coal baseline. This represents 3% of the South African carbon budget associated with NDC low emission pathway. In addition to this, there is a possibility that the project could avoid 556 million tons through increasing the ability of the Eskom grid to accept intermittent renewable energy over the lifetime of the project. This represents 7.2% of the carbon budget

The positive impact of the project on climate change with respect to the avoided emissions from the coal baseline, and the potential avoided emissions through the increase of the grid to accept intermittent renewable energy, far outweighs the contribution of the project to national GHG inventory. With respect to the resilience of the project to climate change, we found that there are no significant risk factors that should be considered in the environmental authorisation.

Climate projections for the KwaZulu Natal province indicate an annual average ambient temperature increase, with overall variability in precipitation with an increasing drought risk. More specifically, Richards Bay is likely to become drier in the future with an increased risk of drought. Parts of the municipality are also predicted to experience floods due to rainfall variability, as well as tropical cyclones due to the municipality's location along the east coast of South Africa. There will be an increase in the number of extreme hot days with an average annual temperature increase of at least 1.6°C to 1.8°C from the baseline period (1961-1990).

Promethium Carbon has not identified any fatal flaws with respect to the CCIA for this project and we do not propose any special conditions with respect to the authorisation of this project. In accordance with our findings, we therefore advise that the proposed Phakwe Richards Bay Gas Power 3 CCPP should receive environmental authorization.

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Key Terms and Definitions[1,2]

Adaptive capacity	Adaptive capacity is a set of factors which determine the capacity of a system to generate and implement adaptation measures. These factors relate largely to available resources of human systems and their socio-economic, structural, institutional, and technological characteristics and capacities.
Climate change[3]	The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as: '*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes.
Climate change impacts	The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure. Impacts may be referred to as consequences or outcomes and can be adverse or beneficial.
Climate change vulnerability	The degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.
Climate resilience	Focuses on the ability to adapt to disturbances and events caused by climate change and investigates future climate-related risks which may pose new challenges for traditional risk management.

1 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

2 IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

3 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

Climate variability	Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).
Exposure	Exposure is directly linked to climate parameters, that is, the character, magnitude, and rate of change and variation in the climate. Typical exposure factors include temperature, precipitation, evapotranspiration, and climatic water balance, as well as extreme events such as heavy rain and meteorological drought. Exposure is the contact between one or more biological, psychosocial, chemical, or physical; stressors, including stressors affected by climate change.
Extreme weather[4]	Is unexpected, unusual, or unforeseen weather and differs significantly to the usual weather pattern, such as droughts, floods, extreme rainfall, and storms.
Greenhouse Gas (GHG)	Greenhouse gasses (GHGs) are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself and by clouds. This property causes the greenhouse effect. The Kyoto Protocol deals with the following greenhouses gases, carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), Sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).
Sensitivity	Sensitivity determines the degree to which a system is adversely or beneficially affected by a given climate change exposure and is a function of the natural and socio-economic context of a particular site.
Social vulnerability drivers[5]	Social vulnerability is defined as a dynamic state of societies comprising exposure, sensitivity and adaptive capacity. It is characterised by high levels of dependence on natural resources for livelihoods and economic development, combined with increasing environmental degradation, which can both increase exposure (e.g. wetland destruction) and reduce adaptive capacity (e.g. declining river flows constraining water provision). Examples of social vulnerability drivers include poverty, low awareness and inability to migrate.
SSP 2 **Shared Socioeconomic Pathway 2**	This is the "Middle of the Road" or medium pathway, which extrapolates the past and current global

[4] GIZ. 2014. The vulnerability sourcebook. Gesellschaft für Internationale Zusammenarbeit, Bonn, Germany.

[5] Tucker, J., Daoud, M., Oates, N. et al. Reg Environ Change (2015) 15: 783. https://doi.org/10.1007/s10113-014-0741-6.

development into the future. In this scenario, there is a certain cooperation between states, but it is barely expanded. Global population growth is moderate, levelling off in the second half of the century. Environmental systems are facing a certain degradation.[6] This scenario is equivalent to RCP 4.5 in the IPCC's Fifth Assessment Report (AR5).

SSP 5
Shared Socioeconomic Pathway 5

This is the "Fossil-fuelled Development" scenario. In the scenario, global markets are increasingly integrated, leading to innovations and technological progress. The social and economic development is based on an intensified exploitation of fossil fuel resources with a high percentage of coal and an energy-intensive lifestyle worldwide. The world economy is growing and local environmental problems such as air pollution are being tackled successfully. This scenario is equivalent to RCP 8.5 in the IPCC's Fifth Assessment Report (AR5).

6 Böttinger, M and D. Kasang. 2021. The SSP Scenarios. Deutsches Klimarechenzentrum, Hamburg, Germany. Available at: https://www.dkrz.de/en/communication/climate-simulations/cmip6-en/the-ssp-scenarios.

Declaration of Independence

The authors of this report do hereby declare their independence as consultants appointed by Savanna Environmental to undertake a Climate Change Impact Assessment for the Phakwe Richards Bay Gas to Power 3 Combined Cycle Power Plant as part of the Environmental Impact Assessment process. Other than fair remuneration for the work performed, the specialists have no personal, financial business or other interests in the project activity. The objectivity of the specialists is not compromised by any circumstances and the views expressed within the report are their own.

Robbie Louw

Sarah Goodbrand

Shantal Beharie

Shannon Murray

Matthias Rommelspacher

Indiana Mann

Details of the Specialist Team

Promethium Carbon is a South African climate change and carbon advisory company based in Johannesburg. The company has been active in the climate change and carbon management space since 2004.

Promethium Carbon's climate change impact studies include an estimation of the carbon footprint of the activity or group of activities, as well as the vulnerability of the activity/ies to climate change. Promethium Carbon has calculated greenhouse gas inventories for over 60 entities and is proficient in applying the requirements of ISO/SANS 14064-1 and the Greenhouse Gas Protocol's accounting standards, as well as South Africa's Greenhouse Gas Reporting Guidelines. Promethium Carbon has also assisted around 40 clients develop climate change risk assessments, which includes the compilation of climate change specialist reports. Promethium Carbon's assessments include thorough analysis of historical and projected weather data specific to the region in which the client operates. Promethium Carbon's assessment of vulnerability goes beyond core operations to include impacts within the supply chain and broader network of the Phakwe Richards Bay Gas Power 3 CCPP Project.

Robbie Louw is the founder and director of Promethium Carbon. He has over 18 years of experience in the climate change industry. Robbie holds both a BCom Honours Degree in Economics as well as a BSc degree in Chemical Engineering. Robbie has significant experience with regards climate change mitigation and adaptation. Robbie's chemical engineering background combined with his extensive experience in climate change has led to him leading several projects related to climate change risk and vulnerability, energy development and developing climate change mitigation and adaptation alternatives. His experience over a period of 35 years covers the chemical, mining, minerals process and energy fields, in which he was, involved in R&D, project, operational and management levels. Robbie is currently a member of The Southern African Institute of Mining and Metallurgy and the Institute of Directors in South Africa (IoDSA). In addition, Robbie is also a member of the Technical Working Group of the Climate Disclosure Standards Board (CDSB). Robbie's experience in climate change includes (but is not limited) to:

- Climate change risk and vulnerability assessments for large mining houses;
- Extensive experience in preparing carbon footprints. The team under his leadership has performed carbon footprint calculations for major international corporations operating complex businesses in multiple jurisdictions and continents;
- Carbon and climate strategy development for major international corporations;
- Climate change impact assessments for various companies and projects;
- Climate change scenario planning and analysis, particularly in terms of the recommendations of the Taskforce on Climate-related Financial Disclosure; and
- In depth understanding of South Africa's climate change regulations and carbon tax requirements.

Sarah Goodbrand is a Senior Climate Change Advisor who holds a Master's in Environmental Sciences specialising in climate change adaptation. Her research investigated ecosystem-based adaptation of urban hydrology to climate change in three South African cities. With nine years of work experience, Sarah has extensive knowledge in climate change mitigation and adaptation within both business and government contexts. Sarah's experience includes GHG inventory calculations, carbon tax liability calculations, climate change impacts assessments, climate change risk and vulnerability assessments and CDP Climate and Water responses. She was instrumental in drafting the first versions of the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry managed by the Department of Forestry, Fisheries, and the Environment ("DFFE").

Shantal Beharie is a climate change advisor at Promethium. She has eight years of experience in the climate change/sustainability field. She holds a master's degree in environmental studies which focused specifically on historical climate change, as well as an honours degree in geography and a Bachelor's degree in environmental management. Shantal has experience in sustainability (corporate reporting, climate-change scenario analysis, CDP, ESG, TCFD, Science-based targets/net-zero) climate change risk and vulnerability assessments, climate impact assessments, strategic projects (environmental management frameworks, strategic environmental assessments and compiling state of environment reports), social assessments, and policy development. She also has regional experience working across countries in Ghana, Botswana, Zimbabwe, Lesotho, Mozambique, and working within the SADC region in strategy development and training on climate change finance. Shantal's experience in climate change includes:

- Climate change risk, vulnerability, and resilience assessments in South Africa;
- Climate Change strategy and policy development in South Africa and within the SADC region;
- Climate finance training within the SADC region;
- Climate change impact assessments as part of the EIA processes in South Africa, Ghana, Zimbabwe and Mozambique;
- Drafting Carbon Disclosures for mining companies; and
- Assisting with company Science-based targets, and climate change roadmap planning for mining industries.

Matthias Rommelspacher is a Climate Change Advisor appointed at Promethium Carbon who holds a Master's in Environmental Engineering. His postgraduate studies focused on urban water management, air quality control, waste management and ecological systems design. Part of his studies included field work on Mahé in Seychelles, where he was part of a transdisciplinary team that assessed the waste management system of Mahé Island. The research for his thesis combined his background as a Chemical Engineer with his studies and focused on the processing of urban wastewater for nutrient recovery. Whilst at Promethium Carbon, Matthias has gained valuable experience. Some of the projects he has been active in include:

- GHG Regulatory and Corporate Reporting;
- Climate change risk and vulnerability assessments; and
- Calculations of various first principle concepts for modelling purposes, including:

- Carbon tax models,
- Carbon footprints, and
- Science-Based Target models.

Indiana Mann is a Climate Change Advisor who holds an honours degree in Atmospheric Science. Her postgraduate studies focused on the impact meteorological conditions have on pollen distribution. With her background in Environmental and Geographical Science and Atmospheric Science, Indiana has knowledge in climate modelling, climate change risk and vulnerability assessments and climate change policies. The projects in which she has been active include:

- Climate Change Risk and Vulnerability Assessment (CCRVA);
- Climate Change Impact Assessments (CCIA);
- The Task Force on Climate-Related Financial Disclosures (TCFD) reports; and
- Handling of weather data for necessary reports.

Shannon Murray is a climate change advisor who only commenced her employment with Promethium Carbon in October 2021. She completed her BA Degree in Sign Language, as well as her LLB degree through the University of the Witwatersrand. Furthermore, Shannon obtained course certificates through the Wits Mandela Institute in Energy Law, Environmental and Sustainable Development Law, Land and Water Law and International Environmental Law. Shannon was admitted as an attorney in November 2019 and practised as such for a small commercial litigation firm until September 2021. In the short period of time that Shannon has been employed with Promethium Carbon, she has done extensive research in relation to the climate change field and has formed part of various teams within the company. She has gained experience in:

- The legal aspects of carbon credit purchase agreements;
- Developing a socio-economic development project list, with climate change project funding benefits, for a global mining company;
- Developing a climate change target for a listed pharmaceutical company; and
- Performing an eligibility assessment for a carbon credit project, including the legal aspects of the carbon credit transaction.

Report structure and reference in terms of NEMA Regulations (2014), Appendix 6

NEMA Regulations (2014) (as amended) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Page ix-xi
The expertise of that person to compile a specialist report including a curriculum vitae	Page ix-xi
A declaration that the person is independent in a form as may be specified by the competent authority	Page viii
An indication of the scope of, and the purpose for which, the report was prepared	Section 2, sub section 2.2
An indication of the quality and age of base data used for the specialist report	Section 4.1.2 and 4.2.2
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5 and 6
The duration date and season of the site investigation and the relevance of the season to the outcome of the assessment	No site investigation took place as this was a desktop study that relied on requested information
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 4
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternative	Section 6.4
An identification of any areas to be avoided, including buffers	This is not relevant in terms of the climate change impact assessment. However, this report does make mention of the impacts of climate change on sensitive areas surrounding the Phakwe Richards Bay Gas Power 3 CCPP Project.

NEMA Regulations (2014) (as amended) - Appendix 6	Relevant section in report
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	This is not relevant in terms of the climate change impact study. However, this report does define the boundaries for which the project's impact on climate change, as well as the project's vulnerability to climate change was determined.
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 4.1.5 and 4.2.4
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 5, 6, and 6.4
Any mitigation measures for inclusion in the EMPr	Section 8
Any conditions for inclusion in the environmental authorisation	N/A
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and regarding the acceptability of the proposed activity or activities	Section 0
A description of any consultation process that was undertaken during preparing the specialist report	N/A
A summary and copies of any comments received during any consultation process and where applicable all responses thereto	N/A
Any other information requested by the competent authority.	N/A

1 Introduction

Savannah Environmental Pty (Ltd) has appointed Promethium Carbon to undertake a Climate Change Impact Assessment (CCIA) as part of the Environmental Impact Assessment (EIA) for the Phakwe Richards Bay Gas Power 3 combined cycle power plant (CCPP). This is specifically for the development of a combined cycle (CC) gas-to-power plant with a capacity of up to 2000 MW. The proposed development site is situated within the Richards Bay Industrial Development Zone (IDZ) Phase 1F. The project is located approximately 5 km north-east of Richards Bay and 1 km north of Alton (Figure 1). The project falls within the jurisdiction of the uMhlathuze Local Municipality and the Cetshwayo District Municipality within the province of KwaZulu-Natal. The nearest surrounding towns within the project area are Richards Bay, Arboretum, Empangeni and Ichubo.

In the context of the Integrated Resource Plan (IRP)[7], gas-to-power technologies provide an opportunity to diversify the current energy mix. In this respect, the Phakwe Richards Bay Gas Power 3 CCPP provides an opportunity for the development of an energy mix that will allow for power generation through cleaner fuels and reduced emissions. The emissions for the project will also be reduced, as there are plans to include green hydrogen within the fuel mix for the power station in the long-term. Although the Phakwe Richards Bay Gas Power 3 CCPP will aim to progressively reduce greenhouse gas (GHG) emissions over time, climate change impacts must still be taken into consideration as part of the EIA process. The impacts of the project on climate change will relate to the combustion of fuel (natural gas) at the CCPP which will contribute toward

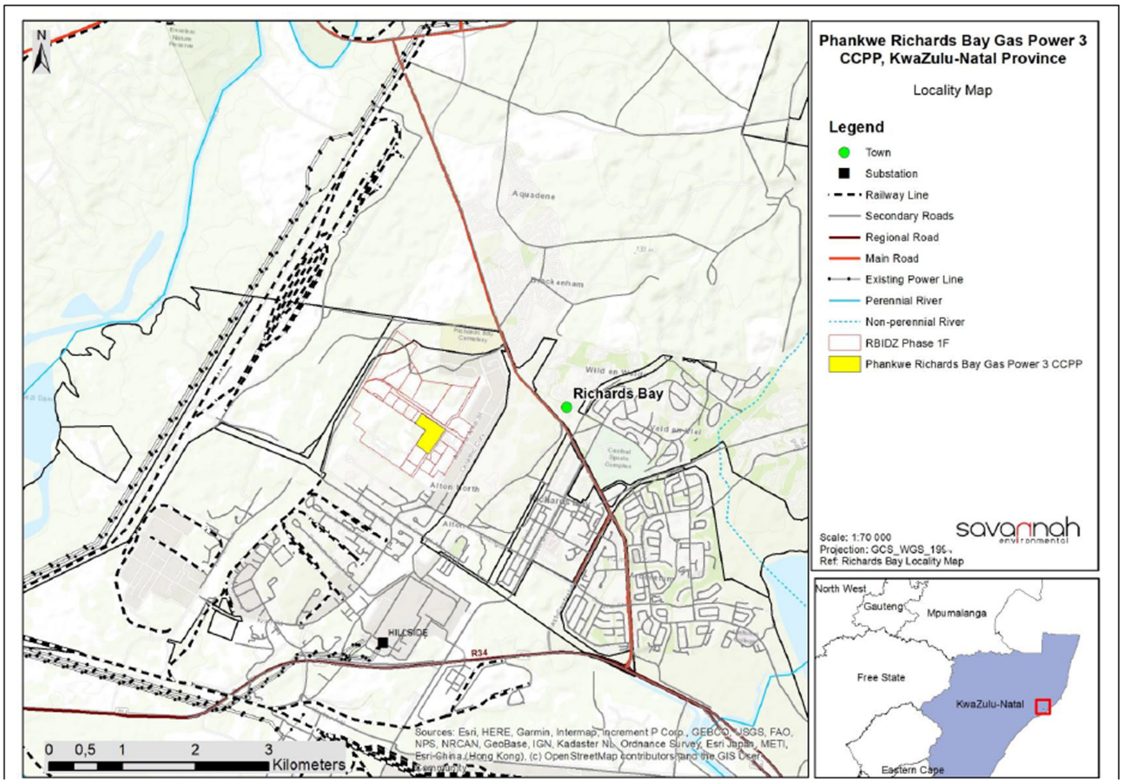

Figure 1: Locality map for the Phakwe Richards Bay Gas Power 3 CCPP.

[7] Department of Energy, 2019, Integrated Resources Plan (IRP2019), Government Gazette, [Online] Available at: http://www.energy.gov.za/IRP/2019/IRP-2019.pdf [Accessed on 10/05/2020].

greenhouse gases and should therefore be considered. The future considerations for the inclusion of hydrogen into the energy mix could potentially be a long-term mitigation option for the project.

2 Background to Climate Change Impact Assessments

The analysis presented in this report is aligned with the principles of the National Environmental Management Act, 1998 (Act No 107 of 1998) and the National Water Act, 1998 (Act No 36 of 1998). This report will inform and assist Phakwe) in developing a climate change strategy for the Phakwe Richards Bay Gas Power 3 CCPP Project, which is aligned to the company's environmental management goals. In this context, the impacts of the Project on climate change and the climate change impacts on the Project must therefore be considered.

2.1 The Legal Precedence for Climate Change Impact Assessments in South Africa

2.1.1 Thabametsi Case

The Thabametsi case judgment[8] set the legal precedent for South African CCIA, which has made provision for the inclusion of climate change in specialist assessments. The case is not only oriented towards fossil-fuel related projects. The Thabametsi case is novel in clarifying the content and legal basis of climate-change impact assessments for development-oriented projects. It is also useful in shaping future administrative decisions on development projects. The environmental authorisation of the proposed Thabametsi coal-fired power station was appealed by Earthlife Africa on the basis that the Chief Director of the Department of Environmental Affairs[9], who initially granted Thabametsi an environmental authorisation, had failed to consider the climate change impacts of the power station. Earthlife Africa (Applicant) maintained that the Minister for Environment, Forestry and Fisheries (now the Department of Forestry, Fisheries, and the Environment "DFFE") was obliged to consider the climate change impacts before granting an environmental authorisation and that it failed to do so[10].

The court found that:

"[…] the legislative and policy scheme and framework overwhelming support the conclusion that an assessment of climate change impacts and mitigating measures will be relevant factors in the environmental authorisation process,

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8 Earthlife Africa Johannesburg v Minister of Environmental Affairs and Others (65662/16) [2017] ZAGPPHC 58; [2017] 2 All SA 519 (GP) (8 March 2017) (saflii.org)

9 Following the announcement of the sixth administration in 2019, the forestry and fisheries functions were amalgamated into the Department of Environmental Affairs, which became known as the Department of Environment, Forestry and Fisheries (DEFF). On 1 April 2021, the DEFF was renamed to the Department of Forestry, Fisheries and the Environment (DFFE).

10 Despite the court victory in March 2017, after reconsideration of the climate change impacts of the plant, the Minister again upheld Thabametsi's environmental authorisation, on the basis that the 2010 Integrated Resource Plan for Electricity (IRP) called for new coal-fired power capacity and had already assessed climate impacts. However, due to its large environmental footprint, funding for the project was pulled and the court ordered that the environmental authorisation be set aside on 19 November 2020.

and that consideration of such will best be accomplished by means of a professionally researched climate change impact report."[11]

Before the legal precedent set by the Thabametsi case, there was no express provision that stipulated that climate change is a relevant factor to be considered as part of an EIA in South Africa. For this reason - and given the lack of domestic guidelines to assess the climate change impacts of a specific activity - it was necessary to not only consider the principles of the National Environmental Management Act (NEMA), but to also consider international best practice and international laws which inform CCIAs.

2.1.2 Constitutional Court's Decision to Dismiss New Coal Mining Operations – Uthaka Energy

In November 2021, the Constitutional Court dismissed an application by Uthaka Energy (Pty) Ltd for leave to appeal an interdict that was granted in the Pretoria High Court in March the same year.

The company was interdicted from starting any mining activities and operations at its proposed coal mine. The Constitutional Court's decision to pause the development of new coal mining operations was in part based on the fact that the impacts coal mining has on Strategic Water Source Areas[12] and on global warming, is irrefutable, the impacts must be considered, and ultimately, Africa (in this case South Africa) needs to build resilience to climate change, and not add to it.

The circumstances of the Uthaka Project are very different to those of the Phakwe Richards Bay Gas Power 3 CCPP, but the case is worth mentioning in terms of what a Court considers as the necessary procedure for implementation of a project that has adverse effects on the environment, and subsequently, the impacts of climate change.

The interdict that was granted in the Pretoria High Court in March 2021, confirms the fundamental importance of fair and transparent decision making, which was not taken by the then Ministers in granting the environmental authorisations. Therefore, in the context of the Phakwe Richards Bay Gas Power 3 CCPP Project, an open and transparent process must be followed when obtaining the necessary environmental authorisations, failing which, the consequences may be dire in terms of being interdicted from commencing project activities.

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11 *Ibid*, See par 91 of the Judgement.

12 In 2018, the Water Research Commission (WRC) updated the definition of "Strategic Water Source Areas" (SWSA), to include groundwater, and now defines SWSA's as:
"*areas of land that either:*
(a) supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size and so are considered nationally important; or
(b) have high groundwater recharge and where the groundwater forms a nationally important resource; or
(c) areas that meet both criteria (a) and (b)".
In short, SWSA's are considered to be of national importance for the water security of South Africa.

2.1.3 Purpose of the Climate Change Impact Assessment

The EIA process is being undertaken for the Phakwe Richards Bay Gas Power 3 CCPP. The process is in accordance with the requirements of the 2014 EIA regulations (as amended) promulgated in terms of the National Environmental Management Act (NEMA: Act No 107 of 1998). As part of the specialist requirements under NEMA regulations 12(1) for the EIA, Promethium Carbon has been appointed to undertake CCIA for the Phakwe Richards Bay Gas Power 3 CCPP. The analysis presented in this report is aligned with the principles of the *National Environmental Management Act* (NEMA), 1998 (Act No 107 of 1998).

Climate change is generally considered to be covered within existing environmental law frameworks, since climate change impacts the environment and societies living in certain environments. South Africa's overarching environmental law framework is founded in NEMA. The *Environmental Impact Assessment (EIA) Regulations of 2017* (which were promulgated under NEMA), were predominantly drafted to govern activities which have an impact on the environment within the Republic of South Africa. Therefore, applying NEMA's principles to a global phenomenon, such as climate change, presents a challenge.

The Phakwe Richards Bay Gas Power 3 CCPP, during the operation phase, is likely to release GHG emissions relating to the combustion of natural gas fuel at the CCPP. This will contribute towards GHGs that will contribute towards climate change. The Phakwe Richards Bay Gas Power 3 CCPP will also contribute towards the national GHG emissions inventory. During the scoping phase of the project, it was recommended that a CCIA must be undertaken. Therefore, the purpose of the CCIA would be to quantify and incorporate the impacts of climate change during the EIA phase of the project.

2.2 Scope of the Climate Change Impact Assessment

The undertaking of the CCIA will include the following and will also be based on the guidance from the Thabametsi judgement. Based on the scoping report, the issues relating to climate change need to be further investigated as part of the EIA phase.

- The **impact of the Project** on climate change:
  - A GHG inventory for the construction and operational phases of the project;
  - An analysis of the GHG inventory regarding the impact of the GHG emissions of the project on climate change;
  - A description of the existing climate conditions of the local area;
  - An impact assessment of the project, which includes the cumulative impacts of climate change in relation to the project;
  - Mitigation and adaptation measures to minimise the impacts of the proposed project on climate change.

- The **impacts of climate change** on the project:
  - Impacts on core operations – likely exposure to climate changes, sensitivity to such and vulnerability assessment;

- Impacts on upstream value chain;
    - Assessment of climate change related impacts on the local natural environment, surrounding communities, local ambient air quality, and human health, and any associated implications for the project.;
    - Assessment of potential climate change adaptations

- The **resilience of the project** in terms of climate change:
    - An analysis of the climate change impacts for the region in which the project will be located;
    - The processes and associated infrastructure of the proposed project that could be affected by climate change, and the potential magnitude of the impacts; and
    - Mitigation and adaptation measures to minimise the impacts of climate change on the proposed project.

The analysis of climate change risks includes both physical and transitional risks. The scope of inclusion of these risks are set out in Table 1 below:

Table 1: Coverage of risks in the CCIA

	Risk	**Included/excluded**
Physical risks	Risk such as extreme weather events, storms, droughts, etc.	Included in the CCIA as it can significantly impact on the resilience of the project to climate change in the core operations, value chain, natural environment and social environment.
Transitional risks	Risks such as regulation, carbon pricing, and stranded asset risks	These risks are excluded from the CCIA as they represent commercial risks to the owner of the project rather than environmental and societal risks that are governed in the context of NEMA

2.3 Description of Project Activities and Associated Infrastructure

The Phakwe Richards Bay Gas Power 3 CCPP and the related infrastructure for the project is proposed to be constructed on erven 16820,16819,1/16674 and a subdivision of erf 17442 within the Richards Bay IDZ Zone 1F. In terms of land required, the project will occupy approximately 11.8ha. The site will be accessed via the existing roads within the IDZ Phase 1F, as well as internal access roads of up to 6m which will be constructed.

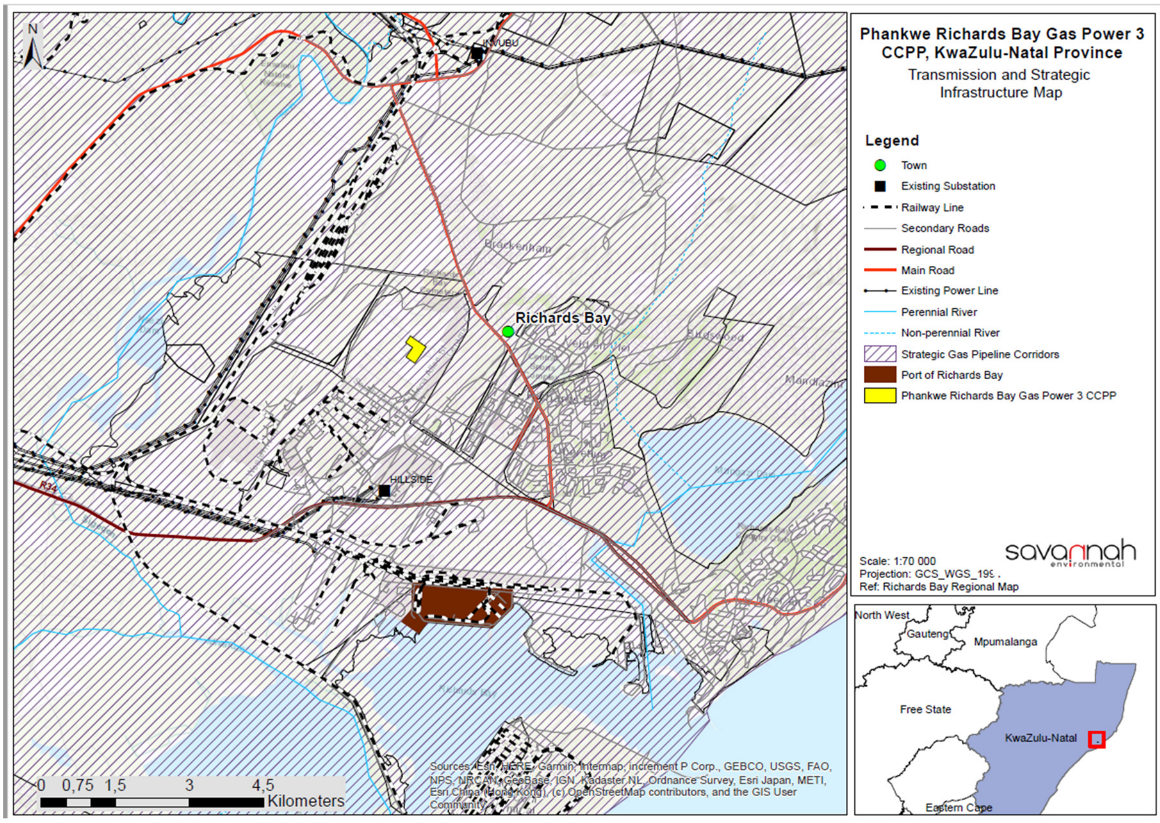

Figure 2: Project Transmission and Infrastructure Layout.

The list of project activities and associated infrastructure is further summarised below.

Table 2: Project Activities and Associated Infrastructure

Power Plant Infrastructure
• Several gas turbines[13] for the generation of electricity using natural gas (liquid or gas forms), or a mixture of natural gas and hydrogen (in a proportion scaling up from 30% H_2) as fuel source, operating all turbines at mid-merit or baseload (estimated 16 to 24 hours daily operation). • Exhaust stacks associated with each gas turbine. • Several Heat Recovery Steam Generators (HRSGs) to generate steam by capturing the heat from the turbine exhaust. • A few steam turbines to generate additional electricity by means of the steam generated by the HRSG. • The water treatment plant will demineralise incoming water from municipal or a similar supply to the gas turbine and steam cycle requirements. The water treatment plant will produce two parts demineralised water and reject one-part brine, which will be discharged to the Richard Bay Industrial Development Zone (Richards Bay IDZ) stormwater system. • The steam turbine water system will be a closed cycle with air cooled condensers. Make-up water will be required to replace blow down. • Air cooled condensers to condensate used steam from the steam turbine. • Compressed air station to supply service and process air.

13 The exact number has yet to be specified by the project developers.

• Water pipelines and water tanks for storage and distributing of process water. (Potential sourcing of alternative water outside Richards Bay IDZ supply (Municipality) • Water retention pond • Closed Fin-fan coolers to cool lubrication oil for the gas turbines • Gas generator Lubrication Oil System. • Gas pipeline supply conditioning process facility. Please note, gas supply will be via dedicated pipeline from the proposed Transnet supply pipeline network of Richards Bay (the location of this network has not yet been confirmed) or, alternatively directly from the Regasification facilities at Richards Bay Harbour. The gas pipeline will be separately authorized.   o Site water facilities including: potable water, storm water, and wastewater • Fire water (FW) storage and FW system • Diesel emergency generator for start-up operation. • Onsite fuel conditioning including heating system. • All underground services: including stormwater and wastewater
Ancillary Infrastructure for functioning of the plant
• Roads (access and internal); • Warehousing and buildings; • Workshop building; • Fire water pump building; • Administration and Control Building; • Ablution facilities; • Storage facilities; • Guard House; • Fencing; • Maintenance and cleaning area; • Operational and maintenance control centre
Electricity infrastructure/Grid Connection

• Power evacuation including:
  o Generator circuit-breakers (GCBs),
  o Generator Step Up (GSU) transformers,
  o Medium voltage busbar,
  o High-voltage (HV)cabling and 1x275kV or 400kV Gas Insulated switchgear (GIS) Power Plant substation.
• Generators and auxiliaries;
• On-site substation (275kV or 400kV)

Service infrastructure
• Stormwater channels • Water pipelines • Temporary work areas during the construction phase (laydown areas)
Raw/Process-Water Storage Reservoir
Storage facilities will be located on site for water this will include: • Raw water tank • Fire water tank • Demineralisation water tank • Tank for partially treated water

2.4 Broader context of climate risks

Climate change results in different types of risks, such as the social /environmental risks and commercial risks. Commercial risks are market-related risks, while social and environmental-related risks are externalities which are not typically priced into commercial risks. In the context of NEMA, commercial risks are not relevant, however the inclusion of externalities must be considered.

2.4.1 Social and Environmental Externalities

The Phakwe Richards Bay Gas Power 3 CCPP could contribute to externalities. Climate change is one of the most significant energy system externalities in South Africa[14]. The Phakwe Richards Bay Gas Power 3 CCPP provides an opportunity for reducing GHG emissions, which would also have the co-benefit of reducing air pollution, which is also a major energy system externality.

2.4.2 Locked-in Emissions

Carbon lock-in can take place in every sector and industry, and from the local to global level through multiple types of mechanisms. The Phakwe Richards Bay Gas Power 3 CCPP will generate emissions throughout the life of the project. Gas is a transitional mechanism and the related carbon lock-in is key towards contributing to increasing the ability of the South African grid to accept intermittent renewable. The Phakwe Richards Bay Gas Power 3 CCPP identifies potential entry points for transitioning towards sustainable energy resources that can promote the use of clean energy despite carbon lock-in.

2.4.3 Avoided Emissions

The proposed Phakwe Richards Bay Gas Power 3 CCPP will enable additional renewable energy capacity to be placed onto the South African grid. This will result in additional benefits posed by the presence of the project. These benefits can include avoided emissions.

The avoided emissions associated with the development of the proposed Phakwe Richards Bay Gas Power 3 CCPP were calculated as per the Avoided Emissions Framework[15]. This framework follows a step-by-step approach which identifies all life cycle emissions for both the baseline scenarios, as well as the life cycle emissions associated with the proposed operational scenario. The difference in emissions between the baseline scenario and the proposed operational scenario can then be accounted for as avoided emissions.

This framework considers rebound emissions, conservative assumptions, and general sense checks, while always considering the most conservative approach. It defines rebound effects as an "increase in business-as-usual emissions occurring as result of the [project's] implementation".

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14 Vivid Economics, 2016: Energy System externalities in South Africa [Available online] :http://www.energy.gov.za/files/IEP/2016/IEP-AnnexureC1-Energy-Systems-Externalities-in-SA.pdf (Accessed 16 March 2022)

15 Stephens, A. & Thieme, V., 2019, Towards >60Gigatonnes of Climate Innovations: Module 2. The Avoided Emissions Framework, Missions Innovation.

The rollout of electricity generation capacity is guided by the IRP[16]. It is expected that the introduction of the proposed Phakwe Richards Bay Gas Power 3 CCPP to South Africa's electricity generation fleet will not have an impact on the energy mix used for electricity generation stipulated in the IRP. Thus, this CCIA does not consider any rebound emissions.

Avoided emissions were calculated assuming natural gas was the only fuel used and did not take into consideration other fuel alternatives. Avoided emissions can be achieved because of two impacts of the project:

i. Natural gas is a less emission intensive fuel than coal (the dominant fuel source for South Africa's electrical grid). The emission factor of natural gas is 0,056 tCO_2e/GJ as compared to the emission factor of coal of 0.095 tCO_2e/GJ; and
ii. The inclusion of power generation technology with high load following capability, such as gas-to-power technology, facilitates the inclusion of increased amounts of intermittent renewable energy technologies on the grid. This project can therefore contribute to shifting the South African grid energy mix from a currently coal-based grid to a renewable-based grid[17].

The analysis presented in this report is offered as an indication of the potential impacts that this project could have on the decarbonisation of the South African grid. It is not offered as a calculation of what emissions will be avoided by the implementation of the project, as there are too many unknowns in the development of the national grid in the near future to do such a calculation. This analysis should therefore be seen as indicative of the contribution that the project can make. As part of this report, we do calculate the lifetime emissions of the project based on the assumption that the project will operate and emit emissions at its designed life.

3 Climate Change Context

The climate change context of this project considers the projected climatic changes in terms of the GHG emissions, as well as global carbon budgets.

3.1 Projected Climatic Changes

GHG emissions from all sources accumulate in the atmosphere and contribute to global climate change. One of the main GHGs is carbon dioxide (CO_2). Like all GHGs, CO_2 contributes to climate change by trapping heat in the atmosphere. The greater the concentration of GHGs, the greater the warming effect.

As a result of the continuous emissions of GHGs, it is highly likely that a warming of global average temperatures will exceed 1.5°C above pre-industrial levels by 2100. Heavy precipitation events will become more intense and frequent. The irreversible melting of the ice sheets will be initiated, resulting in harmful sea level rise. Furthermore, tropical cyclones and wind speeds are

16 Department of Energy, 2019, Integrated Resources Plan (IRP2019), Government Gazette, [Online] Available at: http://www.energy.gov.za/IRP/2019/IRP-2019.pdf [Accessed on 10/05/2020].

17 Wright, J.G., Calitz, J. & van Heerden, R., 2017, *Formal comments on the South African Integrated Resources Plan (IRP) Update Assumptions, Base Case and Observations 2016*, CSIR Energy Centre Pretoria, 31 March 2017

likely to increase globally. These climatic changes increase the possibility of irreversible changes in the way the planet, and in turn, human societies and economies will function.

Based on the most recent climate change projections for the Southern African region[18], South Africa is warming at twice the global rate of temperature increase. Temperatures could increase by up to 3°C, to more than 7°C (Figure 3~~Figure 3~~). Extreme weather events, such as droughts, storms and floods are likely to become more intense, frequent, and unpredictable. Water stress will increase. The western parts of the country are projected to become hotter and drier, and the eastern parts wetter.’[19]

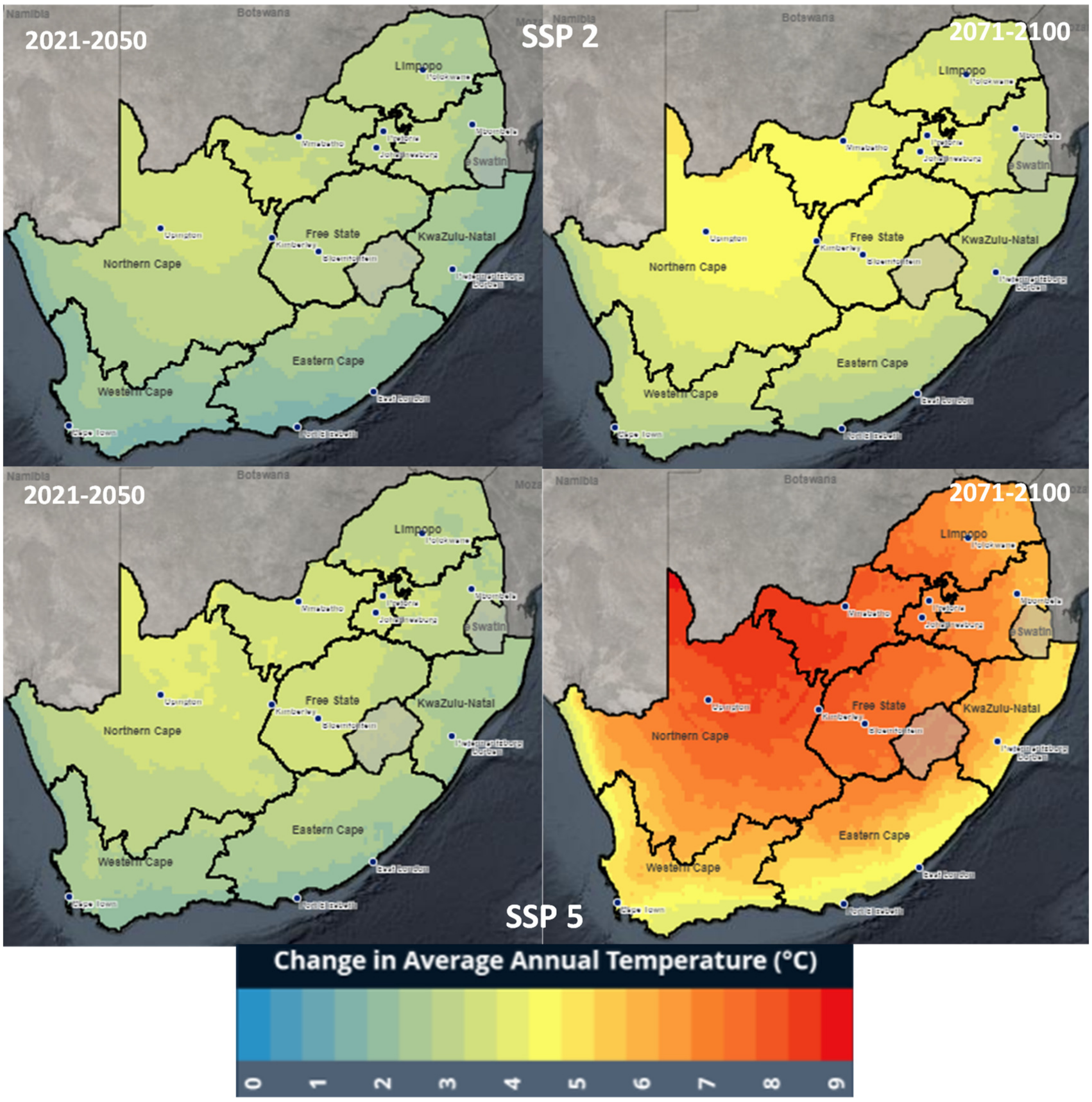

Figure 3: Projected change in average annual temperatures (90th percentile) for the Shared Socio-economic Pathway (SSP) 2 (previously RCP 4.5) and Shared Socio-economic Pathway 5 (previously RCP 8.5)

18 Engelbrecht, F., Le Roux, A., Arnold, K. & Malherbe, J. 2019. Green Book. Detailed projections of future climate change over South Africa. Pretoria: CSIR. Available at: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=b161b2f892194ed5938374fe2192e537.

19 Republic of South Africa. 2021. First Nationally Determined Contribution under the Paris Agreement (Updated September 2021). Republic of South Africa, Pretoria.

The chances, however, are still good, that the global community can restrict global warming to below 1.5°C. To collectively prevent changes in the natural system to the extent that they can no longer support socio-economic activities, as we know them, we need to understand how much more GHGs the global community can afford to emit. This can be done through the use of global carbon budgets.

3.2 Carbon Budgets

A carbon budget can be defined as an allocation of a quantity of GHGs that can be emitted over a specified period. The guiding principle could be limiting global warming to a certain level or meeting a regulatory requirement or a similar limit.

This specialist CCIA is a legal requirement for the environmental authorisation of the proposed Phakwe Richards Bay Gas Power 3 CCPP. Thus, the guiding principle considered for a carbon budget will be the emission limits set out in South Africa's Nationally Determined Contribution[20] (NDC), updated in 2021. Table 3~~Table 3~~ shows the target emissions for the low and high emissions scenarios, as given in the 2021 NDC, with the aim of reaching net zero by 2050.

Table 3: Targeted annual emissions for South Africa, according to the 2021 NDC.

	2020	2025	2030	2050	Cumulative Emissions
Low Emission Scenario	398 $MtCO_2e/y$	398 $MtCO_2e/y$	350 $MtCO_2e/y$	0 $MtCO_2e/y$	7 758 $MtCO_2e$
High Emission Scenario	510 $MtCO_2e/y$	510 $MtCO_2e/y$	420 $MtCO_2e/y$	0 $MtCO_2e/y$	9 585 $MtCO_2e$

Thus, the cumulative emissions from 2020 to 2050 across the low and high emissions scenarios are 7 758 MtCO2e and 9 585 MtCO2e, respectively. These figures are the low and high emission carbon budgets for South Africa. The low emission carbon budget will be used as a conservative estimate of a carbon budget against which to measure the impact of the proposed Phakwe Richards Bay Gas Power 3 CCPP.

4 Approach and Methodology

4.1 Determining Project Impact on Climate Change

4.1.1 GHG Inventory

The basic premise of calculating a GHG inventory is to identify the relevant activities, the relevant emission sources and to quantify the emissions associated with these activities and sources. The emissions are quantified using the following generic equation.

$$Emissions = Activity\ data \times Emission\ Factor$$

[20] Republic of South Africa (2021). *South Africa – First Nationally Determined Contribution Under the Paris Agreement.*

The following section provides more details regarding this process. All equations provided in Section 4.1.1.3 are derivations of this fundamental equation for determining emissions from an activity.

4.1.1.1 Standards used

At the time of writing of this report, South African laws (most are considered under the umbrella of the National Environmental Management Act (NEMA)), do not yet provide adequate guidelines for CCIAs[21]. Thus, this report also makes use of globally accepted international best practice and is guided by the Thabametsi judgement.

The GHG inventory for the proposed Phakwe Richards Bay Gas Power 3 CCPP has been guided by the following reference documents for this CCIA:

- *SANS 14064:2021 Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals* [22];
- The Greenhouse Gas Protocol's *A Corporate Accounting and Reporting Standard (Revised Edition)*[23];
- The Department of Environmental Affairs' *Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry*[24];
- The Department of Forestry, Fisheries and the Environment's *Technical Guidelines for the Validation and Verification of Greenhouse Gas Emissions*[25];
- The 2006 Intergovernmental Panel on Climate Change (IPCC) *Guidelines for National Greenhouse Gas Inventories*[26]; and
- The Intergovernmental Panel on Climate Change (IPCC) *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 4*[27].

The main guiding document used in the calculation of the impact of the project on climate change, is the *SANS 14064:2021 Part 1*. This document sets out principles summarised in Table 4~~Table 4~~, that guide the GHG inventory development process. It requires that emissions be categorised into the following groups:

- **Category 1** – Direct GHG emissions and removals;
- **Category 2** – Indirect GHG emissions from imported energy;
- **Category 3-6** – All other indirect GHG emissions

21 South Africa's Department of Forestry Fisheries and the Environment is in the process of providing further guidelines for Climate Change Impact Assessments. However, these guidelines are only a draft and have not yet been published.

22 Standards South Africa, 2021, *SANS 14064-1:2021 Greenhouse Gases Part 1: Specification with guidance at the organisational level for the quantification and reporting of greenhouse gas emissions and removals*, Pretoria.

23 Greenhouse Gas Protocol, 2015, *A Corporate Accounting and Reporting Standard: Revised Edition.*

24 Department of Environmental Affairs, 2016, *Technical Guidelines for Monitoring, Reporting and Verification of GHG Emissions by Industry.*

25 The Department of Forestry, Fisheries and the Environment ,2021, *Technical Guidelines for the Validation and Verification of Greenhouse Gas Emissions*

26 IPCC, 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*, [Online] Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/ [Accessed on 05/04/2020].

27 IPCC, 2019. *Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.*

Table 4: ISO/SANS 14064-1 principles for carbon footprints

Relevance	Selecting all the greenhouse gas sources, sinks, reservoirs, data and methodologies that are appropriate.
Completeness	Including all the greenhouse gas emissions and removals relevant to the proposed project.
Consistency	Enable meaningful comparisons to be made with other greenhouse gas related information.
Accuracy	Reducing bias and uncertainties as far as is practical.
Transparency	Disclosing sufficient and appropriate greenhouse gas related information to allow intended users to make decisions with reasonable confidence.

The calculation of the GHG inventory for the proposed Phakwe Richards Bay Gas Power 3 CCPP, follows the general steps stipulated here:

- Boundaries of the analysis are set;
- GHG sources/sinks inside the boundary are identified;
- The significance of each of the emission sources is determined;
- Quantification method is established; and
- GHG emissions inventory is calculated.

Note that traditionally, GHG reporting has been done using the 2006 version of SANS14064 - 1 in combination with the Greenhouse Gas Protocol's *A Corporate Accounting and Reporting Standard*, which classified emissions in 3 emission scopes. The relationship between the traditional emission scopes and the latest version of the SANS14064 - 1 standard is shown in the Table 5~~Table 5~~ below:

Table 5: GHG reporting for both standards ISO 14064:2021 and ISO 14064:2006

SANS 14064:2021		ISO 14064:2006	
Category	Description	Category	**Description**
1	Direct GHG emissions and removals	Scope 1	
2	Indirect GHG emissions from imported energy	Scope 2	Energy indirect emissions
		Scope 3 Category 3	Fuel- And Energy-Related Activities
3	Indirect GHG emissions from transportation	Scope 3 Category 3	Fuel- And Energy-Related Activities[28]
		Scope 3 Category 4	Upstream Transportation and Distribution
		Scope 3 Category 6	Business Travel
		Scope 3 Category 7	Employee Commuting

[28] Note that the activities that used to be included under Scope 3 Category 3 have been split into Category 2 and Category 3 of the new standard.

SANS 14064:2021		ISO 14064:2006	
Category	Description	Category	**Description**
		Scope 3 Category 9	Downstream Transportation and Distribution
4	Indirect GHG emissions from products used by organization	Scope 3 Category 1	Purchased Goods and Services
		Scope 3 Category 2	Capital Goods
5	Indirect GHG emissions associated with the use of products from the organization	Scope 3 Category 10	Processing of Sold Products
		Scope 3 Category 11	Use of Sold Products
		Scope 3 Category 12	End-Of-Life Treatment of Sold Products
6	Indirect GHG emissions from other sources	Scope 3 Category 5	Waste Generated in Operations
		Scope 3 Category 8	Upstream Leased Assets
		Scope 3 Category 13	Downstream Leased Assets
		Scope 3 Category 14	Franchises
		Scope 3 Category 15	Investments

4.1.1.2 Significance Criteria for Inclusion of Indirect Emissions

SANS 14064-1:2021 requires that the reporting organization defines and explains its thresholds for a set of significance criteria to determine if indirect emissions should be included in the reporting or not. The following criteria will be applied to determine the inclusion of indirect emissions sources in the GHG inventory:

- **Magnitude** – Activities contributing more than 300 tCO_2e/y (1% of the ***Low*** impact threshold discussed in Section 4.1.4) shall be included in the assessment
- **Level of Influence** – Activities where the project owner could engage with the supplier to reduce upstream emissions, or where the company can choose a supplier based on their emissions, shall be included.
- **Risk/opportunity** – Activities that significantly contribute to the organization's exposure to climate-elated risks or opportunities shall be included.
- **Sector-specific guidance** – The National Greenhouse Gas Reporting Regulations, and the Technical Guidelines for Monitoring, Reporting, Verification and Validation of Greenhouse Gas Emissions by Industry provide guidance of the electricity generation.
- **Outsourcing** – N/A. No core business activities are outsourced within the context of this specialist climate change impact assessment.

- **Employee Engagement** – Activities that could motivate employees to significantly reduce energy use or that federate team spirit around climate change shall be included.

4.1.1.3 GHG Inventory Development

The direct, upstream, and downstream emissions for both the construction and operational phases of the proposed Phakwe Richards Bay Gas Power 3 CCPP were considered. The direct emissions relate to onsite emissions during construction and operation (such as combustion of natural gas for the generation of electricity). The upstream emissions relate to the sourcing of materials consumed during construction and operation (such as emissions arising from manufacture of construction materials and transport-related emissions of material/fuels used onsite). The downstream emissions relate to the end of life of materials and products used (such as waste management activities).

These emissions are given in CO_2 equivalents (CO_2e). A CO_2 equivalent is when the emissions of other GHGs are equated to an equivalent amount of CO_2 using the 100-year global warming potential (GWP) of that gas. The GWP of any GHG is the amount of heat absorbed per mass unit of a GHG, divided by the amount of heat an equivalent mass of CO_2 would absorb over the specified period.

Construction Phase

Estimates of some construction material requirements were provided for the project. These relate to fuel, water, and electricity consumption. However, other material consumption could not be estimated this early in the project development, such as the quantity of steel to be used. Assumptions were made to fill these data gaps, as discussed in section 4.1.5.

The construction-related emissions are calculated using the equation described at the start of Section 4.1.1. The *Emissions*, *Activity Data*, and *Emission factor* terms are replaced with relevant parameters to describe the construction-related emissions considered.

All construction-related emissions are considered as indirect emissions, as the construction of the facility is not the core activity of the project. The emissions from the consumption of materials and energy carriers (fuel and electricity) are accounted for using the following equation, namely

$$Em_{Const,i} = \sum_{i} (m_i \times EF_i)_{production} + (m_i \times EF_i)_{consumed}$$

Where:

- $Em_{Const,i}$ are the emissions association with the production and consumption of material or energy carrier *i* during construction, measured in tCO_2e;
- m_i is the quantity of material or energy carrier *i* consumed, measured in litres, tonnes, MWh or similar;
- EF_i is the emission factor associated with the production or consumption of material or energy carrier *i*, measured in tCO_2e per litre, per tonne, per MWh or similar.

Operation Phase

The operating emissions are calculated using the equation described at the start of Section 4.1.1. The *Emissions*, *Activity Data*, and *Emission factor* terms are replaced with relevant parameters to describe the operating emissions considered. This includes the direct (***$Cat1_{Op,NG}$***) and indirect (***$Upstream_i$*** and ***$Fugitive_{NG}$***) emissions.

During operation, the Category 1 emissions are from the combustion of the natural gas to produce electricity. These emissions can be calculated as follows:

$$Cat1_{Op,NG} = \frac{W}{\varepsilon} \times u_f \times EF_{NG} \times \frac{31\ 536\ 000\ s}{1\ year} \times \frac{1\ GJ}{1000\ MJ}$$

Where:

- ***$Cat1_{Op,NG}$*** represents the annual direct combustion emissions from the operation of the Phakwe Richards Bay Gas Power 3 CCPP, measured in tCO_2e/year;
- ***W*** represents the gross capacity of the Phakwe Richards Bay Gas Power 3 CCPP, measured in MJ/s;
- ***ε*** represents the conversion efficiency of the technology used from fuel energy to electrical energy; measured in $MJ_{electrical}/MJ_{thermal}$;
- ***u_f*** represents the utilisation factor of the facility (i.e., the fraction of the year that the facility operates); and
- ***EF_{NG}*** represents the emission factor of the combustion of natural gas, measured in tCO_2e/GJ.

Upstream indirect emissions during operation are associated with the processing and transport of the materials/energy carriers used during operation. For the proposed Phakwe Richards Bay Gas Power 3 CCPP, this related to emissions from the production and transport of natural gas and water as well as fugitive emissions along the natural gas value chain. Depending on the type of material, these emissions are either allocated under Category 3 or Category 4 of the SANS 14064-1:2021.

The following equation is used to calculate the upstream indirect emissions,

$$Upstream_i = \sum_i (m_i \times EF_i)_{production} + (m_i \times EF_i)_{trasport}$$

Where:

- ***$Upstream_i$*** represents the upstream emissions associated with the production and transport of material *i* used during the operation of the proposed Phakwe Richards Bay Gas Power 3 CCPP, measured in tCO_2e/year
- ***m_i*** is the quantity of material *i* consumed, measured in litres or tonnes or similar units;
- ***EF_i*** is the emission factor associated with the production of material *i*, measured in tCO_2e per litre, per tonne or similar units.

Specifically, the fugitive emissions are calculated using the emission factors in the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 4*. These calculations are described below:

$$Fugitive_{NG} = \sum_j EF_{IPCC,j} \times m_{NG}$$

Where:

- $Fugitive_{NG}$ are the fugitive emissions associated with the use of natural gas, measured as tCO_2e/year;
- j are all the steps/processes in the value chain considered to have fugitive emissions;
- $EF_{IPCC,j}$ is the emission factors for fugitive emissions of portion j in the value chain, measured in tCO_2e/GJ;
- m_{NG} is the total amount of natural gas consumed by the Phakwe Richards Bay Gas Power 3 CCPP in a year, measured in GJ/year.

4.1.1.4 Avoided emissions

As described in section on page 8, the proposed Phakwe Richards Bay Gas Power 3 CCPP will enable additional renewable energy capacity onto the South African grid. This will result in additional benefits from the project. These benefits would include avoided emissions.

Based on work done by the CSIR, in the context of the South African grid, the theoretical maximum renewables for a renewable-based grid is 70%[29], with the remainder being gas-to-power technologies (30%). From this, a theoretical maximum avoided emission can be calculated by comparing the existing grid emission factor with that of a renewable-based grid. This is achieved by subtracting the emissions of natural gas-based grid from the emissions of a coal-based grid, whilst accounting for the difference in energy supplied by the two technologies.

$$AvE_{max} = Energy_{SA}(\varphi_{Coal} \times GEF_{SA} - \varphi_{Gas} \times EF_{Gas})$$

Where:

- AvE_{max} is the theoretical maximum avoided emissions for shifting to a gas-based grid (in tCO_2e/year);
- $Energy_{SA}$ is the total energy currently generated in South Africa (in MWh/year);
- ϕ_{Coal} is the fraction of coal on the assumed coal-based grid with maximum renewable energy (76%);
- GEF_{SA} is the current grid emission factor for South Africa (in tCO_2e/MWh);
- ϕ_{Gas} is the fraction of future energy demand supplied by gas-to-power technologies in the assumed renewable-based grid (30%); and
- EF_{Gas} is the emission factor for a gas-to-power technologies, assuming all gas-to-power technologies in the assumed renewable-based grid have the same emission factor as the proposed Phakwe Richards Bay Gas Power 3 CCPP.

[29] Wright, J.G., Calitz, J. & van Heerden, R., 2017, *Formal comments on the South African Integrated Resources Plan (IRP) Update Assumptions, Base Case and Observations 2016*, CSIR Energy Centre Pretoria, 31 March 2017

The avoided emissions are then allocated to this project proportional to its contribution to the gas-to-power capacity of the renewable-based grid (i.e. if this project covers 10% of the theoretical gas capacity needed, 10% of the avoided emissions are allocated to it).

$$AvE_{proj} = AvE_{max} \times \frac{W_{proj}}{W_{RG}}$$

Where:

- AvE_{proj} are the avoided emissions allocated to the project (in tCO_2e/year)
- AvE_{max} is the theoretical maximum avoided emissions for shifting to a gas-based grid (in tCO_2e/year);
- W_{proj} is the design capacity of the project (in MW); and
- W_{RG} is the theoretical capacity of all gas-to-power technologies for the renewable-based grid (in MW).

4.1.2 Data used

The two main data requirements to calculate the GHG emissions for this project are (i) activity data and (ii) emission factors. The combination of these two data sets results in the development of a GHG inventory. The sources of these data sets vary and are discussed in further detail in the sections below.

4.1.2.1 Activity Data

The activity data was collected from the project developer. Where the project developer could not provide data, activity data was estimated using conservative assumptions, which were agreed upon with the client. Table 6~~Table 6~~ summarises the activity data used.

Table 6: Activity data used to calculate the GHG inventory (running on natural gas).

Construction Phase	Quantity	Unit	Data Source
Electricity consumed	256	MWh/month	Project developer
Number of employees	600		Project developer
Diesel consumed	150 000	L	Project developer
Water consumed	250 000	m^3	Project developer
Steel consumed	35 800	t	Estimated[30]
Construction time	48	months	Project developer
Operation Phase	**Quantity**	**Unit**	**Data Source**
Gross Capacity	2 060	MW	Calculated
Parasitic load	60	MW	Project developer
Net Capacity	2 000	MW	Project developer
Operating Hours	16	h/d	Project developer
Utilisation	67%		Calculated from operating hours
Natural Gas consumed	84 300 000	GJ/y	Calculated from data provided

[30] The design specifications for a Jenbacher J920 gas engine was used to determine a steel requirement per MW of installed capacity (17.4 t steel/MW). This was multiplied by the plant's gross capacity to estimate the total tonnes of steel required.

Lifetime	30	y	Project developer
Overall plant efficiency	51%		Project developer[31]
Employees	60		Project developer
Water consumption	1 130 000	m^3/y	Project developer

For the avoided emissions calculations, reference was made to Eskom reports[32,33] and the CSIR's IRP review model[34]. The key activity data used for the avoided emissions calculations are stated in Table 7~~Table 7~~.

Table 7: Information used to calculate the avoided emissions from the proposed Phakwe Richards Bay Gas Power 3 CCPP.

Activity	Value	Source
Eskom Capacity	46 500 MW	2021 Eskom Annual Report[35]
Energy Availability Factor (EAF)	64.19 %	2021 Eskom Annual Report
Max. RE installed capacity on coal-dominated grid	24%	IRENA document[36]
Average capacity factor of wind and solar energy sources	37%	Eskom weekly status report for week 8 of 2022[37] (Calculated)
Max. RE installed capacity on gas grid	70%	CSIR model document[38]

4.1.2.2 Emission Factors

The emission and conversion factors applied in the calculation of the proposed Phakwe Richards Bay Gas Power 3 CCPP's GHG inventory, are aligned with the following principles:

- derived from a recognised origin;
- appropriate for the GHG source concerned;
- current at the time of quantification;
- take account of quantification uncertainty and are calculated in a manner intended to yield accurate and reproducible results; and

---

31 The efficiency was given based on the higher heating value of the fuel. Thus, the ratio of the higher to lower heating values was used to calculate the efficiency according to the lower heating value.

32 Eskom, 2022, Eskom Weekly System Status Report 2020 Week 8, Eskom [Website] Available at: http://www.eskom.co.za/Whatweredoing/SupplyStatus/Pages/AdequacyReports2018.aspx?Paged=TRUE&p_SortBehavior=0&p_Created=20200226%2008%3a03%3a21&p_ID=226&PageFirstRow=31&&View={20A9CA42-3455-4B7B-9506-4C5C54B43754} [Accessed on 02/11/2020].

33 Eskom, 2021, Integrated Report 2021, Eskom: Investors Integrated Results [Website] Available at: http://www.eskom.co.za/IR2020/Pages/default.aspx [Accessed 02/11/2020].

34 Wright, J.G., Calitz, J. & van Heerden, R., 2017, Formal comments on the South African Integrated Resources Plan (IRP) Update Assumptions, Base Case and Observations 2016, CSIR Energy Centre Pretoria, 31 March 2017.

35 Eskom, 2021, Integrated Report 2021, Eskom: Investors Integrated Results [Website] Available at: https://www.eskom.co.za/wp-content/uploads/2021/08/2021IntegratedReport.pdf [Accessed 28/03/2022].

36 IRENA (2018). *Power System Flexibility for the Energy Transition.* [Website] Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Nov/IRENA_Power_system_flexibility_1_2018.pdf [Accessed on 28/03/2022]

37 Eskom (2022). Eskom Weekly System Status Report 2022 Week 8, Eskom [Website] Available at: https://www.eskom.co.za/wp-content/uploads/2022/03/Weekly_System_Status_Report_2022_w8.pdf [Accessed on 28/03/2022].

38 Wright, J.G., Calitz, J. & van Heerden, R., 2017, *Formal comments on the South African Integrated Resources Plan (IRP) Update Assumptions, Base Case and Observations 2016*, CSIR Energy Centre Pretoria, 31 March 2017

- consistent with the intended use of the carbon footprint.

The emission factors used were taken from a wide variety of sources. Specifically for the emissions from the combustion of fuels, South Africa's *Technical Guidelines on the Monitoring, Reporting and Verification of GHG emissions by Industry* were used. Table 8~~Table 8~~ provides the emissions factors used and their respective sources.

Table 8: Emission and conversion factors used for GHG inventory.

Category 1 Emissions		**Value**	**Unit**	**Reference**
Diesel (Mobile)		0.0032	tCO_2e/l	SA Technical Guidelines[39]
Natural Gas (Stationary)		0.0562	tCO_2e/GJ	SA Technical Guidelines
Category 2 Emissions		**Value**	**Unit**	**Reference**
Purchased Electricity		1.08	tCO2e/MWh	Calculated from Eskom's FY21 Annual Report
Category 3 Emissions	Items	**Value**	**Unit**	**Reference**
Consumables Production	Water Supply	0.1490	kgCO2e/m^3	DEFRA 2021[40]
	Steel	1.89	tCO_2e/t	World Steel Association[41]
	Diesel	0.6287	$kgCO_2e/L$	DEFRA 2021
	Natural Gas	0.0253	tCO_2e/GJ	U.S. Department of Energy[42]
Fugitive	National	0.002230	tCO_2e/GJ	IPCC 2019 V2 CH.4[43]
	International	0.008314	tCO_2e/GJ	IPCC 2019 V2 CH.4
	Terminals	53 650	tCO_2e/terminal /y	IPCC 2019 V2 CH.4
Waste	Wastewater	0.149	tCO_2e/#/y	IPCC 2006 Guidelines - 4D1 Wastewater Treatment[44]

The fugitive emissions were calculated using emission factors published by the IPCC in their *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 4.*

39 Department of Environmental Affairs, 2017, *Technical Guidelines for Monitoring Reporting and Verification of Greenhouse Gas Emissions by Industry.*
40 DEFRA, 2021, UK Government GHG Conversion Factors for Company Reporting.
41 World Steel Association [Online] *Our Performance.* Accessed on 22/03/2022. Available at https://worldsteel.org/steel-by-topic/sustainability/sustainability-indicators/
42 United States Department of Energy (2014). *Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States.*
43 IPCC (2019). *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 4.*
44 IPCC (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Chapter 6.*

These emission factors are generated by the IPCC by gathering available data and scientific literature, including literature on natural gas handling. We are aware that there have been reports which claim that methane emissions from natural gas systems have been significantly underestimated. However, these reports constitute a minority and have been taken into account by the IPCC. Thus, it is our expert judgment that the IPCC values are a good representation of existing natural gas technologies and fully represent the fugitive emissions of methane from natural gas systems.

The IPCC publishes fugitive emission factors for natural gas systems under two scenarios. The first is assuming a system makes extensive use of leak detection and repair technologies as well as appropriate seals to reduce fugitive emissions. The second is assuming the systems makes limited/no use of leak detection and repair technologies and sealing technologies. The latter scenario's emission factors were considered in this report to be in line with developing a worst-case scenario for the proposed Phakwe Richards Bay Gas Power 3 CCPP.

Furthermore, the source of the natural gas used by the proposed Phakwe Richards Bay Gas Power 3 CCPP will be determined by socio-economic factors. These can change significantly and quickly (as recently illustrated by the COVID pandemic and the Ukraine crisis). Thus, using emission factors that represent the global pool of natural gas sources, rather than a specific source, was considered prudent in assessing the upstream GHG emissions. The IPCC's fugitive emission factors represent such a pool.

4.1.3 Environmental Impacts of GHG Emissions

An environmental impact assessment requires that local impacts be quantified according to a given set of criteria. These are the **Nature**, the **Extent**, the **Duration**, the **Magnitude**, the **Probability,** and the **Significance** of the impacts. However, climate change is a global phenomenon, meaning these criteria are inadequate to fully quantify the impact. Despite this, these criteria are currently the only criteria available to measure the impact of the project on climate change.

Table 9: Environmental impact assessment criteria

Nature	A description of what causes the effect, what will be affected and how it will be affected. In the case of climate change assessments, the nature of the impact is the contribution of the project to global anthropogenic climate change.
Extent (E)	An indication of whether the impact will be local (limited to the immediate area or site of development), regional, national, or international. A score of between 1 and 5 is assigned as appropriate (with a score of 1 being local (low) and a score of 5 being international (high). In the case of climate change assessments, the extent is always global, and thus a 5 is allocated to all projects that contribute to global anthropogenic climate change.

Duration (D)	An indication of the lifetime of the impact quantified on a scale from 1-5. Impacts with durations that are; very short (0–1 years) are assigned a score of 1, short (2-5 years) are assigned a score of 2, medium-term (5–15 years) are assigned a score of 3, long term (> 15 years) are assigned a score of 4 or permanent are assigned a score of 5. In the case of climate change assessments, the emission of non-renewable based GHGs can be considered permanent emissions. Thus, a 5 is allocated to all projects that contribute to global anthropogenic climate change.
Magnitude (M)	An indication of the consequences of the effect are quantified as follows: • 0 is allocated to projects that do not have GHG emissions; • 2 is allocated to projects with a rating of ***Low***; • 5 is allocated to projects with a rating of ***Medium***; • 7 is allocated to projects with a rating of ***High***; and • 10 is allocated to projects with a rating of ***Very High***. The quantification of the impact rating thresholds is discussed in more detail in Section 4.1.4.
Probability (P)	An indication of the likelihood of the impact actually occurring estimated on a scale of 1–5. A score of 1 implies that the impact is very improbable, 2 are improbable, 3 are probable, 4 are highly probable and 5 are definite with the impact occurring regardless of any prevention measures. The IPCC has reported that it is 95 percent certain that man-made emissions are the main cause of current observed climate change[45]. Thus, a value of 5 is allocated to all projects that contribute to global anthropogenic climate change.
Significance (S)	The significance points are calculated as: S = (E + D + M) x P. A weighting based on a synthesis of the characteristics described above and can be assessed as low (< 30 points), medium (30-60 points) or high (> 60 points).

4.1.4 Determining the Magnitude of the Project Impact on Climate Change

4.1.4.1 Determination of the Low Impact Level for GHG Impact Rating

The DFFE published the draft *National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric emissions Licenses and Waste Management Licenses*[46] in January 2021. One of the guidelines for when a specialist CCIA is necessary is when

45 IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

46 DFFE. (2021). *National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric emissions Licenses and Waste Management Licenses.* [Available online] https://www.gov.za/sites/default/files/gcis_document/202106/44761gon559.pdf [Accessed on 28/03/2022]

the activity breaches one of the thresholds stipulated in the *National Greenhouse Gas Reporting Regulations*[47].

The upper limit of the low impact level can be calculated according to the regulation indicated above. In this regulation, the threshold for fuel combustion for energy related activities is typically 10 $MW_{thermal}$ installed capacity (IPCC categories 1A1a – 1A1l). Thus, the limit was taken as the combustion of fuel at a capacity of 10 $MW_{thermal}$ operating for 1 year.

$$Upper\ limit\ \text{Low} = 10\ MW_{thermal} \times \frac{31\ 536\ 000\ s}{year} \times \frac{1\ TJ}{1\ 000\ 000\ MJ} \times EF_{coal}$$

Coal was used as the fuel source as this is a typical emission intensive fuel source used for such processes. The emission factor for coal is taken as "Other Bituminous Coal" from Table A.1 of the Technical Guidelines[48]. This equates to approximately 30 000 tCO_2e/year. Thus, emissions less than 30 000 tCO_2/y will be considered to have a ***Low*** impact.

4.1.4.2 Determination of the Very High and High Impact Level for GHG Impact Rating

The lower limit for the ***Very High*** impact category was calculated to be the annual emissions of a new coal fired power station. The size of the hypothetical power station was equivalent to the average capacity of the Eskom coal-fired fleet, namely 2 900 MW[49]. The annual emissions were calculated using an efficiency taken from the 2017 EPRI Report[50] for new coal-fired power stations and the current availability of the Eskom fleet. The annual emissions calculated, and thus the limit between the ***High*** and ***Very High*** impact categories, was 15 000 000 tCO_2e/year.

The lower limit for the ***High*** impact category was then taken as an order of magnitude less than the lower limit for the ***Very High*** impact category discussed above.

4.1.4.3 Summary of Impact Levels

Table 10~~Table 10~~ combines the above-described calculations into one impact table. This is used to assess the magnitude of the impact of a project on climate change. It also compares the thresholds to the low emission NDC carbon budget of 7 758 Mt CO_2e.

Table 10: Impact category thresholds used to determine the magnitude of the impact of the project on climate change.

GHG impact rating as a % of SA's carbon budget	Amount of GHG emissions		Relative to Low Emission NDC Carbon Budget	
	Lower limit (tCO_2e)	Upper limit (tCO_2e)	Lower limit (tCO_2e)	Upper limit (tCO_2e)
Low	-	30 000	0.000000%	0.00039%

47 DFFE. (2020). *Amendments to the National Greenhouse Gas Emission Reporting Regulations, 2016*. [Available online] https://www.gov.za/sites/default/files/gcis_document/202009/43712rg11174gon994.pdf [Accessed on 28/03/2022]

48 Department of Environmental Affairs, 2017, *Technical Guidelines for Monitoring Reporting and Verification of Greenhouse Gas Emissions by Industry*.

49 Calculated from Eskom's 2021 IAR.

50 Electric Power Research Institute (2017). *Power Generation Technology Data for Integrated Resource Plan of South Africa*.

Medium	30 001	1 500 000	0.00039%	0.019%
High	1 500 001	15 000 000	0.019%	0.193%
Very High	15 000 001	+	> 0.193%	

Only the emissions occurring within the national boundary of South Africa will be considered for assessing the magnitude of the impact of the proposed Phakwe Richards Bay Gas Power 3 CCPP on climate change. This is because only emissions within the national boundary should be subject to the national laws and regulations of the country. This also allows the national emissions to be compared to the national carbon budget.

4.1.5 Limitations and Assumptions

This CCIA makes use of data obtained during a desktop review for the development of this GHG inventory and associated impact assessment. Certain assumptions were made to ensure the development of the most accurate and extensive GHG inventory and the associated impact assessment. These assumptions were made considering the significant boundary set out by the EIA reporting requirements. The assumptions are the following:

- In the context that the project developer was not able to supply details about the construction of the plant, the CCIA is based on the assumption that the plant utilises Jenbacher J920 gas engines. This is used as a conservative estimate to determine the amount of the steel per MW of installed capacity (see Table 6~~Table 6~~).
- In line with the "worst-case scenario" calculation, have assumed the facility runs on natural gas only for its lifetime.
- It was assumed that the following aspects of the Phakwe Richards Bay Gas Power 3 CCPP will contribute immaterially towards the GHG footprint of the project during the operational phase:
    - Employee commuting;
    - Quantity of construction and municipal waste generated, including the distance in transporting waste to landfill;
    - Purchase of capital goods, such as vehicles; and
    - Business travel.

The above assumptions were determined by applying the significance criteria in the SANS 14064-1:2021 standard. These assumptions are made based on the specialists' experiences.

4.2 Project Vulnerability to Climate Change

The impacts of climate change are likely to result in increased climate-related vulnerabilities for the Phakwe Richards Bay Gas Power 3 CCPP Project. Climate change management should, therefore, not be limited to emissions reductions (mitigation) but should also take into consideration measures for increasing the resilience of the Project (adaptation) in the face of climate change. Identifying impacts of climate change on the Phakwe Richards Bay Gas Power 3 CCPP Project will be considered in this assessment.

4.2.1 International Best Practice

Due to the current lack of local regulations regarding CCIAs in South Africa, specifically with regards to unpacking and quantifying vulnerability to climate change, international best practice is used in this assessment. In this regard, this report makes use of globally accepted international best practices, including:

- Framework for Climate Change Vulnerability Assessments,[51]
- International Finance Corporation (IFC) performance standards[52];
- European Bank for Reconstruction and Development (EBRB) principles;
- The Equator Principles[53]; and
- International Council on Mining and Minerals (ICMM): Adapting to climate change[54]

The abovementioned documents were used to develop a rating system (indicated in section 4.1.4 of this report), to which the current project is benchmarked. This enables us to adequately assess climate change impacts considering available baselines and relevant information.

4.2.1.1 Key Areas of Impact

The resilience and vulnerability assessment conducted for this CCIA considers four key areas[55] (listed in Table 11~~Table 11~~ below) related to the proposed Phakwe Richards Bay Gas Power 3 CCPP Project that could be vulnerable to climate change impacts.

Table 11: Key areas of impact relevant for the Phakwe Richards Bay Gas Power 3 CCPP Project.

Area of Impact	Relevance
The core operations;	These are operations that are performed by the Project and that its management has complete control over.
The project value chain (both upstream and downstream);	These are operations that are related to the Project, but its management does not have control over. These include activities of suppliers, customers, government, and the greater economic market.
The social environment (surrounding/impacted communities); and	This includes the people that are both directly and indirectly affected by the Project, such as employees, surrounding industry and local communities.

51 GIZ. 2014. The vulnerability sourcebook. Gesellschaft für Internationale Zusammenarbeit, Bonn, Germany.
52 International Finance Corporation, 2012, *Performance Standards*, [Online] Available at: https://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Sustainability-At-IFC/Policies-Standards/Performance-Standards [Accessed on 30/08/2020].
53 The Equator Principles Association, 2020, *Equator Principles EP4*, [Online] Available at: https://equator-principles.com/about/ [Accessed on 30/08/2020].
54 International Council on Mining and Minerals, 2013, *Adapting to a changing climate: implications for the mining and metals industry*. ICMM.
55 International Council on Mining and Minerals, 2013, *Adapting to a changing climate: implications for the mining and metals industry*. ICMM.

Broader environmental risks	This is related to the natural environment directly surrounding the operations of the Project. These include operations, as well as those of surrounding industries and the livelihoods of the local communities.

For widescale considerations of the impacts of climate change, all four of the abovementioned aspects could be impacted by climate change and the Phakwe Richards Bay Gas Power 3 CCPP Project.

4.2.2 Data used

This vulnerability assessment refers to various data sources in the process of determining the critical vulnerability factors faced by the Project. These sources are explained in the table below.

Table 12: Climate change related tools used throughout this CCIA

Tools and Data	Explanation of use
The WRI Water Aqueduct Tool[56]	This tool provides insight into the areas that experience different vulnerabilities to water stress, globally. On a regional level, these identified water-stressed zones are anticipated to impact on the operations and sustainability of various industrial activities, including that of the Project.
The GreenBook Tool[57]	The GreenBook provides a municipal overview of climate-related changes anticipated for 2050 in comparison to present-day climate. In addition, this tool looks specifically at South African municipalities and indicates the increasing vulnerabilities of certain regions and the associated economic, health and environmental impacts of these changing vulnerabilities.
Meteoblue Historical Climate Data	Meteoblue provides historical climate data for the Phakwe Richards Bay Gas Power 3 CCPP project. The parameters include daily temperature and rainfall data from 1985 to 2021 and was further analysed and tested for statistical significance by use of R.
Local demographic factors	Local demographics were used to earmark particularly vulnerable communities, which may be impacted more intensely by climate change and/or the presence of the Project within the region.

These tools were used in conjunction with the information sheet received from the client and considering the specialist's background and understanding of climate-related impacts posed on the Phakwe Richards Bay Gas Power 3 CCPP Project.

[56] Wri.org. 2021. Aqueduct Water Risk Atlas. [online] Available at: https://www.wri.org/applications/aqueduct/water-risk-atlas/

[57] Greenbook.co.za. 2021. Green Book 1 Adapting settlements for the future. [online] Available at: https://greenbook.co.za/

4.2.3 Determining project vulnerability and resilience

The overall vulnerability of the Project, and its surrounds to climate change impacts, can be determined by identifying the exposure, vulnerability, and adaptive capacity of the region in which the Project lies. The IPCC Sixth Assessment Report[58] defines vulnerability as: "*the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.*"[59] This definition aligns with the method of determining the Project's climate-related vulnerability, proposed Figure 4Figure 4 below.

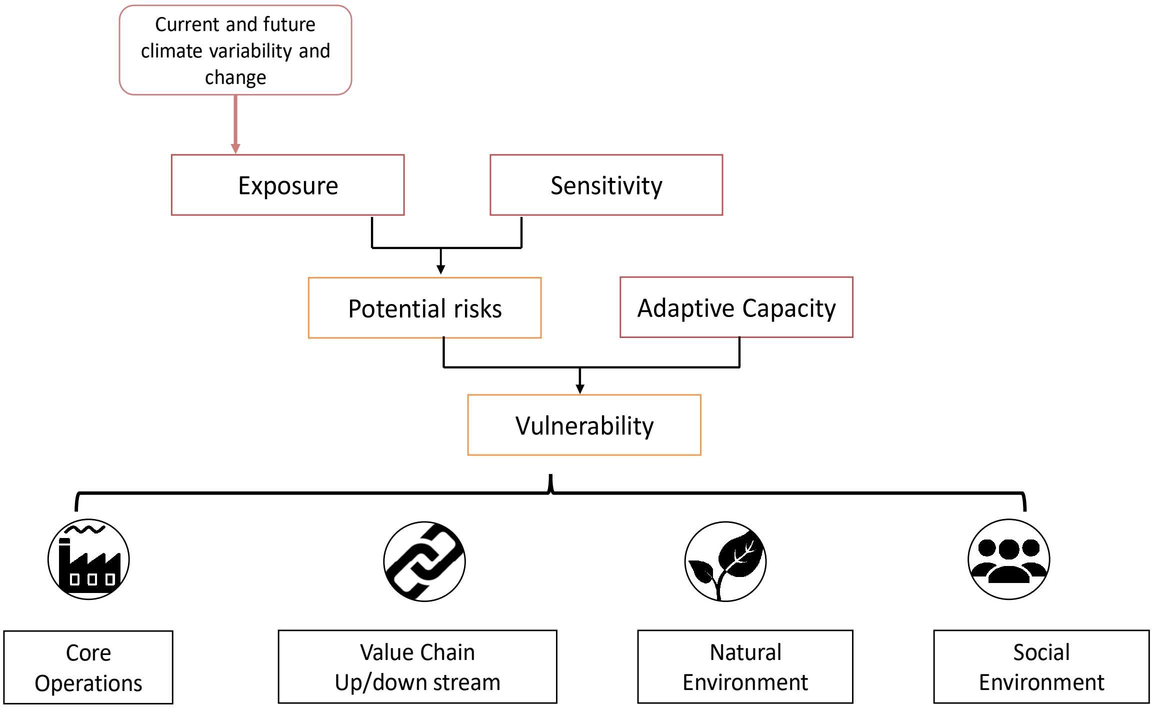

Figure 4: Interrelations of Exposure, Sensitivity and Adaptive Capacity, which makes up the basis of the vulnerability assessment

Figure 4Figure 4 indicates the vulnerability of the core operations of the proposed Phakwe Richards Bay Gas Power 3 CCPP project, the value chain of the Project, as well as the social and natural environments surrounding the project. The diagram also illustrates how climate change impacts and variability could result in changes in the exposure levels experienced in this region.

The vulnerability assessment is conducted considering the impact of climate change on the region's exposure. Thereafter, the overall vulnerability is determined using project exposure, sensitivity, and the current-day adaptive capacity.

58 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

59 IPCC, n.d., *Data Distribution Centre Glossary: Vulnerability*, IPCC [Website] Available at: https://www.ipcc-data.org/guidelines/pages/glossary/glossary_uv.html [Accessed on 10/08/2020].

4.2.4 Limitations and Assumptions

The Project's vulnerability to climate change is assessed within this CCIA through an analysis of available datasets.

Climate projections at finer scales, such as at a municipal level, are much more challenging to project as opposed to subcontinental or continental scale. As a result, there are levels of uncertainty at much finer scales. Therefore, while confidence is growing in global climate models, there is a much greater appreciation of uncertainties involved in downscaling global models to illustrate climate projections at a local scale[60]. This is particularly relevant for rainfall projections where different climate change models are used. As such the latest climate change scenarios and projections were used in this climate change assessment.

This uncertainty should be noted by the project developers since the impacts of climate change may result in decreased investment value over time and possible increases in costs of maintenance.

The assessment of the vulnerability of the project to climate change is subject to further limitations, namely:

- Only impacts on the direct value chain were assessed;
- No modelling of climate change impacts was conducted; and
- Only impacts occurring during the lifetime of the project were considered.

5 Status Quo and Projected Climatic Changes

5.1 Projects Location and Climate

Two main sources of data, namely the province of KwaZulu-Natal and site-specific data relating to the King Cetshwayo District Municipality and the uMhlathuze Local Municipality within which the Project is situated, were analysed for climate forecasting. Based on the Greenbook and the data obtained, the historical weather data trends were used to forecast/foresee weather changes. These historical and projected weather trends are stipulated in the sections below.

5.1.1 Regional Climate Change Considerations

The Phakwe Richards Bay Gas Power 3 CCPP Project is situated within the KwaZulu-Natal province of South Africa. The climate change projections for the Project within KwaZulu-Natal indicate that annual average ambient temperatures are likely to increase, while overall precipitation is becoming more variable and decreasing in terms of SSP 2, with a risk to droughts being likely in terms of SSP 5 (Figure 5~~Figure 5~~). Such climatic changes would impact the Project in terms of its core operations, value chain and broader socio-economic and natural environment.

60 Bourne, A, P. deAbreu, C. Donatti, S. Scorgie, and S. Holness. 2015. A Climate Change Vulnerability Assessment for the Namakwa District, South Africa: The 2015 revision. Conservation South Africa, Cape Town.

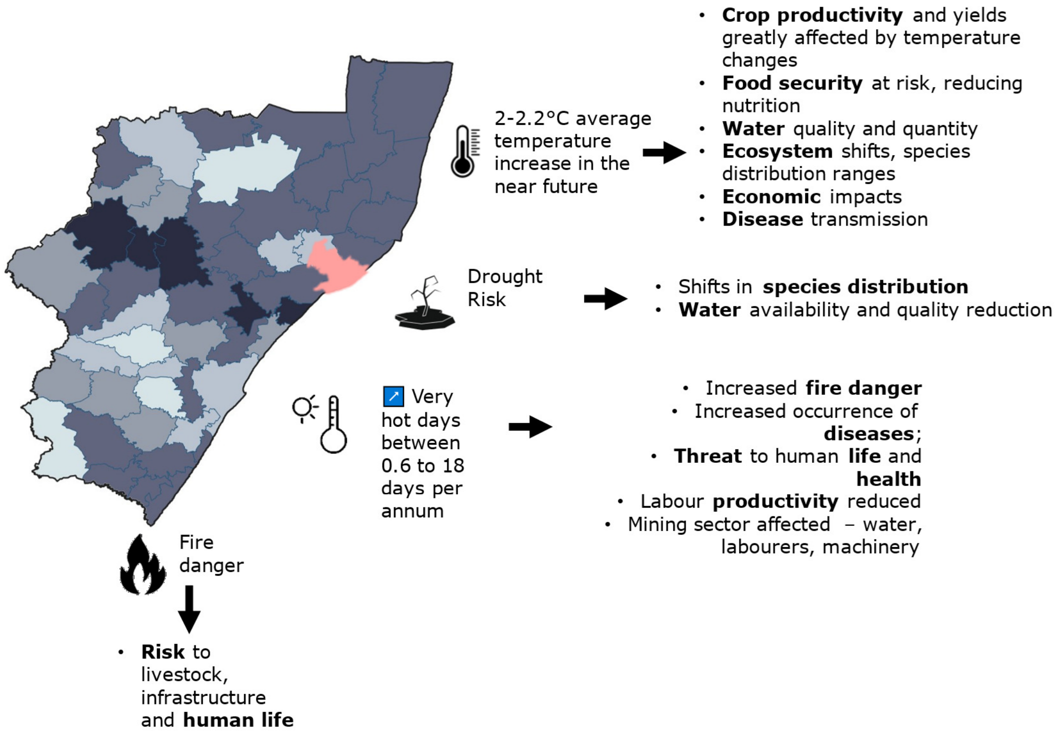

Figure 5: Climatic conditions predicted at KwaZulu-Natal province in reference to uMhlathuze Local Municipality (SSP 5)

The current and future changes in climate for the Phakwe Richards Bay Gas Power 3 CCPP Project, are summarised in the below table.

Table 13: Current and future climate projections for the Project within the uMhlathuze Local Municipality.

Climate change impact	Current	SSP 2	SSP 5
		The projected change for the period 2021 to 2050, relative to the baseline period (1961 to 1990).	
Temperature	Average annual temperature between 19-21 °C.	Average annual temperature increases by between 1.61°C to 1.79°C	Average annual temperature increases by between 1.97°C to 2.15°C
Very Hot Days (>35°C)[61,62]	It is seen that the region will increase between 5 to 12 very hot days.	Potential increase of 0.30 days to 12.04 days	The average increase in the number of very hot days could increase between 0.60 days to 18.26 days
Rainfall	Average of 1300mm to 1500 mm in most regions, however the South is seen to experience 1600 to 1800mm	Average annual rainfall may decrease by 50.30 mm to 17.25 mm	Average annual rainfall may increase between 66.78 mm to 61.73 mm.

[61] Very hot days: the number of days (per 8 x 8 km grid point) where the maximum temperature exceeds 35°C.
[62] Heat wave days: where temperature exceeds maximum temperature of the warmest month of the year by 5°C for a period of 3 or more consecutive days.

Climate change impact	Current	SSP 2	SSP 5
		The projected change for the period 2021 to 2050, relative to the baseline period (1961 to 1990).	
Extreme Rainfall Days[63]	*Information is not available for the baseline*	The region could experience a change of 2.44 days fewer extreme rainfall days or up to 0.34 days more.	The region could experience a change of 0.02 to 1.38 days more of extreme rainfall days.
Flood Risk[64]	North and West regions are seen to have a medium to high flood risk, while the East and South have a low to medium risk.	*Information is not available for the SSP 2 scenario*	Central region there is a medium risk, while most parts of Richards Bay show a low risk.
Drought Risk[65]	Drought tendencies are increasing in most regions of the municipality, with the South have no information reported.	*Information is not available for the SSP 2 scenario*	Most parts of Richards Bay and central part of the municipality shows a high risk
Fire Risk	Likely risk in the central region of the municipality, with Richards Bay specifically having a rare risk.	*Information is not available for the SSP 2 scenario*	High in central regions and South part of Richards Bay, while the East of Richards Bay shows a low risk.

Climatic projections for the Phakwe Richards Bay Gas Power 3 CCPP Project suggest that the area could experience an increase in average annual temperatures of at least 1.6°C to 1.8°C from the baseline period (1961-1990). It is further projected that annual average rainfall volumes would become more variable, and it is likely that there will be an overall decrease in rainfall for SSP 2 and overall increase for SSP 5. It is also seen that the uMhlathuze Local Municipality will experience an increase in extreme hot days for both SSP 2 and SSP 5. Hence, the changes in temperature and the increased variability in rainfall volumes and extreme hot days, increases the drought risk and as a result, will impact the fire risk within the region, particularly within the SSP 5 projection.

The main climate change impacts at the uMhlathuze Local Municipality are **increased temperature**, extreme **heat**, increased **rainfall variability** and high risk to **droughts** and **fires.** The climate in Richards Bay specifically is thus likely to become hotter and drier.

63 20mm of rain occurring within 24 hours over the 8 x 8 km grid point

64 Flood, drought and fire risk data were modelled for the RCP 8.5 scenario only (see greenbook.co.za), therefore no RCP 4.5 data could be included in this analysis. Floods, drought and fires are the most destructive and have the greatest environmental and social impact. RCP 8.5 scenario was selected to give a good indication of how climate change would precipitate as a function of the current conditions under these three aspects. Providing a current and worst-case scenario will help to provide a more conservative approach upon which actions can be based.

65 Number of cases exceeding near-normal per decade for the period 1995-2024 relative to 1986-2005 baseline period, under the low mitigation scenario.

5.1.2 Weather Trends and Projections

This analysis is based on the following datasets:

- Meteoblue's Weather Data for the Phakwe Richards Bay Gas Power 3 CCPP Project.
- World Resources Institute's (WRI) Aqueduct tool.

5.1.2.1 Rainfall data

Historical rainfall data from 1985 to 2021 for the Project was obtained from Meteoblue. The parameters analysed are *average annual rainfall*, *total days over average annual rainfall*, *total consecutive rainfall days over average*, and *total rainfall days*, such graphs can be seen in Figure 6~~Figure 6~~.

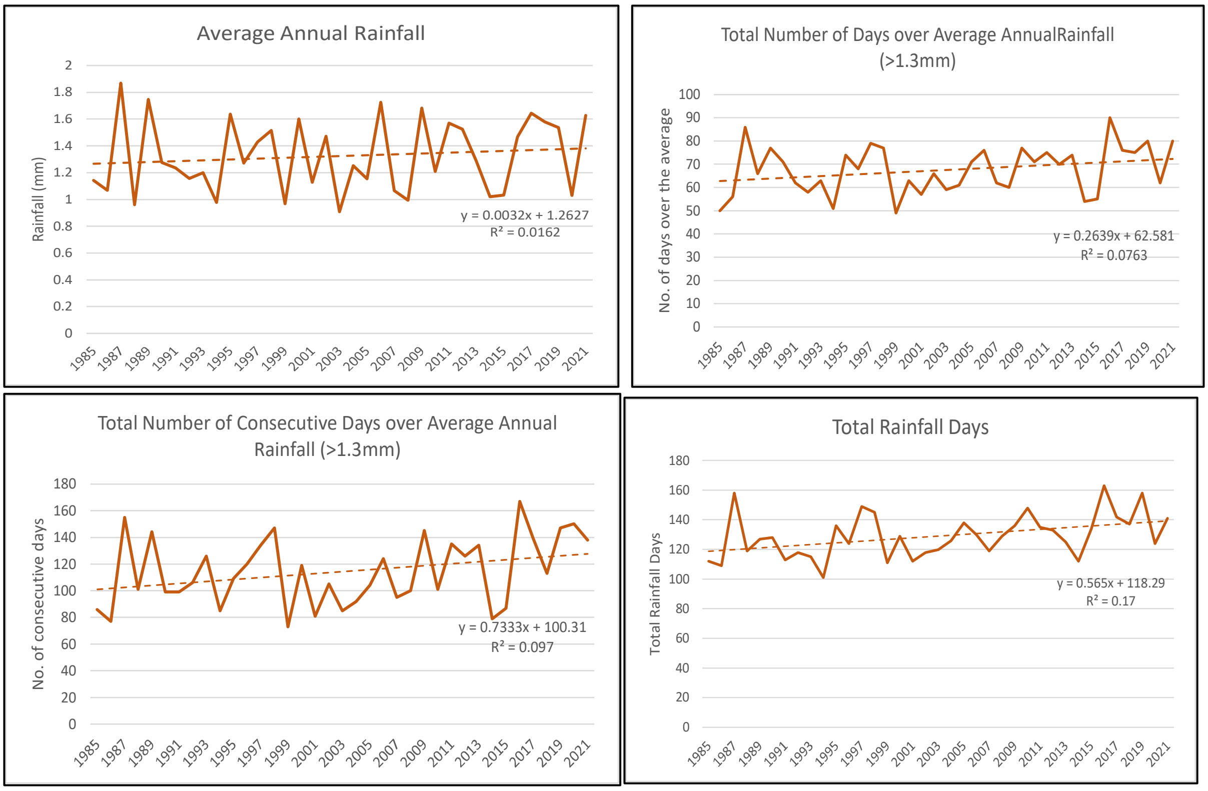

Figure 6: Historical precipitation data from 1985 to 2021 for the Phakwe Richards Bay Gas Power 3 CCPP Project.

It is seen that precipitation parameters show an upward trend. Such trend showcases that the amount of precipitation from 1985 to 2021 has increased over time, with clear evidence of increased rainfall events above average. Furthermore, the number of rainfall days have increased over time as well. With further investigation it seems such information is not statistically significant information to indicate rainfall risk with respect to climate change. This medium-term data used is not statistically significant. However, if we analyse the longer-term data, such as the Greenbook data above (Table 13~~Table 13~~), it does identify that there is more likely to be a drought risk in the future.

5.1.2.2 Temperature data

Historical rainfall data from 1985 to 2021 for the Phakwe Richards Bay Gas Power 3 CCPP Project was obtained from Meteoblue. The parameters analysed are *average annual temperature*, *maximum temperature, total number of uncomfortable days (Discomfort Index>90)* and *total consecutive uncomfortable days,* such graphs can be seen in Figure 7~~Figure 7~~.

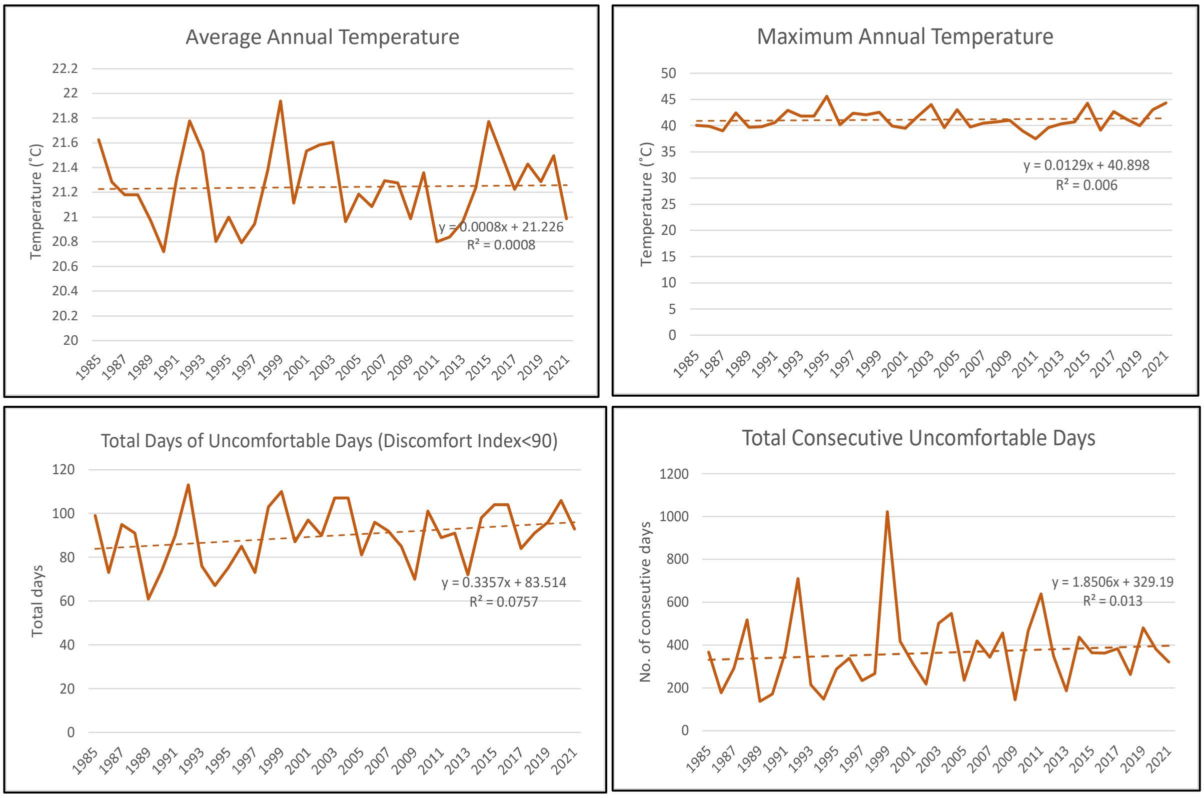

Figure 7: Historical temperature data from 1985 to 2021 for the Phakwe Richards Bay Gas Power 3 CCPP Project.

From the figure above it is identified that the historical temperature parameters show upward trends from 1985 to 2021. Such trends reveal that the temperature from 1985 to 2021 has increased over time, with the uncomfortable days increasing and it is identified that the data is statistically significant. If we look at the long-term data provided by the Greenbook, it is further argued that the temperature within Richards Bay and the municipality will increase overtime. It is therefore evident that the area of the Project has become hotter and such changes could increase the risks to droughts and/or fires in the future.

5.1.3 Projected Climate Change

5.1.3.1 Rainfall

For rainfall projection, information depicted in Table 11~~Table 11~~ will be used. According to the table, it is seen that that average annual rainfall may decrease by 50 mm to 17 mm for SSP 2 and increase between 67mm to 62 mm for SSP 5. Furthermore, the municipality could experience a change of 2.44 days fewer extreme rainfall day or up to 0.34 days more according to SSP 2, and 0.02 to 1.38 days more of extreme rainfall days according to SSP 5. As for the flood risks, it is seen that there is low risk in Richards Bay, with central parts of the municipality showing a medium risk. Hence, Richards Bay is likely to become drier in the future, with parts of the municipality predicted to experience floods. According to the uMhlathuze disaster risk management plan, the areas of occurrence of flooding are Esikhaleni, Nseleni, Mabuyeni, Matshane, Ngwelezane, while risk of droughts is seen to be the entire uMhlathuze municipality area.[66]

5.1.3.2 Temperature

Similar to the rainfall projection above, information depicted in Table 13~~Table 13~~ will be used. According to the table, it is seen that the extreme hot days will increase between 0.3 to 12 days for SSP 2 and 0.60 to 18 days for SSP 5. Furthermore, it is seen that average annual temperature will increase by at least 1.6°C to 1.8°C from the baseline period (1961-1990). As for the drought risk of the region, it is projected that most parts of Richards Bay and the municipality show a high risk to droughts. Hence, the municipality is likely to experience dry, hot conditions in most parts of the region, with a few areas likely to experience wet, hot conditions.

5.1.3.3 Water Stress

By use of the World Resources Institute's Aqueduct tool, the water stress in the Richards Bay region can be analysed. The study area falls within the KwaZulu-Natal province, and the Project is located approximately 5 km northeast of Richard Bays. Projected change in water stress shows how development and/or climate change are expected to affect water stress, which is the ratio of water use to supply. The "business as usual" scenario (SSP2 RCP8.5) represents a world with stable economic development and steadily rising global GHG emissions. The projected increase in water stress is "low-medium", suggesting that there is a 10-20% possibility that water stress will increase by 2030.

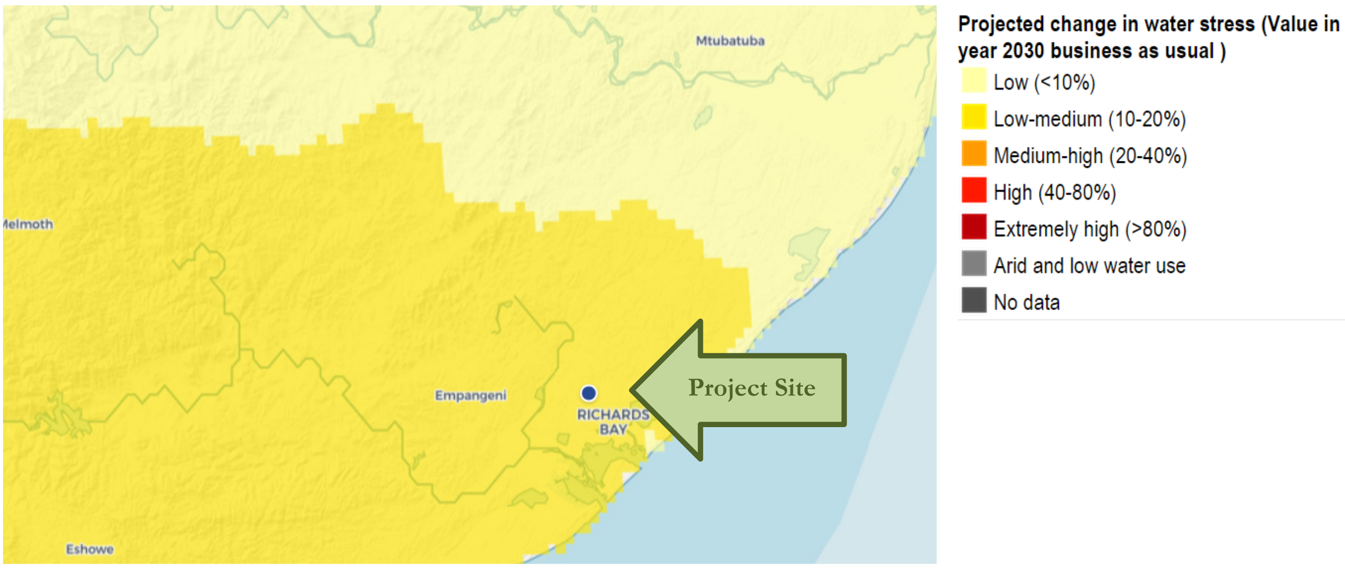

Figure 8: Projected change of water stress for the Phakwe Richards Bay Gas Power 3 CCPP Project.

[66] City of uMhlathuze, 2021. Disaster Management Sector Plan.

The projected change in seasonal variability of water, based on the Aqueduct tool, is shown in Figure 9~~Figure 9~~ below. Currently, the WRI Aqueduct Tool indicates that seasonal variability in the Project area is considered "Medium-High". According to the WRI, seasonal variability measures the average within-year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations of available water supply within a year.

The projected change in seasonal variability of water moves from "Medium-high" to "Low-medium" in 2030 under a "business-as-usual" scenario. Lower values indicate narrower variations of available water supply within a year. This indicates that seasonal variability[67] may become less extreme in 2030. Please note that Figure 8~~Figure 8~~ and Figure 9~~Figure 9~~ are not related to one another. Figure 8~~Figure 8~~ indicates projected change in water stress while Figure 9~~Figure 9~~ indicates seasonal variability of water availability for the project area.

Figure 9: Seasonal variability at the Phakwe Richards Bay Gas Power 3 CCPP Project.

[67] Seasonal variability is an indicator of the variability between months of the year. Increasing seasonal variability may indicate wetter wet months and drier dry months, and higher likelihood of droughts or wet periods.

6 Project Impact on Climate Change

The proposed Phakwe Richards Bay Gas Power 3 CCPP will emit GHGs into the atmosphere. Section 6.1 quantifies the GHG inventory for the proposed Phakwe Richards Bay Gas Power 3 CCPP, whilst Section 6.2 will look at the GHG inventory within the context of the requirements for a specialist climate change impact assessment.

The impact of a project on climate change through the emissions of GHGs into the global atmosphere is, by its very nature, a cumulative impact. Therefore, one cannot disaggregate the singular impact from the cumulative impact due to the nature of anthropogenic GHG emissions and climate change.

Furthermore, the decommissioning of the proposed Phakwe Richards Bay Gas Power 3 CCPP will have negligible amounts of GHG emissions. This is due to most of the material that would be landfilled (concrete and steel) not releasing any GHG emissions when landfilled.

6.1 Project Greenhouse Gas Inventory

The GHG inventory for the proposed Phakwe Richards Bay Gas Power 3 CCPP was developed in accordance with the SANS 14064-1:2021 standard, as well as the GHG Protocol (ISO 14064-1:2006), as described in Section 4.1.1 above. The development of the GHG inventory for the proposed Phakwe Richards Bay Gas Power 3 CCPP is based on certain assumptions (as described in Section 4.1.5 above), to overcome some unavoidable data gaps. The inclusion of indirect emissions was done according to the significance criteria discussed in Section 4.1.1.1. For the purposes of this assessment, the GHG inventory according to SANS 14064-1:2021 will be considered.

The boundaries of the analysis were set, as indicated above. This analysis took into consideration the relevant emissions from core operations, as well as upstream and downstream emissions.

Table 14~~Table 14~~ shows the summary of the GHG inventory calculated for the proposed Phakwe Richards Bay Gas Power 3 CCPP when running on natural gas. The direct emissions will be 4 740 ktCO_2e/year, or 142 000 ktCO_2e across the lifetime of the plant. The significant indirect emissions are 3 130 ktCO_2e/year, or 93 900 ktCO_2e across the lifetime of the plant. Thus, the indirect emissions make up 40% of the total emissions considered in this GHG inventory.

However, it is important to also differentiate where the emissions occur. Only emissions occurring within the boundaries of South Africa should be subjected to the South African legal system. The emissions occurring within South Africa are the direct emissions and the indirect emissions relating to the manufacture of some materials and some of the fugitive emissions. These emissions total 4 980 ktCO_2e/year and 149 million tCO_2e across the lifetime of the project, including the applicable construction emissions. This equates to emitting 1.9% of the low emission NDC carbon budget calculated over the life of the project.

Table 14: Construction and operation emissions for Phakwe Richards Bay Gas Power 3 CCPP – SANS14064-1 (2021) (natural gas as fuel).

Emission category	Emission source	Construction phase ($ktCO_2e$)	Operation phase ($ktCO_2e/y$)	Total over life of project ($ktCO_2e$)
Category 1: Direct GHG emissions and removals)	Natural Gas (Stationary Combustion)	-	4 740	142 000
	Diesel (Mobile Combustion)	-	0	-
	Total direct emissions	**-**	**4 740**	**142 000**
Category 2: Indirect GHG emissions from imported energy	Electricity	13	-	**-**
Category 3: Indirect GHG emissions from transportation	Fuel & energy related emissions not included in category 1 and 2	1	2 130	64 000
	Fugitive emission (National)	**-**	242	7 250
	Fugitive emission (International)	-	755	22 600
	Total Category 3 emissions	**1**	**3 130**	**93 900**
Category 4: Indirect GHG emissions from products used by organization	Purchased goods and services	68	-	-
	Total Category 4 emissions	**68**	-	**-**
Total indirect emissions		**82**	**3 130**	**93 900**
Total emissions		**82**	**7 870**	**236 000**

6.2 Project contribution to climate change

The proposed Phakwe Richards Bay Gas Power 3 CCPP will lead to direct emissions within South Africa and to indirect emissions that occur both nationally and internationally. Table 15~~Table 15~~ discusses these emissions according to the context of the impact of the proposed Phakwe Richards Bay Gas Power 3 CCPP on climate change within the requirements of the environmental authorisation process.

The proposed Phakwe Richards Bay Gas Power 3 CCPP has significance score of 85. This is according to the impact methodology described in Section 4. This means that the project has a ***High*** climate change impact.

Table 15: Climate Change Impacts of the Phakwe Richards Bay Gas Power 3 CCPP Project.

Nature: The proposed Phakwe Richards Bay Gas Power 3 CCPP is a gas-to-power facility. It will combust the natural gas in a gas turbine or gas engine to generate electricity. The combustion of the natural gas will lead to direct GHG emissions from the project.

The manufacture and transport of fuels (such as the natural gas) and materials consumed (such as the steel in the turbines/engines) will also lead to the release of GHG emissions. These emissions are indirect emissions.

The emissions taken into consideration within the context of this impact assessment are all those that occur within the boundary of South Africa. This includes the direct emissions from the combustion of the natural gas and the indirect emissions relating to the manufacture of some materials consumed and some of the fugitive emissions. Phakwe Richards Bay Gas Power 3 CCPP direct and indirect GHG emissions total 4 980 ktCO_2e/year.

Extent (E)	5 (International)
Duration (D)	5 (Permanent)
Magnitude (M)	7 (High)
Probability (P)	5 (Definite)
Significance (S)	85 (High)

Mitigation: Making use of natural gas as the fuel source for the generation of electricity is already a mitigation measure relative to the current standard of using coal as the dominant fuel source for grid electricity.

Further mitigation could be achieved by using renewable fuels, such as biomethane and green hydrogen. The extent of reduction in emissions would be directly proportional to the reduction in natural gas used. This is discussed further in Section 8.1.

Residual risks: There is a low residual risk associated with the proposed Phakwe Richards Bay Gas Power 3 CCPP due to fossil fuel GHG emissions lock from the combustion of natural gas.

6.3 Avoided Emissions

The avoided emissions are calculated according to the scenarios described on page 8, and according to the methods outlined in Section 4.1.1.4.

The proposed Phakwe Richards Bay Gas Power 3 CCPP avoids emissions due to two aspects. Firstly, due to the reduced emission intensity of combusting natural gas versus coal as the fuel source for generating electricity. Secondly, due to enabling the increased uptake of renewables on the grid.

The equivalent emission factor for the proposed Phakwe Richards Bay Gas Power 3 CCPP is calculated as 0.41 tCO_2e/MWh. The current intensity of South Africa's national grid is 1.08 tCO_2e/MWh. Thus, the avoided emissions by displacing the use of coal are 7 880 $ktCO_2e/y$, or 236 000 $ktCO_2e$ across the lifetime of the project.

Intermittent renewables can be expanded from a maximum of 24% to a maximum of 70% according to the theoretical scenarios described on page 8, and Table 7~~Table 7~~ above. The inclusion of the proposed Phakwe Richards Bay Gas Power 3 CCPP onto South Africa's grid contributes towards this shift. The proposed Phakwe Richards Bay Gas Power 3 CCPP would supply 14% of the required natural gas capacity to achieve a renewables-based grid. Thus, the attributable avoided emissions are 18 500 $ktCO_2e/y$, or 556 000 $ktCO_2e$ across the lifetime of the project. Therefore, the total avoided emissions are approximately 793 000 $ktCO_2e$ across the lifetime of the project.

The value quoted above is only indicative of the potential avoided emissions that can be achieved if more renewable energy is added to the South African grid. In this context, the magnitude of the avoided emissions is only relative to two theoretical grid scenarios and are not an accurate reflection of reality, as this depends on the evolution of the energy mix of South Africa's grid. It is however important to note that South Africa's commitments in the NDC can only be reached if more intermittent renewable energy is added to the grid, and this can only be achieved if generation capacity with load following capability, like this project, is added to the grid.

6.4 Cumulative Impacts

The analysis presented in this report is based on the assessment of the cumulative impacts of the GHG emissions from this project on a global scale – see Table 9~~Table 9~~ above. As the impacts of GHG emissions on climate change cannot be disaggregated on a local scale, this study does not consider cumulative local impacts of the project on climate change. It remains different from the air quality impacts which are largely cumulative and has a more localised impact.

7 Project Vulnerability to Climate Change

Vulnerability is defined as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes[68]. The map presented below indicates fire, drought and floods risks as well as extreme hot days[69] for the uMhlathuze Local Municipality, within which the Phakwe Richards Bay Gas Power 3 CCPP is located. The trends displayed in the map indicate that the uMhlathuze Local Municipality is prone to extreme hot days which are widespread throughout the municipality. These trends also support a study undertaken by Buthelezi *et al.*, (2020)[70] which revealed that the uMhlathuze Local Municipality experiences variations in rainfall and temperature and these variations have resulted in drought conditions within the area.

The Phakwe Richards Bay Gas Power 3 CCPP will consume up to 1 130 000 m^3 of water per annum at base load and 755 000 m^3 per annum at mid-merit[71]. The volume of water required will be dependent on the final design of the facility as well as on the technology. The volume of water required will be supplied via the Richards Bay IDZ water supply network that has an allocation from the uMhlathuze Municipality Water Works.

The King Cetshwayo District Municipality's (which the uMhlathuze Local Municipality falls under) Climate Change Response Plan[72] as also reported that the uMhlathuze Local Municipality is prone to climate-related hazards, with fire hazards being one of the risks that the area is highly vulnerable to.

Rainfall variability is expected within the uMhlathuze Local Municipality. Due to this variability the municipality will potentially be exposed to both flooding events but also droughts. The risks mentioned above must therefore be considered within the context of the project and within the context of the vulnerability of the local municipality.

[68] IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

[69] Extreme hot days are defined as summertime temperatures that are much hotter and/or humid than average (https://www.cdc.gov/disasters/extremeheat/heat_guide.html)

[70] Buthelezi, N.N., Rawlins, B.K., Ilesanmi, K.D., and Oladejo, A.O., 2020: Economic Impacts of Drought on Water Users of uMhlathuze Municipality of South Africa, Journal of Human Ecology, 69(1-3):127-133.

[71] Savannah Environmental, 2022: Phakwe Richards Bay Gas Power 3 Combined Cycle Power Plant (CCPP), Richards Bay, KwaZulu-Natal Province Final Scoping Report, DFFE Ref: 14/12/16/3/3/2/2117

[72] Available at: https://letsrespondtoolkit.org/municipalities/kwazulu-natal/king-cetshwayo/

Climate change projections have also indicated that the east coast of South Africa may experience tropical cyclones. Severe tropical cyclones made landfall on the east coast of South Africa in the past. Under projected climate change conditions, these hazards along the east coast are likely to become more vulnerable to tropical cyclones in the future.[73]

According to the information provided by the Greenbook and uMhlathuze Local Municipality disaster risk management plan, the map presented below summarises the risks associated with uMhlathuze Local Municipality within which the Phakwe Richards Bay Gas Power 3 CCPP is located.

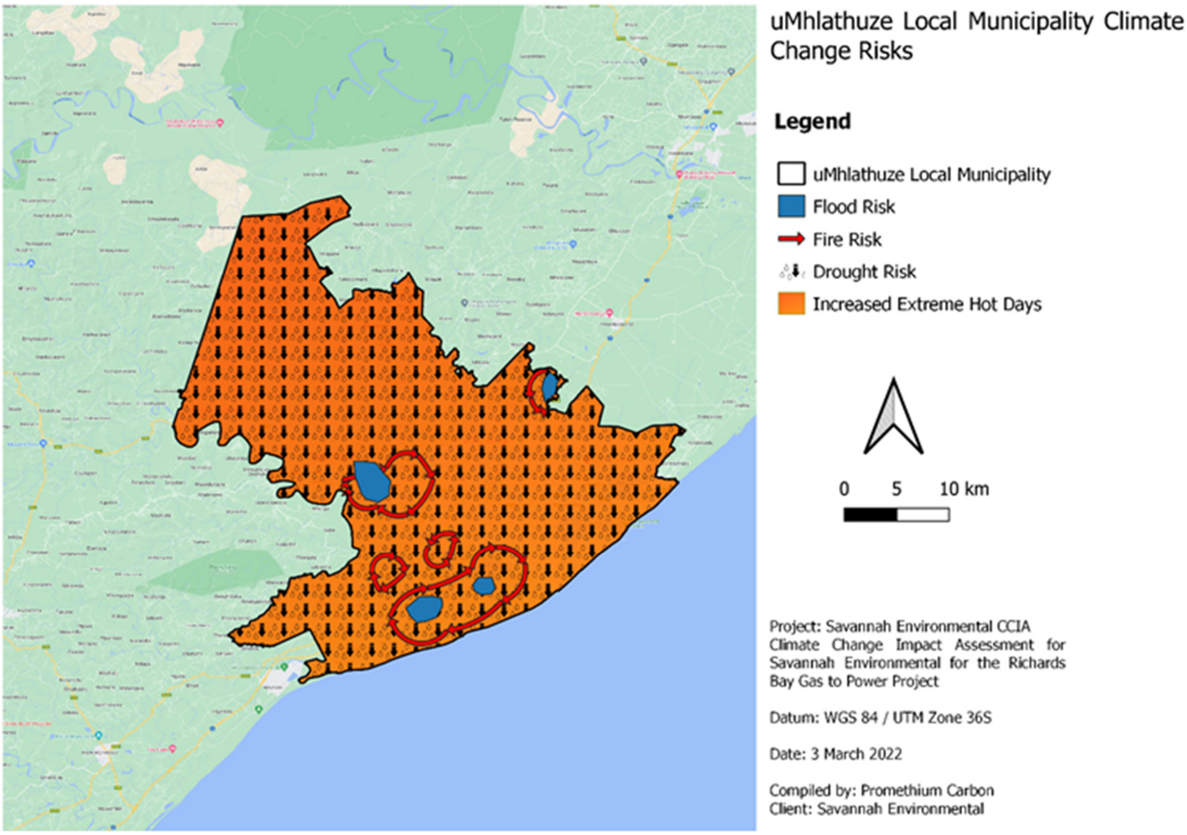

Figure 10: uMhlathuze Local Municipality fire, drought, extreme hot days, and flood risks.

7.1 Core operations

The core operations of the Phakwe Richards Bay Gas Power 3 CCPP are related to the plant facilities and site operations. Physical structures may be at direct risk from weather extremes and may cause physical damage. Climate change may also affect the efficiency of production processes on site, cost of operations and maintenance.

[73] Green, A.N., Cooper, J,A,G, Louriero, C., Hahn, A., and Zabel, M., 2021: Stormier mid-Holocene southwest Indian ocean due to poleward trending tropical cyclones, Natural Geoscience, 15, 60-66.

7.1.1 Physical Risks

Such risks relate to the direct impacts climate change conditions may have on numerous sectors of society and the environment. With relevance to the Phakwe Richards Bay Gas Power 3 CCPP, the physical risks will look at the impacts temperature and rainfall will have on the project, as well as the labour and working force.

7.1.1.1 Temperature

It is expected that the uMhlathuze Local Municipality will experience an increase in average temperature, as well as an increase in the frequency of hot days. The GreenBook tool indicates that by 2050, the average temperature will increase by between 1.6°C to 1.8°C under the SSP 2 (RCP 4.5) scenario and between 2.0°C to 2.2°C under an SSP 5 (RCP 8.5) scenario. The number of very hot days is also predicted to increase by up to 12 days under SSP2. Typical risks associated with increased temperatures include increased energy demand for cooling and associated energy costs.

7.1.1.2 Rainfall

The area will experience an increase seasonal variability and high drought risks in the regions of the uMhlathuze Local Municipality and Richards Bay, with specific areas of the municipality exposed to flood risks. However, rainfall variance information is not significant for this projects water availability as the amount provided by uMhlathuze is sufficient for the amount required for the project. With that being said, in the past there have been tropical cyclone events present in Mozambique, i.e., Cyclone Idai, which fortunately did not migrate South. However, if such movements do occur in the future, the project should consider the risk of floods on operations and project site.

uMhlathuze Local Municipality has also previously experienced droughts during 2013-2017 which resulted in level 4 water restrictions[74]. The risk posed for the municipality will affect industry, communities and agriculture that are dependent on water to operate.

7.1.2 Labour and working conditions

The Phakwe Richards Bay Gas Power 3 CCPP will employ 600 average full-time employees over the construction period. The existing climatic conditions within the uMhlathuze Local Municipality are typically sub-tropical to tropical, with very high levels of humidity[75].

The climatic trends for the region indicate that the area will experience an increase in the number of hot days. In terms of the impact on the workforce for the project, this could negatively impact on employees exposed to extreme heat stress. Jagarnath et al (2020)[76], indicate that heat stress

[74] uMhlatuze Spatial Development Framework2017/2018-2021/2022 [Available online]: https://www.umhlathuze.gov.za/images/Performance/2018-2019/x48152-1.pdf (Accessed 14 March 2022

[75] https://www.umhlathuze.gov.za/index.php?option=com_content&view=article&id=73&Itemid=338

[76] Jagarnath, M., Thambiran, T., and Gebreslasie, M., 2020: Heat stress risk and vulnerability under climate change in Durban metropolitan, South Africa-identifying urban planning priorities for adaptation, *Climate Change,* 163, 807-829.

because of climate change is projected to increase and will become a future concern mainly as a function of social vulnerability due to demographics and characteristics of the local setting.

Heat stress will also be a major occupational health risk and can directly impact labour productivity and consequently, operations at the Project site. High heat exposure restricts an employee's physical functions, their capabilities and ultimately, work productivity and capacity.

On the contrary. increased drought spells will result in greater onsite water needs due to increased dehydration, as well as an increased investment required in employee health care systems. The local employees will also be increasingly exposed to heat-related illnesses, such as heat stroke and dehydration, which could affect the number of sick leave days employees require.

7.2 Value chain

Analysing the impact climate change will have on the value chain at the Phakwe Richards Bay Gas Power 3 CCPP will allow for an understanding of how materials, equipment, and resources (upstream), and manufacturing, production, and distribution (downstream) process, will be affected.

7.2.1 Upstream value chain

The upstream value chain for the Phakwe Richards Bay Gas Power 3 CCPP will be impacted by climate change, as indicated for the main items used in the Project, in Table 16~~Table 16~~ below.

Table 16: Climate change impacts on the upstream value chain of the Phakwe Richards Bay Gas Power 3 CCPP.

Item	Aspects affected by the impacts of climate change
Natural Gas	Natural gas (LNG or similar) has been earmarked as a key factor in South Africa's transition to a low-carbon economy, as indicated in the IRP. With the rising interest in gas-to-power technologies, the local legislation, and climate-related regulations regarding the use of LNG is anticipated to become more stringent. With the introduction of more climate-related regulations and increased pressure on the energy sector to minimise climate-related impacts, the use of natural gas will be scrutinised considering the low carbon transition. *Increasing temperatures* Hotter ambient temperatures will lead to more frequent surpassing of equipment heat thresholds. This is of particular concern considering LNG equipment since increased leakages of LNG implies increased inefficiencies and costs associated with fuel losses. A key challenge will be in terms of LNG pipelines. With higher atmospheric temperatures, these cooling pipelines may heat up, causing increased LNG expansion and hence, increased possibility of gas leakages or explosions. *Increased flooding*

	The anticipated increases in flood occurrence could cause increased pipeline damages, resulting in more extensive corrosion activity and increased maintenance requirements. Flooding may also lead to flooded trenches, wherein the pipelines lie, resulting in further potential damage to pipelines. *Increased storm events* The imported LNG is expected to be transported via ships, which will dock in the Port of Richards Bay. Possible increased occurrences of storms, sea surges and long-term sea-level rise could result in damage to the Port and potentially the pipelines feeding the Power Plant.
Cement	Similarly, to steel, concrete is mainly used during the construction phase of the Project. The main risk associated with concrete production is the possible ingress of water into the mining quarries for limestone (which is used to produce concrete). This is of concern since this region is currently and anticipated to experience flooding. If limestone mining quarries are affected by water ingress, this could disrupt the supply of concrete to the Project, which could delay construction and further operations.
Transport and storage of all goods	It is anticipated that diesel will also be used onsite for machinery and generators. Similarly, all equipment and other such goods will be transported to the project site. These items will make use of the well-established road networks in and around the uMhlathuze Local Municipality. *Increased temperatures* Increasing ambient temperatures and extreme hot days increases exposure to heat and in turn, heat stress. Heat stress at work, as result of (climate-related) increasing temperatures, impacts workers health, safety, productivity, and social well-being. Therefore, the projects transport of goods and services workers may be exposed to heat stress and increased temperatures and will inevitably impact operations. In addition, storage areas for the various goods used by the project may experience increased temperatures and possible damage, thus causing delays in product deliveries to the project site. *Extreme weather events.* With increased rainfall variability, the Phakwe Richards Bay Gas Power 3 CCPP may be exposed to erratic rainfall, periods of drought, but then also periods of intense rainfall. Increased flooding may also lead to pipeline damages, resulting in potential water supply constraints. This could lead to decreased road access to the project and cause delays in product deliveries to the Project site.

7.2.2 Downstream value chain

The downstream value chain for the proposed Project will also be impacted by the effects of climate change, as indicated in the table below.

Table 17: Climate change impacts on the downstream value chain of the Phakwe Richards Bay Gas Power 3 CCPP.

Item	Aspects affected by the impacts of climate change
Electricity use/ demand	The electricity generated by the Phakwe Richards Bay Gas Power 3 CCPP Project will be fed into the National Electricity Grid for further distribution, via 400kV electricity distribution power lines. *Increasing daily temperatures* Hotter ambient temperatures will result in increased demands for electricity. Within the Richards Bay IDZ, many industrial processes will require increased cooling of manufacturing and industrial equipment. There will also be an increased demand for electricity due to increased use of air conditioning systems. Considering the increasing atmospheric temperatures, the demand for electricity is expected to increase, hence the Phakwe Richards Bay Gas Power 3 would assist with the grid pressure experienced due to increased atmospheric temperatures. However, it should be noted that newer, more efficient electrical components, LED lighting, and other such technologies may minimise this anticipated electricity demand increase.
Distribution lines and substations	Various infrastructure is in place during the construction phase to allow for the distribution of the electricity. For instance, the construction of a 275KV or 400KV overhead power line, connecting the Eskom interface substation *Increasing daily temperatures* Hotter ambient temperatures and air pollution often decreases the efficiency of electric components like substations, and will impact the performance of kV distribution lines, causing increases in transmission and distribution losses. *Extreme weather events.* With increased rainfall variability, Richards Bay may be exposed to erratic rainfall and periods of drought, but then, also periods of intense rainfall. Heavy rains would cause the pylons and poles to be increasingly susceptible to uprooting and toppling, resulting in a disruption of electricity supply to consumers.
Road access for maintenance and services	*Extreme weather events.* With increased rainfall variability, the Phakwe Richards Bay Gas Power 3 CCPP may be exposed to erratic rainfall and periods of drought, but then, also periods of intense rainfall. This could lead to decreased road access to the location and disrupt the distribution of supplies, as well as impact the maintenance workers health and work productivity.

7.3 Broader network

Due to the complex nature of climate change, climate vulnerability is not only caused by the level of exposure, but also by the social, economic, environmental, and institutional contexts that interact with the changing climate. In this regard, for the purposes of the climate change impact assessment, the broader social and environmental context of the project must be considered.

Similarly, to section 6.2 and section 7.1 of this report, the purpose of this section is to highlight potential risks associated with climate change that could have a social and environmental impact for the Phakwe Richards Bay Gas Power 3 CCPP Project.

7.3.1 Broader Social Context

The Phakwe Richards Bay Gas Power 3 CCPP social context considers the province, district, and local municipal context in terms of population, access to education, poverty, inequality, and basic services. This is also linked to the vulnerability and the ability of the local population to cope with the impacts of climate change.

7.3.1.1 Demographics

Population trends have multiple implications in the climate change context. Vulnerability, exposures, and the ability to adapt to climate change are often shaped by demographic issues. Vulnerability to climate change is affected by socio-economic status, the dependence on natural resources, and the demographic characteristics (age, gender, etc).

The 2016 Community survey recorded 11 065 240 people living in the KwaZulu-Natal, while the King Cetshwayo District Municipality approximately has population of 971 135 based on the 2016 Community Survey. uMhlathuze Local Municipality situated within the King Cetshwayo District Municipality has a population of 410 465. Table 18~~Table 18~~ present indicative statistics related to the population and households within the study regions.

Table 18: Indicative statistics related to population.[77]

Indicator	KwaZulu-Natal	King Cetshwayo District Municipality	uMhlathuze Local Municipality
Population	11 065 240	971 135	410 465
Size (km^2)	94 451		1 235
Population density (whom people/ km^2)	117.2	110	332.3
Number of households	2 875 843	225 797	110 503
Average household size	3.43	4.3	3.7

A breakdown of the population by age groups within the province, district, and local municipality can be seen in the figure below. Functional age groups highlight the level of potential work force in the district and local municipalities. Across the province and within the municipalities, a higher percentage of the population fall within the age group of 15 to 64.[78] This is an indication that most

[77] Adapted from Statistics South Africa 2016
[78] Statistics South Africa (2016) South African Community Survey 2016

of the population is within the potentially economically active age. The dominance of the young population age group is also an indication of a higher dependency ratio[79].

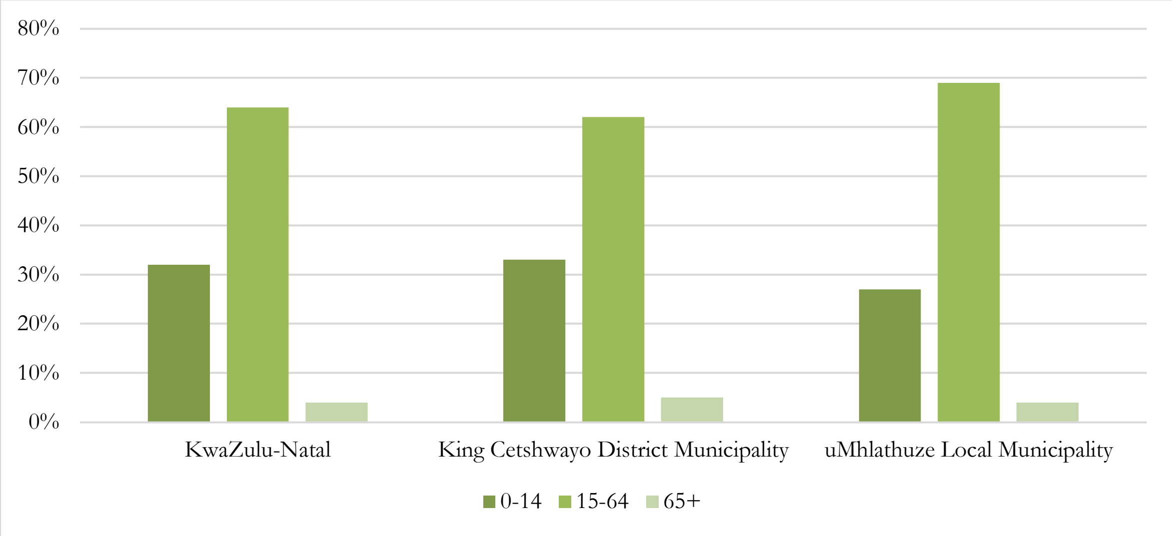

Figure 11: Age Distribution[80].

7.3.1.2 Inequality

The Inequality in Southern Africa report published by the World Bank (2022)[81] highlights that South Africa is one of the most unequal regions in the world. Globally South Africa ranks first among the 164 countries in the World Bank's global poverty database. The Gini coefficient remains high at 0.68, and it is evident that vast majority of the population live in informal settlements, persistent wealth gaps exist, and gender and wealth imbalances contribute to inequality[82]. The respective Gini coefficient for the province and respective municipalities are further described below.

In 2019, the Gini coefficient[83] in King Cetshwayo District Municipality was 0.61. The KwaZulu-Natal Province and the uMhlathuze Local Municipality had a more unequal spread of income amongst their residents at 0.62 when compared to King Cetshwayo District Municipality. The IPCC (2022) report highlights that poverty and inequality decrease human capacity to cope with climate change[84]. Factors such as limited access to resources may further reduce the ability of individuals and societies to adapt to the impacts of climate change.

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79 Dependency ration relates the number of children (0-14) and older persons (65 years or over) to the working age population (15-64 years old), Source: https://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/demographics/dependency_ratio.pdf

80 Statistics South Africa (2016) South African Community Survey 2016.

81 International Bank for Reconstruction and Development / The World Bank, 2022: Inequality in Southern African, an assessment of the Southern African customs union,

82 Republic of South Africa, Medium Term Strategi Framework 2019-2024.Available at: https://www.dpme.gov.za/keyfocusareas/outcomesSite/MTSF_2019_2024/2019-2024%20MTSF%20Comprehensive%20Document.pdf

83 The Gini coefficient is based on a comparison between cumulative proportions of the population against cumulative proportions of income they receive and it ranges between 0 in the case of perfect equality and 1 in the case of perfect inequality

84 IPCC Climate Change 2022: Impacts, Adaptation and Vulnerability, Summary for Policymakers.

Table 19: Gini coefficient for the project regions (2019) [85]

Regions	Gini Coefficient
KwaZulu-Natal	0.62
King Cetshwayo District Municipality	0.61
uMhlathuze Local Municipality	0.62

7.3.1.3 Education

Low levels of education are shown across the province and municipalities. Only 39% of the provincial population have completed matric, while for King Cetshwayo District Municipality 32% of the population have matric and this is shown as slightly higher within the uMhlathuze Local Municipality. Higher education attendance is relatively low across the regions.

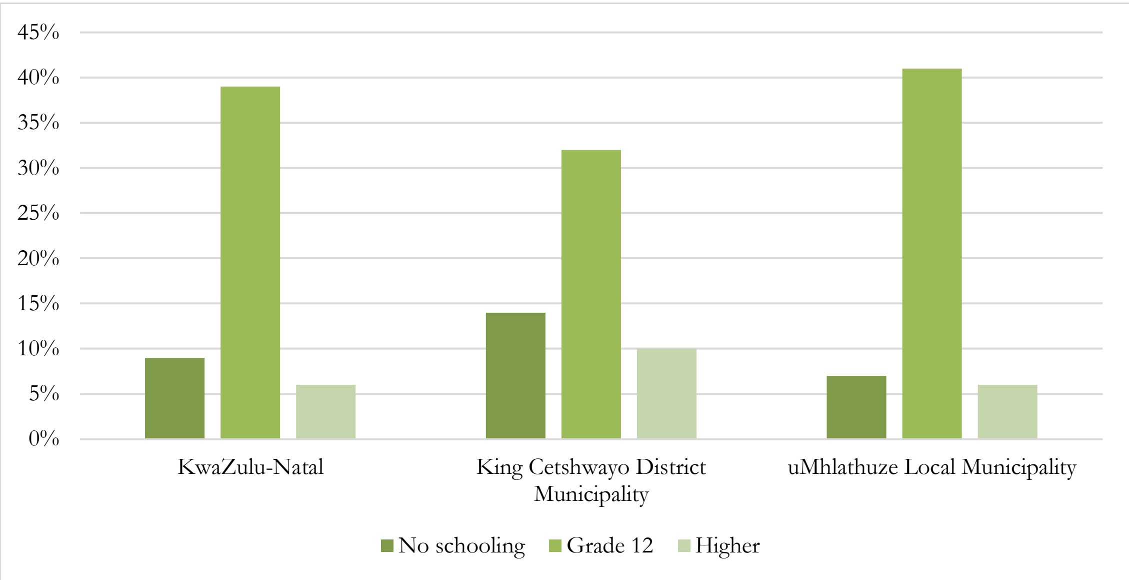

Figure 12: Highest level of education. [86]

7.3.1.4 Annual household Income

Table 20~~Table 20~~ shows the annual household income distribution for KwaZulu-Natal and the respective provinces relevant to the Phakwe Richards Bay Gas Power 3 CCPP. A substantial portion of the population do not have an income. The range also shows the most households earn between of the income bracket of R 9,601 – R 19,200 and R 19,201 – R 38,400. This is indicative of a monthly salary of between R 800 - R 1,600 and R1,600- R3,200. This means that many of these the households are living within the extreme food poverty line, which is R624 per person per household[87]. Food price instability is likely to be exacerbated by climate change. Food trade is

[85] Cooperative governance and Traditional Affairs (CoGTA), 2020: Profile and Analysis District Development model, King Cetshwayo District [Available online]: https://www.cogta.gov.za/ddm/wp-content/uploads/2020/11/King-Cetshwayo-October2020.pdf (Accessed 11 March 2022)

[86] Statistics South Africa (2016) South African Community Survey 2016.

[87] Food poverty line – R624 (2021 prices) per person per month (Source https://www.statista.com/statistics/1127838/national-poverty-line-in-south-africa/
This refers to the amount of money that an individual will need to afford the minimum required daily energy intake. This is also commonly referred to as the "extreme" poverty line.

expected to play a major role in adjusting to climate-change-driven shifts in agricultural and food production patterns.

Table 20: Household Income Distribution. [88]

	KwaZulu-Natal	King Cetshwayo District Municipality	uMhlathuze Local Municipality
No Income	15%	14%	15%
R 1 – R 4,800	5%	4.8%	4%
R 4,801 – R 9,600	8.6%	9%	8%
R 9,601 – R 19,200	19%	20%	14%
R 19,201 – R 38,400	20%	21%	16%
R 38,401 – R 76,801	12%	12%	12%
R 76,801 – R 153,600	8%	8%	11%
R 153,601 – R 307,200	6%	6%	10%
R 307,201 – R 614,400	4%	4%	7%
R 614,401 – R 1,228,800	1,20%	1,20%	2,2%
R 1,228,801 – R 2.457,600	0.4%	0.3%	0.5%
R 2,457,601 and above	0.2%	0,2%	0.3%

7.3.1.5 Access to Basic Services

The **table** below summarises the access to basic services in terms of water, electricity, and sanitation facilities. The 2016 Community Survey indicated that within the KwaZulu-Natal province and the respective municipalities majority of the population had piped water inside the dwelling/yard. Access to electricity for lighting (the most basic level of access) within the uMhlathuze Local Municipality is better than access on a district and provincial level. Similarity within the uMhlathuze Local Municipality, sanitation facilities are better compared to provincial and district level. The percentage of the population with access to waste removal is significantly low, as majority of the population are dependent on their own dump to manage waste.

Table 21: Summary of access to basic services. [89]

	KwaZulu-Natal	King Cetshwayo District Municipality	uMhlathuze Local Municipality
% of households with access to water			
Piped water inside dwelling/yard	69%	71%	94%
Communal standpipe	20%	18%	4%
No access to water	11%	11%	2%
% of households with access to electricity			
Access to electricity for lighting	81%	86%	96%
% of households with access to sanitation			

[88] Statistics South Africa (2016) South African Community Survey 2016.
[89] Statistics South Africa (2016) South African Community Survey 2016.

Flush or chemical toilet	59%	47%	70%
Pit toilet	34%	40%	25%
Bucket latrine	2%	2%	2%
No access to any toilets	5%	11%	3%
% of households with refuse disposal			
Refused disposal from local authority, private company, or community	43.3%	21%	37%
Own dump	46%	43.3%	50%

This section describes the socio-economic context of the King Cetshwayo District Municipality and the uMhlathuze Local Municipality based on current demographic distributions. The trends indicate high levels of poverty, low-income distribution and education levels which contribute to vulnerability. Social vulnerability from climate change will result in further equalities and reduced capacity to cope with climate shocks.

7.3.2 Broader Environmental Context

The environment plays a critical role in providing services that support the health and wellbeing of the population. Climate change will affect natural systems, reducing their ability to withstand impacts. The continuing loss of biodiversity and degradation of ecosystems, and impacts to water resources weakens their ability to provide essential services.

The key environmental assets reported in the uMhlathuze Spatial Development Framework[90] are noted to be the beaches, water resources and ecological features in the region. Climate change is likely to have an impact on the existing natural environment within the project location. The beaches remain a significant tourism asset for the municipality. The coastal Lakes such as Lake Mzingazi, Lake Cubhu and Lake Nseze) are critical water resources for the municipality. The development of Richards Bay IDZ in particular, with its industrial development, has seen a significant increase in the abstraction rates of these lakes over the past 20 years. Waterlogged areas which have been previously drained to accommodate development have resulted in important hydrological and downstream impacts. These waterlogged areas have formed valuable natural assets which support biodiversity and species endemism, such example is the Thulazihleka Pan system in Richards Bay[91].

7.3.2.1 Terrestrial Ecology and Biodiversity Areas

The critical biodiversity areas (CBAs) that intersect with the project site include areas that have the Critically Endangered Kwambonambi Hygrophilous Grassland ecosystem[92]. Other terrestrial features that intersect with the project site are the Endangered Maputaland Wooded Grassland, and the Vulnerable Subtropical Freshwater Wetlands. The project site falls in an area with medium sensitivity to plants and high sensitivity to animal species. This is because of the sensitivity feature associated with the flora and fauna, for example the high rating for the Zoothera guttata (bird) that

90 Available at: https://www.umhlathuze.gov.za/images/Performance/2018-2019/x48152-1.pdf
91 uMhlatuze Spatial Development Framework2017/2018-2021/2022.
92 Savannah Environmental, 2022 Phakwe Richards Bay Gap Power CCPP Final Scoping Report

is present within the area.[93] Climate change is likely to impact on these areas by altering vegetation structure which can also be a driver of ecological shifts and disturbance of species distribution. Other climate -related impacts to these areas are loss of flora species, habitat losses, and the spread of invasive alien species.

7.3.2.2 Water Resources

There are numerous hydrological features within the project site. Firstly, the presence of Freshwater Wetlands and other wetland systems such as depressions, flats, and a valley bottom feature. Secondly, the existing Nseleni River which is a major tributary of the Mhlatuze River and contributes to the ecological functioning of the Mhlatuze lagoon and Richards Bat Harbour. Lastly, an extensive list of fish species is seen to be present with the project area. It is seen that the project showcases potential risk to the threatened species as the appropriate habitat for the species potentially falls within the project area.[94] Therefore, considerations need to be made in terms of conservation of aquatic habitats and species, as well as the important wetlands present.

The area is characterised by a complex hydrology as described. The impact of climate change could therefore affect water resources in the area. At present, the availability and variability of water within the catchment is fully subscribed or allocated and there are predictions that water demands will increase. Furthermore, a decline in water quality in streams, lakes and rivers pose a risk for communities that extract water for subsistence, household, or personal consumption.

7.3.2.3 The coast

The uMhlathuze Local municipality is bordered by approximately 48 km of coastline. This presents several economic, conservation and recreational opportunities. The shoreline is characterized by sandy beaches, well established dune formations, estuarine environments, and hosts the country's largest deep-water Port. Some risks for coastal municipalities are coastal erosion, which can be exacerbated through climate change. Intense coastal storms and sea swells results in severe beach erosion. The northern beaches in Richards have been severely affected by erosion[95]. The coastal dune areas are also sensitive to climate change and erosion.

8 Project Mitigation and Adaptation Measures

Mitigation and adaptation measures will need to be addressed in terms of both the measures the proposed Phakwe Richards Bay Gas Power 3 CCPP must take to reduce its *impact on climate change*, as well as the measures needed improve the *resilience of the project to climate change*. These are discussed further below.

8.1 Measures to reduce the impact of the Project on Climate Change

The Phakwe Richards Bay Gas Power 3 CCPP would need to reduce it GHG emissions over its lifetime to reduce its impacts on climate change. There is little the project can feasibly do to achieve

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[93] Savannah Environmental, 2021: Terrestrial biodiversity assessment for the development of a 2000 MW gas to power plant within Richards Bay IDZ phase 1F, KwaZulu-Natal

[94] Savannah Environmental, 2021: Soil and Freshwater Scoping Report for the Phakwe Richards Bay Gas Power 3 Facility.

[95] uMhlathuze Local Municipality,2017/2018-2021/2022 Spatial Development Framework

this. This is due to the inherent nature of the project requiring the combusting of natural gas to produce electricity.

The option to switch to renewable gaseous fuels to supplement/replace the use of natural gas is a viable GHG mitigation option. Such fuels include green hydrogen, biogas, biomethane and other fuels that are generated from renewable resources. For example, the International Renewable Energy Agency predicts that green hydrogen will become competitive with the use of fossil fuels in the near- to medium-term future[96]. According to the International Energy Association, South Africa has access to enough solar and wind resources to produce hydrogen at less than 2.5USD/kg H_2 throughout most of South Africa[97].

GHG emissions from the combustion of renewable fuels are accounted for as zero due to the short-cycle nature of these emissions. Thus, increasing the fraction of energy sourced from renewable fuels has a linear decrease on the amount of emissions from the proposed Phakwe Richards Bay Gas Power 3 CCPP. This is illustrated in Figure 13 below.

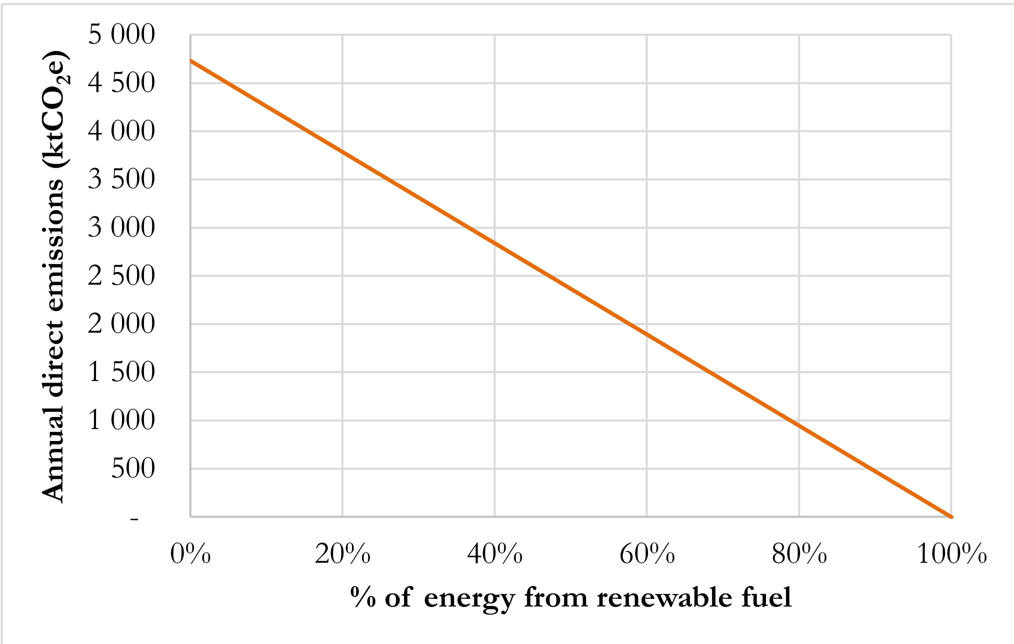

Figure 13: Change in emissions due to uptake of renewable fuels.

8.2 Adaptation Measures to Increase the Project's Resilience to Climate Change

As described in Section 7 of this report, climate change impacts are likely to influence the proposed Phakwe Richards Bay Gas Power 3 CCPP, as well as the surrounding communities and broader natural environment.

[96] IRENA (2019) *Hydrogen: A Renewable Energy Perspective.* International Renewable Energy Agency, Abu Dhabi.
[97] IEA (2019) *The Future of Hydrogen: Seizing today's opportunities.* International Energy Agency.

The most notable mitigation measure is to ensure that the design and layout of the plant takes into consideration the increased likelihood of severe rainfall events, as these could lead to more frequent and severe localised flooding onsite. However, the details around the mitigation of this impact needs to be provided by the relevant water specialist.

The hydrological study should also consider the need for climate change impacts on surface stormwater management in the area. Stormwater infrastructure design should accommodate the likelihood for severe rainfall and extreme events. The inclusion of floodproof stormwater infrastructure should be considered where possible.

9 Opinion of the Project

The assessment of the climate change impact of this project has considered the impact of the project on climate change, the resilience of the project to climate change, as well as the options for mitigation of the impacts.

The impact of the project on climate change was assessed in the context of both GHG emissions from the project, as well as the potential positive impact the project can have through the avoidance of emissions. This was assuming natural gas is the only fuel used. The results are compared to South Africa's carbon budget for the NDC Low Emission Scenario, which was calculated as 7 760 million tons CO_2e.

The project will emit 82 ktCO_2e during the construction phase, 7 870 ktCO_2e/year during the operational phase and 236 000 ktCO_2e over its lifetime. The portion of these emissions emitted inside the borders of South Africa represents 1.9% of the low emission NDC carbon budget calculated, for the lifetime of the project.

When considering the potential positive impact of the proposed project, the expected GHG emissions from the project will avoid emissions through the displacement of coal. In addition to this, the project will enable an increased level of intermittent renewable energy capacity to be placed onto the South African grid. In the long-term, hydrogen can be a potential fuel source used to offset the projects carbon emissions. The total avoided emissions is 236 million tCO_2e over the lifetime of the project through the displacement of the coal baseline. This represents 3% of the South African carbon budget associated with NDC low emission pathway. In addition to this there is a possibility that the project could avoid 556 million tons through increasing the ability of the Eskom grid to accept intermittent renewable energy over the lifetime of the project. This represents 7.2% of the carbon budget

The positive impact of the project on climate change with respect the avoided emissions from the coal baseline, and the potential avoided emissions through the increase of the grid to accept intermittent renewable energy far outweighs the contribution of the project to national inventory. With respect to the resilience of the project to climate change, we found that there are no significant risk factors that should be considered in the environmental authorisation.

There are limited mitigation measures available to this proposed project, and as a result this project will be exposed to a low residual risk of lock in emissions, due to the combustion of natural gas.

In accordance with the findings of this CCIA, we advise that the proposed Phakwe Richards Bay Gas Power 3 CCPP should not be refused environmental authorisation authorization on climate change related issues.