

Thabametsi Power Station

Limpopo Province

Climate Change Study and Palaeontological Impact
Assessment

Final for Public Review

June 2017

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PROJECT DETAILS

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Project Developer:	:	Thabametsi Power Company Proprietary Limited
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1. BACKGROUND AND PURPOSE OF THIS REPORT

Thabametsi Power Company Proprietary Limited, an Independent Power Producer (IPP) is proposing the construction of a coal-fired power station (the "Project") on the farm Onbelyk 254LQ near Lephalale in the Limpopo Province (refer to Figure 1). The project is known as the Thabametsi Coal-Fired Power Station. The power station will have a maximum generating capacity of 1200MW which is intended to provide baseload electricity for integration into the national grid.

The project was authorized by the National Department of Environmental Affairs (DEA) on 25 February 2015 (in terms of the 2010 NEMA EIA Regulations). Following this, an appeal was lodged on 11 May 2015 by the Centre for Environmental Rights. On 7 March 2016 a decision on the appeal was issued by the Minister of Environmental Affairs. The grounds of the appeal were dismissed, however it was contended that climate change impacts had not been adequately addressed in the EIA. As a result, **Condition 10.5** was subsequently inserted into the Environmental Authorization.

The new **Condition 10.5** states that *"the holder of the authorization must undertake a climate change impact assessment prior to commencement of the project which is to commence no later than six months from the date of signature of the appeal decision. The climate change study must be lodged with the department for review and the recommendations contained therein must be considered by the department"*.

In the Appeal Resolution, the Minister further stated that a paleontological study is required to be conducted for the proposed project. The palaeontological study was conducted in 2014 in terms of the requirements of the South African Heritage Resources Agency (SAHRA). Although this study was submitted to the DEA for review as part of its decision-making process, it did not form part of the EIA report for the project. Notwithstanding this, **Condition 10.6** was subsequently inserted into the Environmental Authorization.

The new **Condition 10.6** states that *"A palaeontological Impact Assessment Report (PIAR) must be prepared and submitted to the Department for consideration prior to commencement of the project and within six months of the date of this decision. The PAIR must be lodged with the Department for review and it must also be lodged with the South African Heritage Resources Agency (SAHRA) for official commenting in terms of Section 38(8) of the National Heritage Resources Act, No 25 of 1999. The PAIR must be based on a field assessment, and be prepared by a suitably qualified palaeontologist."*

The scope of work for the above-mentioned studies was presented in a Scope of Work Report. The purpose of this report was to present the Scope of Work proposed for these two required studies and to provide an opportunity for the public to provide comments in this regard. This report was made available for public review from 20 April 2016 to 23 May 2016 and the final scope of work report was submitted to DEA for consideration and acceptance on 15 July 2016. This final Scope of Work document was subjected to a public review period from 10 October 2016 to 10 November 2016. The Scope of Work report was accepted by the DEA on the 16 January 2017 (refer to **Appendix B**).

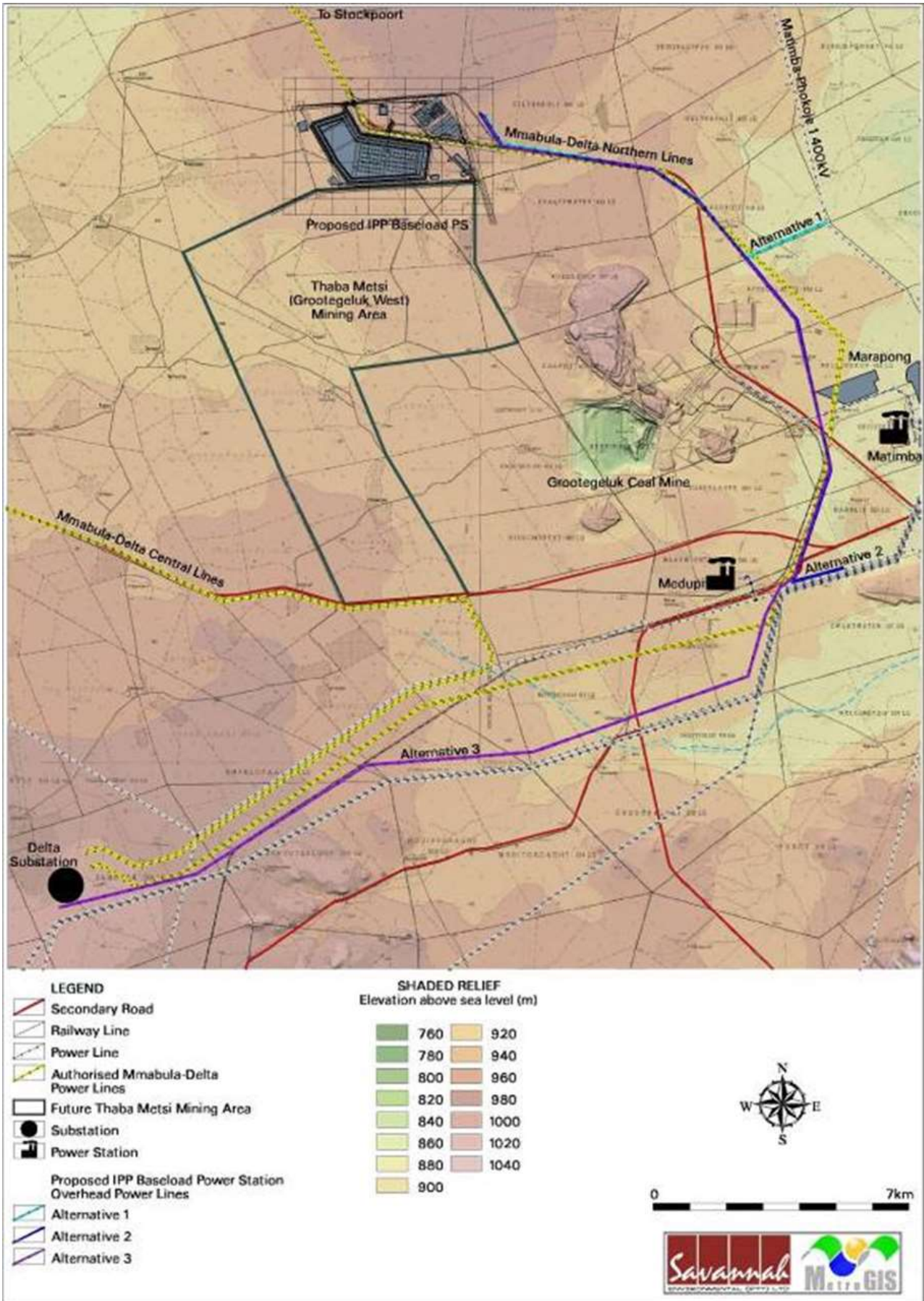


Figure 1: Locality Map showing the proposed site for the Thabametsi Power Station

This report presents the detailed outcomes of the climate change study, paleontological assessment and resilience report in line with the accepted Scope of Work and additional requirements of the DEA as detailed in their letter dated 16 January 2017. A draft report was made available for public review from 27 January – 27 February 2017. All comments received have been considered and addressed within this Final Report and associated appendices. Changes made in this report from the draft report are underlined for ease of reference.

1.1. Public Review of Final Report

This report is available for public review for a commenting period of 30-days **from 30 June 2017 to 31 July 2017.**

Please submit your comments to
Gabriele Stein of Savannah Environmental PO Box 148, Sunninghill, 2157 Tel: 011 656 3237 Fax: 086 684 0547 Email: gabriele@savannahsa.com
The due date for comments on the Environmental Impact Assessment Report is <u>31 July 2017.</u>

Comments can be made as written submission via fax, post or e-mail.

2. CONTEXT FOR ADDITIONAL STUDIES

2.1. Climate Change Study

The Climate Change Impact Assessment has been undertaken by ERM Southern Africa (Pty) Ltd and is included as Appendix D. CVs of the project team are contained within Appendix A.

This final Climate Change Impact Assessment Report responds to comments made by stakeholders in relation to the draft Report, issued in January 2017. Specifically:

- » It applies more accurate calculation methods based on 'Tier 3' technology-specific GHG emission factors as opposed to generic 'Tier 1' emission factors¹ to assess the projected GHG emissions from the proposed Thabametsi plant and to compare these against the emissions of other coal-fired power plants on the South African grid. The use of 'Tier 3' emission factors will become more widely used in South Africa following the implementation of the National Greenhouse Gas Emission Reporting Regulations, which were gazetted on 3 April 2017.
- » It clarifies the contribution made by different GHGs (specifically CO₂, CH₄ and N₂O) to the overall GHG emissions of the proposed Thabametsi plant (in tonnes of CO₂e)²()
- » it updates and expands the comparison of GHG emissions from the proposed Thabametsi plant against the GHG emissions of other coal-fired power plants on the South African grid, specifically those plants that are scheduled for retirement in the period before 2030, in an effort to assess the impact of the proposed plant on South African GHG emissions.

2.1.1. Context for the Climate Change study

Greenhouse gas emissions, caused mainly by the combustion of carbon-based fuels ('Fossil Fuels'), are contributing to the global climate change threat. 'Climate change' refers to long term changes in the Earth's climate system, including increased average temperatures, and the knock-on effects on climate and weather systems.

The effects of climate change will impact on ecosystems and communities across the globe. There is an increasing focus at the global, national and local levels on climate change mitigation, for example shifting to renewable energy sources and reducing land-use change in order to reduce greenhouse gas (GHG) emissions, as well as adaptation to the physical impacts of climate change. In 2011, South Africa set out its climate policy in its National Climate Change Response White Paper, which includes a national GHG emissions trajectory range, projected to 2050. South Africa is also a Party to the United Nations Framework Convention on Climate Change ('UNFCCC'), and has committed to reducing GHG emissions in line with the pathway set out in the Climate Change White Paper. In parallel, South Africa's Integrated Resource Plan (IRP) developed by the Department of Energy (DoE) sets out the expansion of power generation capacity required in order to support the country's economic development, and, whilst a large portion of the new capacity will come from renewable energy, the Independent Power Producers (IPP) program gives provision for an additional generation capacity of 2 500 MW from coal-fired power plants.

¹ An explanation of the difference between 'Tier 3' and 'Tier 1' emission factors is provided in Section 2.2 of the Climate Change Impact Assessment Report.

² The difference between CO₂ and CO₂e is provided in Section 2.2 of the Climate Change Impact Assessment Report.

The climate change impact study contained within Appendix D aims to assess the impacts of all project phases (construction, operation and decommissioning) of the IPP Thabametsi Project on the environment through an assessment of the GHG impacts associated with the project. The impact of these GHG emissions (and therefore the impact of the project in terms of contribution to global climate change) is assessed by way of comparing estimated annual operational GHG emissions from the project with South Africa's baseline and projected annual GHG emissions, through reference to GHG magnitude scales for projects from various lender standards, and through the benchmarking of the project's emissions and energy performance against other coal-fired power stations in South Africa and worldwide. In addition, the degree to which the planned project is consistent with South Africa's stated climate change and energy policy is also considered.

2.1.2. Baseline Description and Climate Change Landscape

A number of key national energy and climate change policies and plans are reviewed in the Report, including the Integrated Resource Plan for Electricity ('IRP') 2010-2030 and the National Climate Change Response Policy ('NCCRP'), both published in 2011 in order to assess the extent to which the Project is in line with South African energy and climate policy. The promulgated IRP 2010-2030 (2011) factors in an increase in generating capacity to meet future demand, incorporating provision for new coal-based generation but with an emphasis on low-carbon energy sources including nuclear power and renewables such that South Africa's dependence on coal-based electricity generation is reduced. In line with this, the Independent Power Producers Procurement Program (IPPPP) has the mandate to procure energy from Independent Power Producers (IPP) aligned to the capacity allocated to different electricity generation sources in the IRP, including 2 500 MW from coal. In parallel, South Africa's NCCRP outlines a 'Peak, Plateau and Decline' ('PPD') GHG emissions trajectory whereby South Africa's emissions should peak between 2020 and 2025, plateau for approximately a decade, and then decline in absolute terms thereafter, and based on this the country has pledged to reduce emissions by 34% and 42% below Business As Usual (BAU) emissions in 2020 and 2025, respectively.

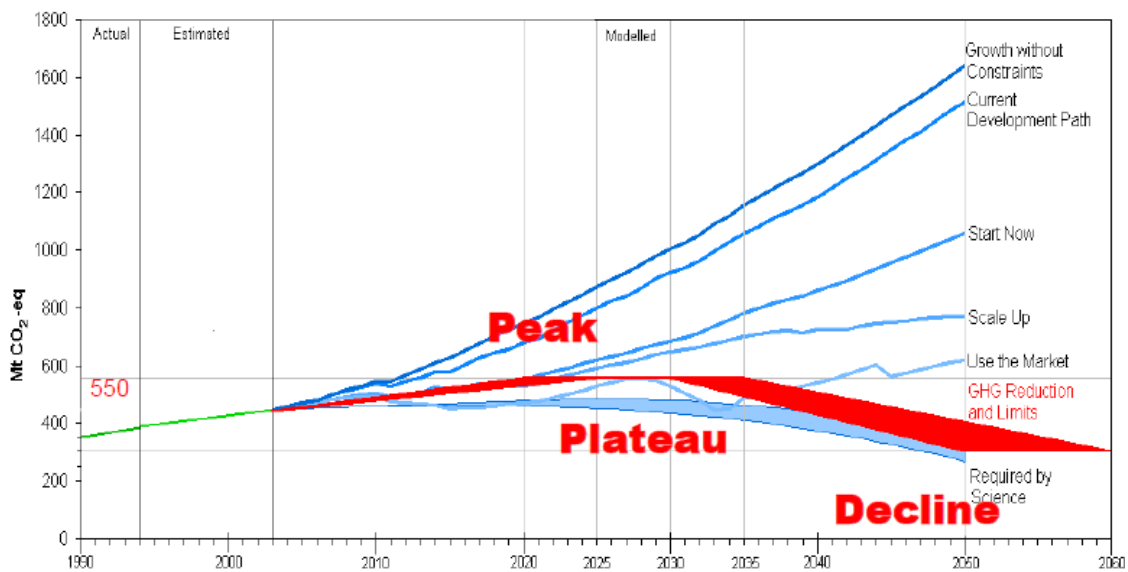


Figure 2.1: South Africa's 'Peak Plateau and Decline' Trajectory³

³ Source: Department of Environmental Affairs (DEA)

The Department of Environmental Affairs (DEA) is responsible for ensuring delivery of South Africa's climate change commitments as laid out in the National Climate Change Response Policy (NCCRP), published in October 2011, and confirmed through South Africa's recent commitments to the United Nations Framework Convention on Climate Change (UNFCCC).

In 2015 the DoE issued briefing notes on the Coal Baseload IPP Programme. The DoE has allocated a maximum of 2 500 MW to be sourced through the Coal Baseload IPP Programme, with the main objective to secure South Africa's baseload energy supply.

The Coal Baseload IPP Programme comprises separate bid 'windows' and the first bid window opened on 2 November 2015. Bidders have been limited to a maximum 600 MW (net capacity) per project submitted (no minimum generation capacity was prescribed). Project bids can be submitted in relation to Single, Multiple, or Cross Border purchasers of capacity or energy generated by a project. New generation capacity under the Coal Baseload IPP Programme is required to be connected to the national grid by no later than December 2021 (IPP Coal, 2016b). The proposed Thabametsi power Project (Phase 1 – 630 MW (Gross)) is an application for development under the Coal Baseload IPP Programme.

Integrated Resource Plan for Electricity 2010-2030 (2011)

In 2011 the DoE promulgated the first iteration of the 2010-2030 Integrated Resource Plan (IRP) for Electricity ('IRP') (DoE, 2011). The IRP 2010-2030 (2011) constitutes a 20 year electricity capacity plan, formulated to guide decision making around electricity policy and the future make up of South Africa's total generation capacity between 2010 and 2030 in terms of the proportion of total electricity to be sourced from coal, nuclear, hydro/pumped storage, imported gas, wind, and solar, including Concentrated Solar Power (CSP) and Photovoltaic (PV). The IRP 2010-2030 (2011), having been promulgated by parliament in 2011 and published as a notice under the Electricity Regulation Act No. 4 of 2006, provides the adopted legal basis for Government's electricity planning. It also aims to provide clarity around the Government's plans for acquisition of least-cost energy resources. The IRP 2010-2030 (2011) factored in GHG emissions more fully than previous plans for the electricity sector, through factoring in the GHG emissions limits specified in South Africa's Long term Mitigation Scenarios (LTMS) 2007 study (see Section 3.2.1), whilst also taking into account the impacts of the 2008 economic recession on electricity demand.

In 2010, 90% of South Africa's energy consumption was generated using coal, 5% using nuclear and 5% using hydro (DoE, 2011). The IRP 2010-2030 (2011) proposed that South Africa would effectively reduce its dependence on coal based electricity generation from 90% to 65% by 2030 and transition to alternative generation options, so that electricity generated using nuclear power would comprise 20% of the total electricity share in 2030, and 14% would be generated from renewables including wind and hydropower (5% each), PV (3%), and CSP (1%). This transition was intended to be supported by a shift in new build options expected to come on stream over the period 2010-2030, with coal expected to make up 29% (including Medupi and Kusile), renewables (including imported hydropower and pumped storage) 40%, nuclear 17%, and gas 4% of the additional 56 539 capacity (net 45 637 MW, including decommissioning of 10 902 MW) planned between 2010 and 2030.

IRP 2010-2030 Update (2013)

The IRP 2010-2030 (2011) was designed to be a 'living document' with a two year review cycle. As such, in November 2013 the DoE issued a draft update of the document, hereafter IRP 2010-2030 (2013), for public comment. The original date set for Cabinet's final approval of the IRP 2010-2030 (2013) was established as

March 2014 (DoE, n.d.). Given the delay in finalising the update, both Eskom and the DEA's 2014 GHG Mitigation Potential Analysis study defer to the data contained in the promulgated IRP 2010-2030 (2011) in the analysis applied to current and future electricity planning.

The draft update of the IRP 2010-2030 (2011) in 2013 followed a prolonged period of depressed economic growth which has a direct correlation to electricity demand in the country. The 2013 update estimated an overall peak generation demand of 6 600 MW less than the first iteration of the IRP and a different contribution from electricity generation technology options.

Table 2.1: Proposed electricity generation mix for 2030 based on the IRP 2010-2030 produced in 2011 and 2013 against 2010 baseline capacity

Energy Technology Option in 2030	2010 Baseline capacity (DoE, 2011) ⁴	IRP 2010-2030 (2011) Generation mix for 2030 in MW (DoE, 2011) ⁵	IRP 2010-2030 (2013) Generation mix for 2030 in MW (DoE, 2013b) ⁶
Existing Coal*	34 435	34 821	36 230
New Coal**	N/A	6 250	2 450
CCGT (Combined Cycle Gas Turbine)	0	2 370	3 550
OCCGT (Open Cycle Gas Turbine)	2 400	7 330	7 680
Hydro Imports***	0	4 109	3 000
Hydro Domestic	600	700	690
PS (Pumped Storage) (incl. Imports)***	1 400	2 912	2 900
Nuclear	1 860	11 400	6 660
PV (Photo-voltaic)	0	8 400	9 770
CSP (Concentrating Solar Power)	0	1 200	3 300
Wind	0	9 200	4 360
Other	730	890	640
Non-Eskom***	3 260	N/A	N/A
Total Installed Capacity (Eskom)	40 635	N/A	N/A
Total Installed Capacity (Eskom and non-Eskom)	43 895	89 532	81 230

*Existing Coal in 2030 (columns 2 and 3) includes Medupi and Kusile (Eskom power stations currently under construction), which do not play a role in 2010 Baseline Capacity. Existing coal indicated for 2030 in columns two and three therefore takes into account the decommissioning of older power stations

**Including Coal Baseload IPP Programme

***For the 2010 Baseline capacity as per IRP 2010-2030 (2011), imports for Hydro and Pumped Storage are incorporated into non-Eskom installed capacity. Based on detail in the draft updated IRP 2010-2030 (2013), non-Eskom installed capacity as of 2010 includes imported hydro (45%), coal-fired power plants (28%), co-generation (11%), medium-term power purchase program (8%), pumped storage (5%) and diesel temporary plants (3%)

2.2. Climate Resilience Assessment

The Climate Resilience Assessment has been undertaken by ERM Southern Africa (Pty) Ltd and is included as Appendix E. This final Climate Resilience Assessment responds to comments made by stakeholders in relation to the draft Report, issued in January 2017. Specifically, a Water Resources Report has been included as an appendix to this report, and provides a review of the potential impacts of climate change on water resources in the area in respect of the project.

⁴ Table 27 – Existing South African Generation Capacity Assumed for IRP

⁵ Table 4 – Policy-adjusted IRP Capacity

⁶ Table 2 – Technology options arising from IRP 2010 and the Update Base Case in 2030.

2.2.1. Context for the Climate Resilience Assessment

The climate resilience assessment (CRA) aims to highlight the key climate-related risks to the project, taking into account future climate change impacts in the study area. High level risk mitigation ('adaptation') measures are proposed in order to enhance the resilience of the project to current and future climate conditions. The methodology draws on widely used risk assessment methodologies, using likelihood and consequence scales to undertake a qualitative scoring of risks such that they can be prioritised, and applies guidance from different jurisdictions (including the UK and Australia) on using such methodologies in the context of a climate change risk assessment. It is consistent with established international good practice such as the International Finance Corporation's Performance Standards (IFC PS), for considering climate change within the Environmental Impact Assessment (EIA) process.

2.2.2. Climate baseline

The climate baseline (i.e. a description of current climate conditions) for the site was developed using climatic data records purchased from the South African Weather Service (SAWS) for Lephalale. The site is located in a semi-arid area in the summer precipitation region of South Africa. Average temperatures range from 15.7°C in winter (June to August) to 26.0°C in summer (December to February), and average daily maximum temperatures in January and February, the hottest months of the year, reach 32.7°C. Extreme high temperatures of 43.6°C have been recorded in the past.

Lephalale is a generally a water-scarce area with annual precipitation levels of 401mm (compared to South African and world averages of 456mm and 860mm per year respectively), the bulk of which falls during the summer months (October through to May), with convectional thunderstorms being common. Very little precipitation occurs between April through to September.

The area is vulnerable to extreme weather events. Flooding has impacted the town of Lephalale in the past, including the Grootegeluk mine (Thabametsi will source its coal from a mine adjacent to the Grootegeluk mine), damaging houses and buildings, infrastructure (including roads) and requiring the evacuation of numerous people. Tropical cyclones (which can bring heavy rains and strong winds) have reached the eastern parts of Limpopo in the past, although Lephalale itself has not been directly affected historically. At the same time, the area is vulnerable to drought, with numerous below-normal rainfall years historically impacting agriculture and causing widespread livestock losses. Wildfires are also common in the region, and have previously impacted communities through the destruction of game land, lodges and houses.

2.2.3. Climate change projections

Downscaled climate change projections for the area were obtained from the University of Cape Town (UCT)'s Climate Systems Analysis Group (CSAG). Climate change projections were obtained for the period 2040-2060 (also referred to as the '2050s') in order to allow overall climate change trends for the site to be identified (this is harder to do using timeframes closer to present), and to align with the timescales used by other climate change studies for South Africa and used to support this study (such studies often use two timeframes for projections: the 2050s and the 2080s). A high greenhouse gas (GHG) emissions scenario was selected, representing a conservative approach and ensuring that the full extent of potential climate change is assessed. Other national climate change studies were reviewed to support the generation of the climate change projections including the *Climate Risk and Vulnerability Handbook* published by the

Council for Scientific and Industrial Research (CSIR), and the Africa chapter of the latest (5th) Intergovernmental Panel on Climate Change (IPCC) Assessment Report.

Whilst noting the various sources of uncertainty inherent in modelling the effect of future climatic changes on the Earth's system and processes, and resulting from natural climate variability in the Earth's system, the climate projections for Lephalale suggest that temperatures are likely to increase by 2 - 3°C by the 2050s relative to a 1961-2000 baseline, that there is likely to be a significant increase in 'hot' and 'very hot' days (days where temperatures exceed 30°C and 35°C, respectively), and that there are likely to be increased heatwave events. Dry spells are projected to increase in duration between March and August (i.e. in autumn and winter), suggesting increased drought risk.

Whilst there is good agreement between different climate models on the projected temperature increases (translating to high confidence in the projected changes), there is significant model disagreement with respect to precipitation projections for the area, with some climate models projecting an increase and others a decrease in seasonal and annual precipitation levels. Projections for changes in wind speeds and the frequency of wind gusts were not available for the area (and the challenges in modelling wind speeds are widely known). Given these uncertainties, both a potential increase and decrease in precipitation levels are considered in the assessment, and potential increase in the frequency and intensity of wind gusts is also considered.

2.3. Palaeontological Impact Assessment

The Palaeontological Impact Assessment has been undertaken by Barry Milstead (refer to Appendix F). A CV of the specialist is contained within Appendix A. [This final Palaeontological Impact Assessment responds to comments made by stakeholders in relation to the draft Report, issued in January 2017. Comments received from SAHRA on the draft report are included within Appendix C4.](#)

2.3.1. Context for the Palaeontological Impact Assessment

The possible extent of the project on the palaeontological landscape is restricted to damage, destruction or accidental relocation of fossil materials caused by excavations and construction work. The field-based palaeontological heritage report falls under Sections 35 and 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999).

Both the power line foundations as well as the foundations and excavations for the power station itself could impact on local fossil resources.

2.3.2. Receiving Environment

The land surface underlying almost the entire extent of the power station and the three alternative power line routes is flat and featureless, save for the prominent hill Nelsons Kop. No significant fluvial drainage lines cross-cut the site of the proposed power station, but a small number of ephemeral channels (particularly in the extreme south of the area) cross-cut the routes of the proposed power lines.

The project area is underlain by the strata of several geological sequences that in part constitute the basin fill succession of the Ellisras Basin and the Waterberg Basin (Figure 2.2).

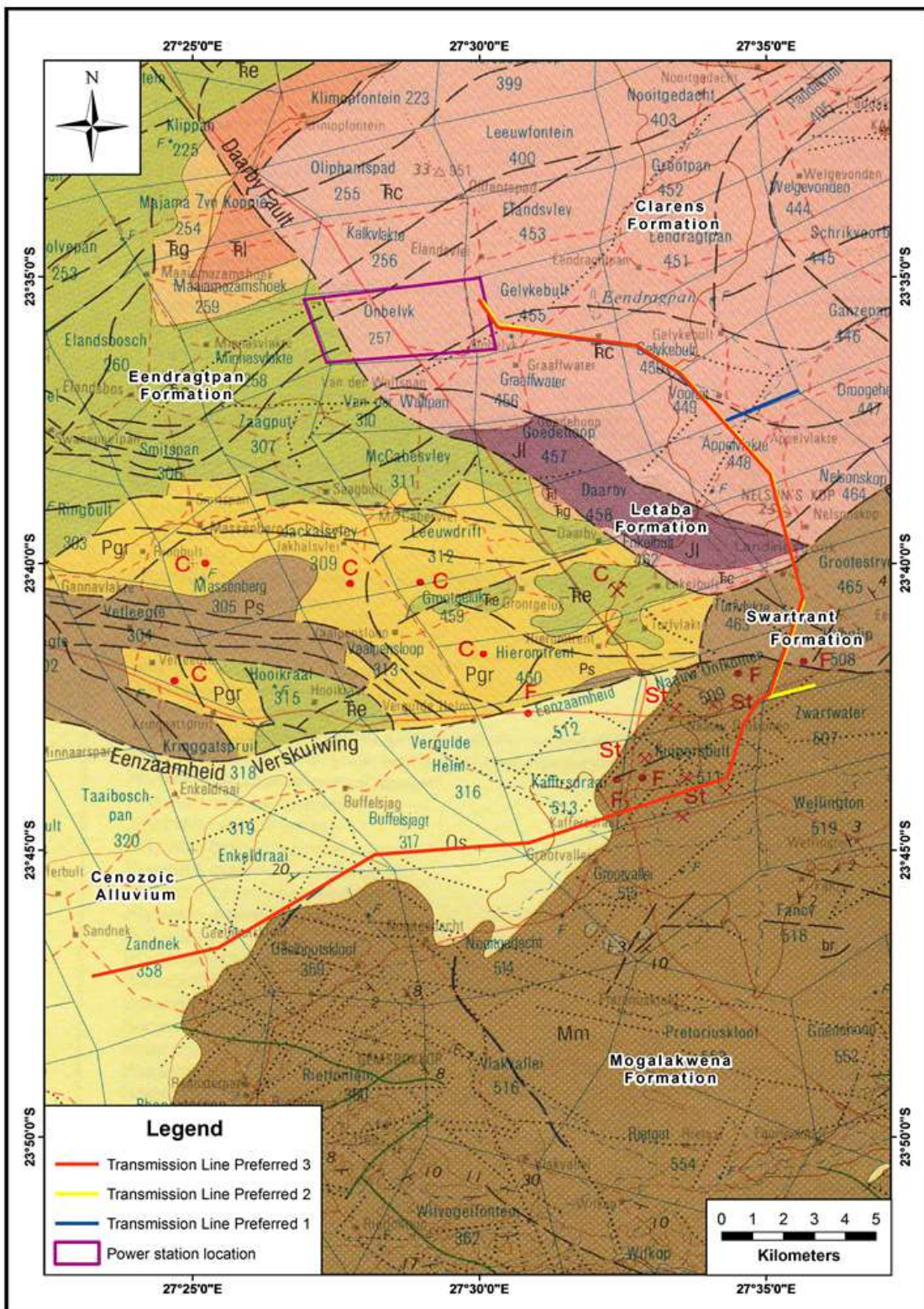


Figure 2.2: Detailed geological map showing the aerial extent of the superficial geological units that underlie the proposed project infrastructure.

The oldest of the bedrock units is found in the southern portions of the project area and consists of Achaean rocks of the Kransberg Subgroup, Waterberg Group. The younger bedrock lithological sequence is found in the northern portions of the study area and is composed of Permian to Jurassic

sedimentary rocks of the Karoo Supergroup and Jurassic lavas of the Letaba Formation. The majority of the land surface is essentially flat lying and is extensively overlain by a regolith composed of coarse-grained, unconsolidated Cenozoic sands. Outcrops of bedrock units are very rare, and the most significant by far is formed by an exposure of the Clarens Formation that forms the isolated hill known as Nelsons Kop.

3. IMPACT ASSESSMENT SUMMARY

This section of the report provides a summary of the findings of the additional specialist studies undertaken for the Thabametsi Power Station. This section must be read together with the detailed specialist reports contained within Appendix D and E.

3.1. Findings of Climate Change Study

Activity Data for the calculation of GHG emissions from the plant's construction and decommissioning was sourced from the decommissioning study prepared by WSP | Parsons Brinckerhoff (2015b), and by way of a GHG data request issued to the Project developer. Data for the calculation of operational emissions was sourced from the 630 MW (Phase 1) Project feasibility study prepared by WSP | Parsons Brinckerhoff (2015a) with the assumption that emissions associated with Phase 2 (570 MW) would be the same as estimated for Phase 1. Using the activity data, the relevant GHG emissions factors were applied in order to estimate total emissions of GHGs, expressed as 'carbon dioxide equivalents' (CO₂e), per year.

In addition to the above, emissions factors have been sourced from the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and Global warming potentials (GWPs)⁷ are taken from the IPCC's Fourth Assessment Report (AR4, published in 2007), in alignment with South Africa's national GHG inventory for 2000-2010 (DEA, 2014b)⁸. Where specific emissions sources and factors were not available from the IPCC 2006 Guidelines and/or South Africa's 2000-2010 national GHG inventory, other sources were referred to including the UK Department for Business, Energy and Industrial Strategy (BEIS)'s GHG Conversion Factors (UK BEIS, 2016).

Table 3.1 presents a summary of the GHG emissions for the full lifecycle of the Thabametsi power plant including the construction and decommissioning phases, assuming that operating conditions remain the same over the 30 year life-time of the plant, and not accounting for any decrease in thermal efficiency over time.

Table 3.1: Thabametsi's GHG emissions over its life-cycle split by activity⁹

<u>Source of emissions</u>	<u>Estimated GHG emissions (tCO₂e)</u>	<u>%</u>
<u>Construction</u>	<u>261 707</u>	<u>0.088%</u>
<u>Operations</u>	<u>296 385 671 (9 879 522 per year)</u>	<u>99.911%</u>
<u>Decommissioning</u>	<u>3 736</u>	<u>0.001%</u>
<u>TOTAL</u>	<u>296 651 114</u>	<u>100%</u>

GHG emissions from each activity and phase are discussed in the sections below.

⁷ A number of different gases contribute to the greenhouse effect. The effect that they have varies according to their relative ability to trap and retain radiant energy arriving at the Earth. These differences are reflected in the gases' global warming potentials (GWP), which are a measure of their greenhouse effect 'strength' relative to CO₂.

⁸ Note that the 2000-2010 GHG Inventory for South Africa uses GWPs as published in the IPCC's third assessment report, but notes that future GHG inventories for South Africa will use GWPs from AR4 in line with UNFCCC guidelines.

⁹ It is assumed that the plant will operate at the same load factor annually, despite decrease in thermal efficiency. This will result in slight decrease in electrical output yearly.

3.1.1. GHG Emission Impacts during Construction

Emissions arising from activities during the construction phase of the project include all those of “Scope 1” and “Scope 2” emissions, and are in line with the IFC’s Performance Standard 3 on Resource Efficiency and Pollution Prevention (IFC, 2012). Scope 1 Emissions are those direct GHG emissions from sources owned or under the operational control of the Project, and Scope 2 Emissions are all indirect emissions resulting from the consumption of purchased electricity.

Construction of Phase 1 (630 MW) will take place over an estimated 54 months (4.5 years), including a 6-month lag between individual 315 MW blocks. Since the exact timings for the construction of Phase 2 (570 MW) are not yet known, the final 1 200 MW plant (i.e. Phase 1 and Phase 2) emissions are scaled up by a factor of 1200/630, and in doing so, an assumption is made that the same activities will take place during the construction and decommissioning of Phase 2 as for Phase 1.

A total of **261 707 tonnes of CO₂e** is expected to be released during the construction phase. This amounts to 0.11% of the total overall lifecycle emissions anticipated for the project and is considered Medium-High in terms of the EBRD reporting thresholds. Taking into consideration the multiplex nature of the development, a contribution of <1% can be considered insignificant since 99.98% of GHG emissions for the project is generated during the operation phase.

Figure 3.1 illustrates the split of total (cumulative) Scope 1 & 2 emissions for the construction phase by activity.

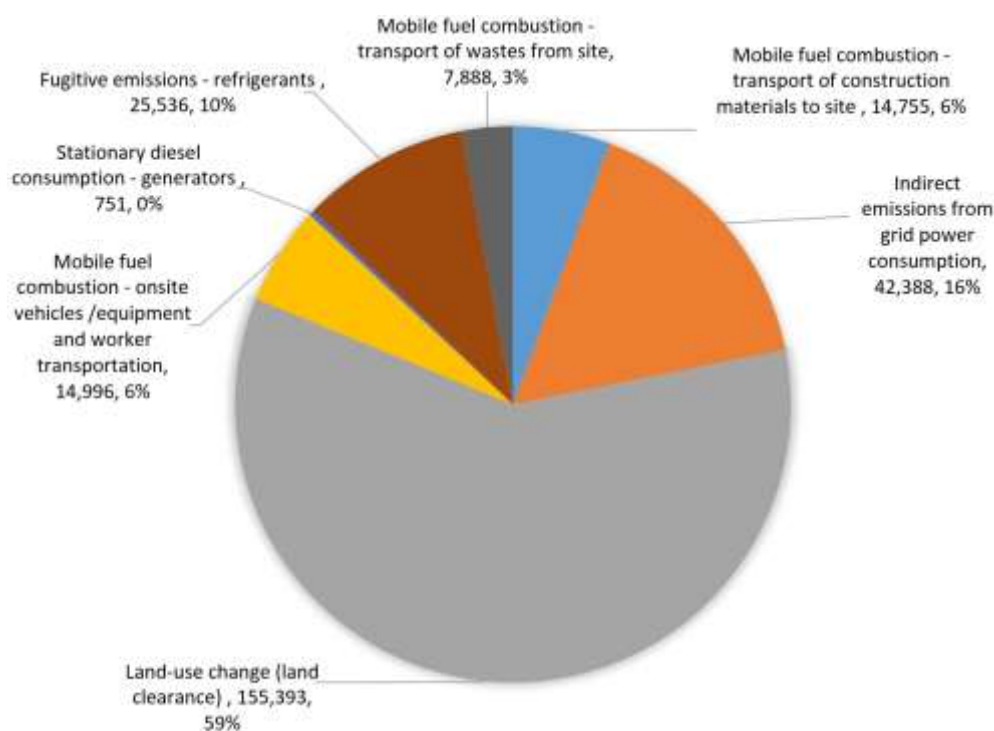


Figure 3.1: Thabametsi 1200 MW power plant construction phase emissions (tCO₂e) split by activity

As shown, land-use change emissions represent the most significant source of emissions during construction (59%), followed by Scope 2 grid electricity emissions (16%), fugitive emissions from the use of refrigerants for

cooling (10%), and mobile fuel combustion emissions associated with the use of construction vehicles and equipment and worker transportation (6%), and the transport of construction materials to the site (6%). Mobile fuel combustion emissions associated with the transport of solid and liquid wastes from the site, and stationary diesel consumption emissions, account for the smallest proportion of construction emissions (3% and 0.3%, respectively).

Scope 3 (indirect / value chain) GHG emissions associated with embedded carbon in construction materials were also calculated, though not presented as part of overall Construction emissions since this focuses on Scope 1 and 2 emissions sources.

Scope 3 emissions from embedded carbon in construction materials, including the total estimated mass of concrete, steel, and PVC pipes required for construction of the 1 200 MW plant, are estimated to be 37 745 tCO₂e. This is considered to be Medium-Low in terms of the EBRD GHG Emissions Reporting Categories

3.1.2. GHG Emission during Operation

The plant has an estimated emissions intensity of 1.23 t CO₂e / MWh generated based on total estimated annual GHG emissions and total electricity generated and sent to the grid (i.e. excluding plant auxiliary consumption and any losses from transmission and distribution). The total emissions intensity factor for Eskom's coal-fired power plants was calculated based on data published by Eskom for 2010-11 at 1.05 t CO₂e / MWh. By 2021-22, when the Thabametsi plant is estimated to come into operation, the emissions intensity specific to Eskom's coal fired power plants is projected by ERM, using IPCC Tier 3 emission factors, at approximately 1.05 t CO₂e / MWh, including Kusile and Medupi, and accounting for loss in thermal efficiency over time.

It is important to note that all of Eskom's five coal-fired power plants (Camden, Hendrina, Grootvlei, Kriel and Komati) which are scheduled by Eskom for decommissioning prior to 2020 have relatively high GHG emission intensities compared to this average intensity factor. The GHG intensity of electricity generated by these five plants is summarised in Table 0.1 below. By 2021/22 it is projected that the proposed Thabametsi plant will have similar emissions intensity to the five power plants (Camden, Hendrina, Grootvlei, Komati, Kriel), if those power plants remain in operation until 2021-22. This is a result of the relatively high N₂O emissions from the proposed Thabametsi plant, which otherwise has a lower CO₂ emissions intensity than all the five plants scheduled for decommissioning (refer to Table 0.2 and Figure 0.1 of the Climate Change Impact Assessment within Appendix D).

Table 3.2 summarises the Project's estimated annual GHG emissions during Operations (Phase 1 and 2). Total estimated annual emissions for the first 630 MW Phase of the Project, based on information given in the Feasibility Study (WSP | Parsons Brinckerhoff, 2015) and applying a load factor of 85%, are 5 186 074 9 t CO₂e (5.3 Mt CO₂e). Assuming the same technologies, load factor and operating patterns are used for the second 570 MW Phase, annual emissions from the final 1 200 MW plant are estimated to be 9 879 659 t CO₂e (9.9 Mt CO₂e)¹⁰. Assuming the same load factor and operating patterns, and not including any decrease in thermal efficiency over time, total (cumulative) estimated emissions over the 30 year lifetime of the 1 200 MW plant are in the range of 304 Mt CO₂e.

¹⁰ Note that there may be an opportunity to use more efficient technologies for Phase 2 which would result in an improved thermal efficiency and reduced emissions intensity. Absolute GHG emissions may decrease if future operations shift to cycling and the Plant is not running continuously, although increased start-ups could have a detrimental impact on plant thermal efficiency and emissions intensity (GHG emissions per MWh generated).

Table 3.2: Estimated emissions intensity of proposed Thabametsi plant vs. Eskom coal-fired power plants scheduled for decommissioning before 2030

Operational activity	Estimated Emissions in Phase 1 (630MW) (t CO ₂ e)	Annual Emissions in Phase 1 (630MW) (t CO ₂ e)	Estimated Emissions in Phase 2 (1200MW) (t CO ₂ e)	Annual Emissions in Phase 2 (1200MW) (t CO ₂ e)	Data Source, Notes and Assumptions
Coal combustion for power production (CO ₂ emissions)	4 184 071		7 969 659		Annual coal consumption of 3 901 332 tonnes per 630 MW unit, based on 85% load factor (7 446 hours per annum). Coal carbon content = 29.5% (WSP Parsons Brinckerhoff, 2015) Coal oxidation factor = 0.9915 (Source: email communications from WSP Parsons Brinckerhoff) ¹¹ <u>Converted to GJ on the basis of NCV for coal of 11.81 MJ/kg (LHV)</u>
Coal combustion (CH ₄ emissions)	1 095		2 085		<u>Applying plant design data on CH₄ emissions¹²</u>
Coal combustion (N ₂ O emissions)	885 344		1 686 370		<u>Applying plant design data on N₂O emissions¹³ which results in a calculation approximately 6% higher than the calculation using IPCC Tier 3 emissions factor¹⁴</u>
In situ desulphurisation (limestone)	109 450		208 477		Annual limestone consumption of 255 547 tonnes per 600 MW unit, based on 85% load factor. CaCO ₃ content of limestone: 93.5% by weight (WSP Parsons Brinckerhoff, 2015) Assumes 99.15% of limestone is used in the desulphurisation process (producing CO ₂) (Source: email communications from WSP Parsons Brinckerhoff) ¹⁵
Light diesel oil consumption for cold start-ups	5 154		9 817		12 tonnes light diesel oil per 150 MW boiler, 8 hours for a cold start-up, and 4 cold start-ups per year (Parsons Brinckerhoff, 2015) WSP
Diesel consumption in back-up generators	6		12		Based on an expected consumption of 550 litres / hour during full load test for 1 hour in Phase 1. Assumes 4 tests per year ¹⁶
Refrigerant consumption (cooling)	1 624		3 094		Assumes one refrigerant system refill per year, requiring 921 kg refrigerants in Phase 1 Assumes an equal split of R407c, R410a and R134a refrigerant gases are used ¹⁷
Lubricant and grease consumption	4		8		Based on estimated lubricant and grease consumption of 7 030 litres / year and 405 kg per year (respectively) in Phase 1 ¹⁸
TOTAL ANNUAL EMISSIONS (t CO₂e)	5 186 749		9 879 522		Assumes the technical specifications outlined in the 630 MW Feasibility Study apply to the second 570 MW unit (Phase 2) <u>Not taking into account any thermal efficiency losses over that period.</u>

Figure 3.2 illustrates total operational emissions split by activity.

¹¹ Email correspondence to ERM from WSP | Parsons Brinckerhoff, 20th May 2016

¹² Email correspondence to ERM from Marubeni, 7th April 2017

¹³ Email correspondence to ERM from Marubeni, 7th April 2017

¹⁴ IPCC, 2006a

¹⁵ Email correspondence to ERM from WSP | Parsons Brinckerhoff, 25th May 2016

¹⁶ Email correspondence to ERM from Marubeni, 28th Oct 2016

¹⁷ Ibid.

¹⁸ Ibid.

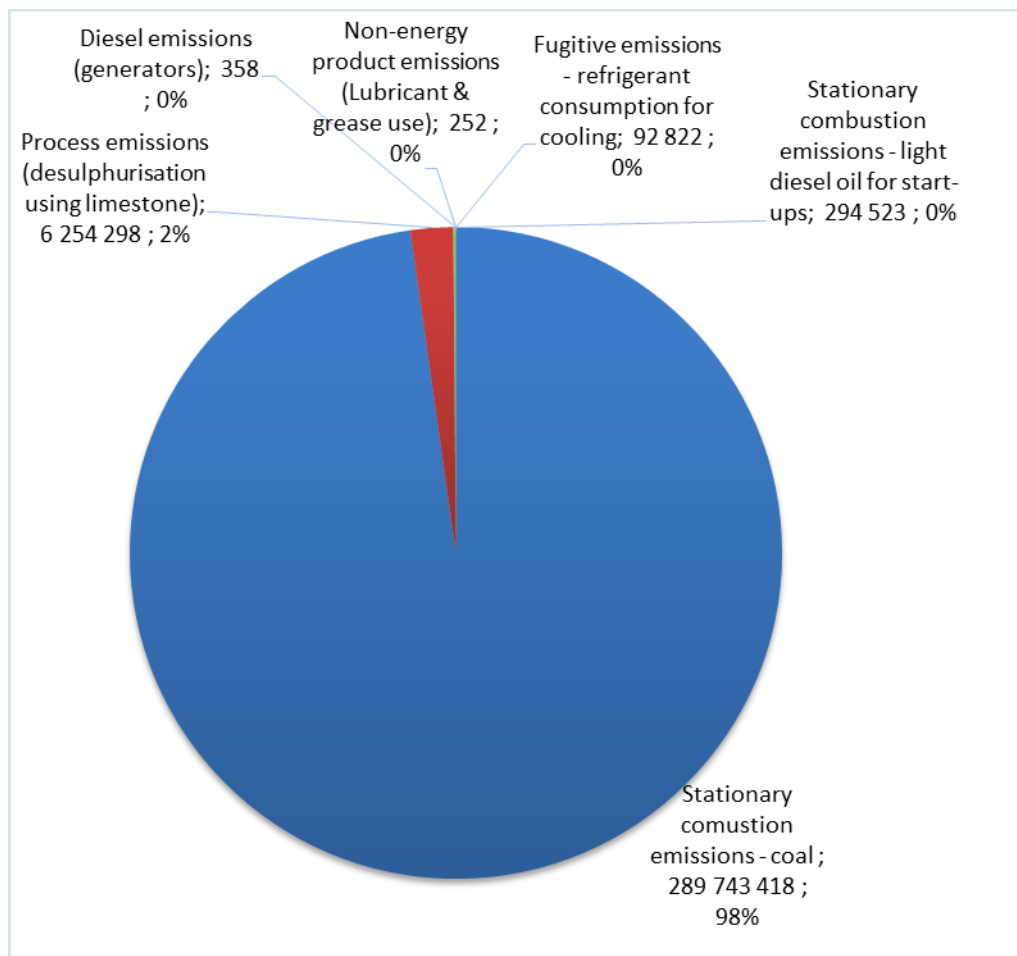


Figure 3.2: Thabametsi 1200 MW power plant operational phase emissions (tCO_{2e}) split by activity

Table 3.3 illustrates the thermal efficiency of the plant, and the emissions intensity of grid electricity generated (using annual estimated emissions above and annual estimated generated electricity in MWh). These metrics are used to inform the benchmarking in Section 4.2.2 (Impact Assessment chapter of the climate change study). The metrics are given for the final 1 200 MW plant on the basis of the Feasibility Study data for the first 630 MW phase; as such the metrics (thermal efficiency and emissions intensity) are assumed to be the same for the 600 MW (Phase 1) and 1 200 MW (Phase 2) plant.

Table 3.3: Thabametsi Coal Fired Power Plant GHG emissions intensity and thermal efficiency

	Thabametsi 1200 MW project	Data Source, Notes and Assumptions
Total estimated annual emissions (t CO _{2e})	<u>9 879 522</u>	Estimated total annual GHG emissions from the plant (calculations in Table 3.2). <u>Not including any thermal efficiency losses over time.</u>
Total annual electricity generation (MWh)	8 037 689	Plant net power (539.732 MW per 600 MW unit) * 2 units * 7 446 (annual operating hours, applying 85% load factor).
Electricity emissions intensity (t CO_{2e} / MWh, or kg CO_{2e} / kWh)	<u>1.23</u>	Total annual emissions divided by total annual electricity output.
Thermal efficiency	36.25%	Thermal efficiency = 36.25% (LHV); 34.07% (HHV) (Source: EPC data as communicated by Marubeni) ^{19 20}

¹⁹ Email correspondence to ERM from Marubeni, 9th June 2016

²⁰ Note that the thermal efficiency values stated are based on the latest available technical data for Phase 1 operations (630 MW).

Based on South Africa's current and future projected national GHG emissions, the project's GHG emissions are expected to comprise 1.7 – 2.5% of South Africa's national emissions in 2021, rising to 2.3 – 4.7% in 2050. The magnitude of the project's emissions (2,879 million t CO_{2e} per year) is Very Large based on a GHG magnitude scale drawing from various international lender organisation standards including standards set by the International Finance Corporation (IFC), European Bank for Reconstruction and Development (EBRD) and Equator Principles (EP).

3.1.3. GHG Emission Impacts during Decommissioning

Figure 3.3 illustrates the split of total Scope 1 and 2 emissions for the decommissioning phase by activity. As shown, the most significant emissions source is from electricity consumption (3 031 tCO_{2e}, 81% of decommissioning emissions), followed by mobile combustion emissions from fuel used in vehicles / mobile equipment (672 tCO_{2e}, 18% of decommissioning emissions). The remaining 1% of emissions is associated with the use of diesel generators for back-up power production. Although there are positive emissions impacts associated with returning the site to 'greenfield status', they have not been included due to challenges in making necessary reasonable assumptions and estimations. For the same reason, emissions associated with transporting materials for reuse or recycling elsewhere have not been included. Overall, decommissioning contributes 3 736 tCO_{2e} (0.002%) to overall lifecycle emissions, this is considered Negligible in terms of the IFC, EBRD and EP reporting standards.

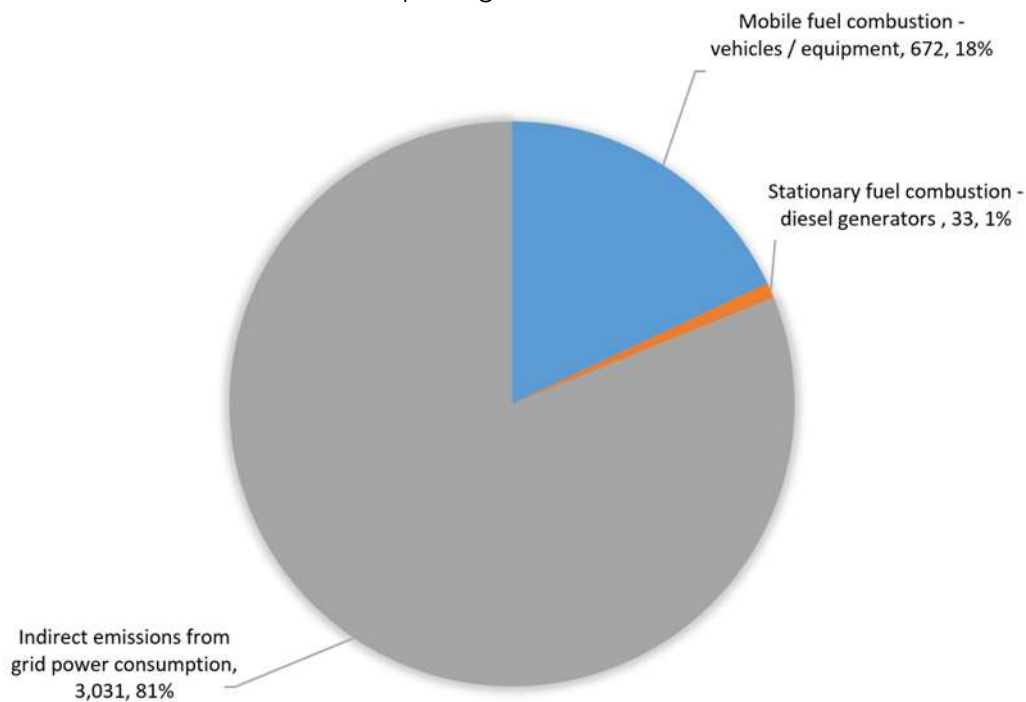


Figure 3.3: Thabametsi 1200 MW power plant decommissioning phase emissions (tCO_{2e}) split by activity

3.1.4. GHG Impact Assessment

A traditional impact assessment is conducted by determining how the proposed activities will affect the state of the environment described in the baseline. As noted in Section 2.1 of the specialist report, in the case of GHG emissions, this process is complicated by the fact that the impact of GHGs on the environment cannot be quantified within a defined space and time. The greenhouse effect occurs on a global basis and the point source of emissions is irrelevant when considering the future impact on the

climate. CO₂ has a residence time in the atmosphere of approximately 100 years by which time emissions from a single point source have merged with other anthropogenic and natural (e.g. volcanic) greenhouse gas emissions. Therefore it is not possible to link emissions from a single source – such as the Thabametsi Project – to particular impacts in the broader study area.

Considering the above, the impact assessment for the Project's GHG emissions is based on an assessment of the magnitude of estimated annual GHG emissions during operations (accounting for >99.9% of Scope 1 and 2 emissions across the construction, operations and decommissioning stages), and the Project's contribution to global climate change for the Full Project Lifecycle. As South Africa has not specifically defined thresholds to understand GHG emissions impact or magnitude within its Environmental Impact Assessment or National Environmental Management Act legislation, this assessment of magnitude (i.e. the scale of GHG emissions from the Project) is based on a GHG magnitude rating scale developed from international lender standards including IFC, EBRD, and EP. The magnitude of the Project's emissions relative to South Africa's current and future projected GHG emissions is also presented, but owing to the significant limitations associated with using national GHG emissions as a way to understand the magnitude of a project's emissions, this comparison is not used to inform significance.

The GHG impact significance rating for the plant is based on the magnitude of GHG emissions. This differs to a traditional ESIA study where significance is based on a combination of the magnitude and likelihood of an impact. This is because likelihood is irrelevant in the context of GHG emissions given that increased levels of GHG emissions will result from the project, and given the body of scientific evidence linking GHG emissions to global climate change impacts.

The above analysis highlights the following with respect to the magnitude of the Project's GHG emissions, estimated to be 5 186 749 t CO₂e annually during operations on completion of Phase 1, and 9 879 522 t CO₂e annually on the completion of Phase 2:

» Using benchmarks from international lender standards with respect to the magnitude of annual emissions from a development, and considering the highest rating ('Very Large') applies to projects emitting >1 000 000 t CO₂e per annum, the magnitude of this Project's GHG emissions is considered to be 'Very Large'.

Based on the above analysis, the magnitude of the Project's GHG emissions is considered to be Very Large. Relating this to the impact significance scale being used for the project, this translates to an overall significance rating of High (Negative). As noted previously, in the absence of abatement technologies such as CCS, most coal-based power plants will fall into this category by nature of their high GHG emissions, including Eskom's Kusile and Medupi plants currently under construction.

Whilst the Project will likely have a High (Negative) impact with respect to GHG emissions, it is important to consider the contextual information relating to South Africa's energy context, national energy plans including the planned increases in baseload power to meet needs, the role of coal to meet increased baseload power requirements and the high emissions intensity of the older Eskom coal power plants, and the key objectives of the Coal Baseload IPP Programme in terms of providing a rationale for the development of this Project as described above.

3.1.5. Emissions Management Measures

The vast majority (>99.9%) of total emissions during the construction, operation and decommissioning of the plant are attributed to emissions from the operation of the plant. The 1 200 MW Project's annual GHG emissions are estimated to be 9 879 522 t CO₂e during operations assuming a baseload supply scenario. As noted previously, the emissions are 'Very High' when benchmarking against a project-wide emissions magnitude scale based on various international lender standards, as is expected for a coal-fired power plant. The emissions intensity (t CO₂e per MWh) is also relatively high when benchmarked against other power plants. As such, measures should be implemented to monitor and manage energy consumption (thermal efficiency) and GHG emissions during operations. Specific emissions management measures are presented in this section.

There are a number of key technologies that can be employed in order to reduce GHG emissions and improve efficiencies for coal-fired power plants. The most significant improvements are influenced by the design of the plant, and in terms of the steam conditions. These are discussed in detail in Section 5 of the Climate Change Impact Assessment contained within Appendix D, and include:

- » Emissions management through optimisation of plant thermal efficiency in order to reduce the coal consumption and therefore GHG emissions per unit of electricity (i.e. kWh or MWh) generated.
- » Managing changes to operating philosophy, considering any potential implications with respect to plant performance, thermal efficiency and the GHG intensity of electricity production.
- » Development and implementation of a GHG management plan.
- » Abatement of N₂O emissions

It is important to note that the choice of technology and the size of the plant constrain the extent to which technology-based GHG mitigation measures can be used. The key constraints are:

- » **Coal quality:** CFB plants are better suited to low quality (low calorific value (CV)) coal, relevant to the Thabametsi plant which will be using coal with a relatively low CV of 11.81 MJ / kg (LHV). Whilst CFB technologies offer some advantages including reduced emissions of nitrous oxides (NO_x) and sulphur dioxide (SO₂), and water use reduction through the use of in-situ SO₂ mitigation (rather than 'wet' FGD units), the use of SC and USC steam conditions in CFB plants is currently limited compared to PCC plants, and it is therefore not possible to benefit from the enhanced efficiencies offered by these technologies. The specified tariff under the IPPPP will have contributed the choice of the CFB technology which is more cost-effective, given the availability of low quality coal.
- » **Boiler and steam unit size:** The Coal Baseload IPP Programme calls for projects with a maximum 600 MW capacity, and the strong emphasis on and requirement for redundancy for IPP baseload projects means that the selected configuration for the Thabametsi plant is four 150 MW boilers and two 315 MW steam units. This has some important implications with respect to plant efficiency:
 - (Noting the above constraints associated with the use of supercritical steam in CFB plants): It is not possible to use more efficient (and less GHG-intensive) supercritical or ultra-supercritical steam technologies, which are rarely applied to 'small scale' 300 MW units due to the comparatively high cost of materials to support supercritical steam on a small scale (WSP | Parsons Brinckerhoff, 2015); and
 - Typical steam turbine configurations used in commercial power plants include non-reheat, single reheat and double reheat configurations. Double reheat offers the most efficiency but is used in larger, 600 MW units. Single reheat configurations can be used for units of 150 MW or greater. This

plant will use single reheat steam turbine configurations in order to achieve the greatest increase efficiency possible considering size constraints.

- » **Availability of water:** Water is a scarce resource in South Africa, including in the Lephalale municipality of Limpopo Province where the plant is sited. This has the following technology selection implications:
 - CFB technologies are preferable from a water perspective since 'in situ' SO_x control, achieved through the injection of limestone into the boiler, avoids the need for dedicated 'wet' (water intensive) flue gas desulphurisation units that would be required for a pulverised coal boiler; and
 - Dry air cooled condensers are selected for the plant since these use 6 to 10 times less water than 'wet cooled' plants. However, air cooled condensers generally require more power than other systems in order to drive the fans which gives the plant a greater auxiliary load and has a negative impact on plant thermal efficiency.
- » **Proven Technology:** The configuration and technology to be used by bidders under the Coal Baseload IPP Procurement Programme in respect of the power generation equipment must be based on thermal steam units and the boiler shall be of the pulverised Coal or fluidised bed type, both of which should conform to the proven design and technology requirements in the technical qualification criteria of the RFP²¹.

3.1.6. **Conclusions**

The operation of the 1 200 MW Thabametsi Power Station under the South African DoE's Coal Baseload IPP Programme will result in significant GHG emissions, projected to be 9.879 million t CO₂e per year²². The emissions are of a similar but slightly lower magnitude per kWh generated than those from the Eskom coal-fired power plants which are scheduled to be decommissioned around the time of the Thabametsi plant's entry into service.

The choice of technology and specifications for this Project were informed by the technical requirements of the DoE as set out in the bid criteria under the Coal Baseload IPP Procurement Programme established under the IRP 2010, including the requirements for proven technology and tariff cap of ZAR0.82/KWh.

3.2. **Findings of Climate Resilience Assessment**

Potential climate-related risks were identified through the assessment of the interaction between the climate baseline and future climate scenarios, and the project's operations. The aspects of the project considered when identifying project-related climate change risks included the power plant and ancillary infrastructure (e.g. pollution control dam, water treatment plants, access roads etc.), raw materials handling (i.e. coal, limestone, fuel oil, and water), transmission lines, staff and local communities, all of which have the potential to affect the performance of the plant.

²¹ Technical Qualification Criterion 4 : Proven Design and Technology Requirements) of Volume 3 (Technical Requirements) Part 1 (Technical Qualification Criteria) of Part B (Functional and Qualification Criteria Requirements of the Coal Baseload IPP Procurement Programme RFP.

²² In line with international good practice, such as that advocated by the IFC Performance Standards, this report does not attempt, nor is it appropriate, to try to calculate the climate change impacts in the broader study area that will be due specifically to emissions from a single source, such as the Thabametsi Power Station. In line with international good practice, this report calculates the projected GHG emissions from the project, across its lifetime. It compares those emissions against appropriate comparators and reference benchmarks in South Africa and globally, and considers their relevance in the context of South Africa's national GHG emissions and policy

Twelve (12) climate-related project risks were identified, and each potential climate-related risk was further explored through a detailed review of project documents, a desktop review of climate change impacts to the power sector, and through engagement with project engineers. Subsequently, risks were scored using a high level, qualitative scoring system based on the likelihood of the impact occurring, and the consequence to the project, should the impact occur.

The following risk categories are assigned using the risk assessment matrix presented in Table 3.2 (Australian DEH, 2006):

- » **Low** (1-4) – Risks that should be monitored over time, with existing controls sufficient unless the level of risk increases.
- » **Medium** (5-10) – Risks that can be accepted as part of routine operations, but that require ownership / management by relevant staff, and continual monitoring and reporting.
- » **High** (11-19) – The most severe risks that can be accepted as part of routine operations without executive sanction. Requires continual monitoring and reporting.
- » **Extreme** (20+) – Critical risks demanding urgent attention from senior management / executives.

Table 3.2: Risk assessment matrix

		CONSEQUENCES				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
LIKELIHOOD	Almost Certain 5	Medium (5)	Medium (10)	High (15)	Extreme (20)	Extreme (25)
	Likely 4	Low (4)	Medium (8)	High (12)	High (16)	Extreme (20)
	Possible 3	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
	Unlikely 2	Low (2)	Low (4)	Medium (6)	Medium (8)	Medium (10)
	Rare 1	Low (1)	Low (2)	Low (3)	Low (4)	Medium (5)

This risk scoring exercise was done for the below risks / impacts considering baseline (current) climate conditions, and future (projected) climate conditions in the 2050s.

Table 3.3: Results from the risk assessment

Risk		Present climate conditions			Future climate scenario (2040-2060)			Notes
		Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	
1	High temperatures result in reduced thermal efficiency	3	1	3	4	2	8	<p>Consequence type: Financial</p> <p>Present: Reference site conditions of 24°C are used in the Feasibility Study and assumed to be based on recent climate. Unusually high temperatures / heatwave events have occurred in recent years, but financial impacts tied to reduction in plant output and hence revenue are understood to be already integrated into the projected plant availability.</p> <p>Future: Significant increases in temperatures (average and maximum) are likely across the year which will impact on the project's output. Considering the inability to exactly match the baseline periods and projections, it is impossible to confirm what the exact daily temperature changes would be in the future and hence to adjust for it, however as part of their planning the project has accounted for some variability in output. Hence the financial impact of this is expected to be minor.</p>
2a	High temperatures and heatwave conditions pose a health risk to the workforce	3	2	6	4	2	8	<p>Consequence type: Safety</p> <p>Present: Isolated cases of extreme high temperatures with the potential to cause discomfort / heat stress amongst workforce</p> <p>Future: Increased cases of extreme high temperatures / heatwaves with the potential to cause discomfort / heat stress amongst workforce</p>
2b	High temperatures and heatwave events result in spontaneous combustion at the coal stockpiles	3	1	3	3	1	3	<p>Consequence type: Safety, Financial, Environmental</p> <p>Present: Risk of sponcom exists but fire detection & suppression equipment will be in place to deal with any events. Impact is likely to be limited to smoke generation</p> <p>Future: Increased risk of sponcom with higher temperatures, though not becoming 'likely'. Impact still likely to be limited to smoke generation on account of fire detection and suppression systems in place</p>

Risk		Present climate conditions			Future climate scenario (2040-2060)			Notes
		Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	
2c	Wildfires in the wider area disrupt access to the site and damage utilities infrastructure	2	2	4	3	2	6	Consequence type: Financial (Operational Disruption) Present: Wilfire events are known to occur in the area, though impacts to plant-related infrastructure are likely to be minor Future: Wildfires likely to occur with increasing frequency, though consequences are thought to remain minor
3a	Lower than normal precipitation levels and increased drought result in water shortages *	3	4	12	4	4	16	Consequence type: Financial; Reputational (failure to deliver power) Present (considering Phase 1 Thabametsi, 630 MW): The MCWAP-1 will run at a high risk until MCWAP-2 comes on-stream to enable all water requirements to be met (DWS, 2017). The allocations for different water users are determined via water use agreements between approved users and DWS. The project's water will be ceded from Exxaro's existing MCWAP-1 allocations and are expected to be provided in line with the existing water use agreement. Future (considering Phase 1 & 2, 1200 MW): Uncertainties exist in relation to whether the surplus in the Crocodile River catchment will be able to meet demand in Lephalale, and the timings in relation to completion of MCWAP-2. Climate change impacts pose further uncertainty in relation to the ability of MCWAP-2 to meet demands.
3b	Lower than normal precipitation levels and increased drought create water quality issues *	2	3	6	4	3	12	Consequence type: Financial (cost of additional water treatment) Present: (considering Phase 1 Thabametsi, 630 MW): Water from Mokolo Dam is of a relatively good quality and will be treated by the plant to the required standards Future (considering Phase 1 & 2, 1200 MW): Water quality is lower in the Crocodile River catchment. Much of the water transferred by MCWAP-2 will be run-off effluent from industrial users. Climate change impacts

Risk		Present climate conditions			Future climate scenario (2040-2060)			Notes
		Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	
								are likely to exacerbate existing water quality issues and additional water treatment may be required
4	High wind speeds / wind gusts damage infrastructure	2	2	4	3	2	6	Consequence type: Financial (asset damage / operational disruption); Safety Present: Detailed wind data is not available; however, likelihood of high winds damaging infrastructure is considered Unlikely on account of relatively low windspeeds in the area. Consequence is assumed to be Minor on the basis that repairs can be made relatively quickly Future: Conservative assumption that wind gusts increase in the area with climate change such that Likelihood increases to Possible. Consequences are assumed to remain Minor. <i>Note: Site-level wind speed data should be assessed with respect to structural design criteria (e.g. wind gust thresholds) to confirm likelihood & consequence ratings</i>
5a	Flood events affect the site causing equipment damage / operational disruption	2	3	6	3	3	9	Consequence type: Financial (asset damage / operational disruption); Safety Present: The area is vulnerable to flooding. The likelihood of the site itself flooding is deemed to be low (unlikely) as the area will be raised 200mm above surrounding elevation, and topography maps suggest natural drainage away from the site Future: Conservative assumption is made that precipitation intensity increases with climate change, causing flooding events of increased frequency / severity. In this scenario, in-built protection (e.g. site elevation) may not be sufficient to prevent flooding <i>Note: A site-specific flood risk assessment is required to confirm likelihood & consequence ratings</i>
5b	Flood events affect the site causing polluted water overflows	3	3	9	4	3	12	Consequence type: Environmental; Financial; Safety Present: The area is vulnerable to flooding. Current design plans for the coal stockpile run-off pond allow

Risk		Present climate conditions			Future climate scenario (2040-2060)			Notes
		Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	
								for a 1:50 year flood event, based on historical rainfall intensities. Recent flooding at Grootegeluk mine illustrates the potential for 1:50 flood events to occur. Details of flood design parameters for ash dump run-off drains and pond are not yet available Future: Future climate scenario assumes precipitation intensity increases, causing flooding events of increased frequency / severity. In the absence of a detailed flood risk assessment, consequence is assumed to be Moderate. <i>Note: A site-specific flood risk assessment is required to confirm likelihood & consequence ratings</i>
5c	Flood events affect the wider area resulting in reduced / lack of accessibility to the site	4	2	8	4	2	8	Consequence type: Financial (e.g. if delays in supplies / staff reaching site) / Safety Present: The area is vulnerable to flooding and infrastructure (including access roads to the site) have been damaged in the past. The consequences are assumed to be minor on the basis that alternative access routes are likely to be available and no significant accidents occur Future: Future climate scenario assumes precipitation intensity increases, causing flooding events of increased frequency / severity. In this scenario disruption to key access roads could be come more frequent (though remaining in the 'Likely' category). Consequences remain minor, assuming alternative access routes are available and no significant accidents occur
6a	Dry spells / drought events result in increased dust generation	2	2	4	3	2	6	Consequence type: Financial (e.g. increased water costs for dust suppression) / Safety / Reputational (if communities are affected) Present: Dust suppression systems will be in place in order to minimise dust generated and are likely to be able to control dust generation in the event of a dry spell

Risk		Present climate conditions			Future climate scenario (2040-2060)			Notes
		Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	Likelihood of impact (L)	Consequence of impact (C)	Risk (L*C)	
								Future: More frequent and prolonged dry spells / droughts increase dust generation at the site. Consequence is considered to be Minor and relates to increased water requirements / costs for dust suppression
6b	Dry spells / drought events affect communities and threatens social license to operate	3	2	6	4	3	12	Consequence type: Reputational / Financial (e.g. if operations are disrupted) Present: Concerns already exist amongst communities in relation to increasing water allocations to industry / new power plants (e.g. Medupi), with minor reputational impacts at present Future: More frequent and prolonged dry spells / droughts are likely to increasingly affect communities, particularly those dependent on rivers or groundwater (e.g. rural villages and farms) but potentially also municipalities who may struggle with falling dam levels. Consequences may include widespread protests / reputational impacts as the power plants in the area are perceived to be taking water 'from' communities

* Note that risks relating to water shortages and water quality issues are influenced by multiple factors, one of which is climate change. Climate-related risks to water supplies cannot be considered in isolation, and therefore the likelihood and consequences of water shortages (3a) and water quality issues (3b) as scored here reflect the various risk drivers as discussed previously. In the case of water shortages, this includes the risk of surplus water in the Crocodile River catchment failing to meet demand and risk of slower than anticipated progress with the construction of MCWAP-2 and/or subsequent infrastructure issues. In the case of water quality issues, this includes risk of increasing pollution in the Crocodile River catchment which could result from poor land-use practices and poor enforcement of WUL conditions in relation to discharges.

There are three risks where residual risk remains 'High' following the implementation of adaptation measures. The risk of plant efficiency losses due to increasing temperatures remains high because there are limited options to manage or prevent these efficiency losses. Additionally, the risks relating to water shortages and water quality issues remain high. This is because these risks are affected by numerous drivers, a number of which the plant has limited influence over. The plant will rely on the successful implementation of the water reconciliation schemes driven by the relevant WMAs and Catchment Management Agencies (CMAs) to ensure adequacy of water supplies in Lephalale in the future, and whilst measures can be implemented to minimise the plant's impact with regard to water resources, the plant is likely to have more limited control and influence over the broader water planning context.

Two risks are ranked as 'Medium' following the implementation of adaptation measures. These include the risk of flood events affecting the wider area and causing reduced accessibility to the site, and the risk of increasing dry spells and drought conditions affecting the plant's social license to operate. Again, in these cases there are actions that the plant can take to reduce risks, but likely only to a certain extent. In the case of floods affecting the wider area, the plant is reliant on the existing roads and transport routes in the area in terms of being able to make use of alternative access routes. In the case of community concerns around industrial users' water consumption in the area in the context of increasing future water stress, the plant can implement actions to improve community relations and address concerns, but this may not be sufficient to address more widespread concerns in relation to water shortages, should the area come under pressure due to lower dam levels and/or delays or issues encountered with the implementation of the water transfer scheme into the area (MCWAP-2).

It is considered that the remaining risks could be reduced to 'Low' following the successful implementation of the recommended adaptation measures.

3.2.1. Conclusions

It is important to note that the risk assessment conducted as part of this study is a qualitative risk assessment, based on high level categories or definition of likelihood and consequence. This is on account of the uncertainty in relation to assigning specific likelihoods and consequences or impact descriptions as the project is not yet in existence (i.e. there is a lack of historical precedent) and has not yet entered detailed design phase, and also due to the uncertainties the climate scenarios themselves (i.e. uncertainties in projecting future emissions of GHGs and modelling future climatic change, inherent uncertainty due to natural internal variability in the climate system, and potential data uncertainty with respect to historical climate conditions and extreme weather events). It is recommended that the findings from the CRA are further investigated as the project progresses into more detailed design stages and that the risk assessment and risk register is continually revisited, updated and refined over time. Procedures (integrating with project-level risk management) should be put in place in order to track risks over time and a register of adaptation actions (relating to monitoring, management measures, and technical adaptation measures and projects) should be developed and maintained. This process should be integrated into plant-level risk management procedures and risk registers that cover broader business/project risk (e.g. political, economic, social etc.). Finally, it will be important for someone or a team of individuals to have ownership of both the climate risk assessment process, and associated risk (and mitigation project) registers.

3.3. Findings of the Palaeontological Impact Assessment

The construction of the power transmission line will involve the establishment of regularly spaced pylons. It is anticipated, herein, that the pylons will have foundations that will require excavation of the land surface down to bedrock where they will affect the upper 1-2 m of the bed rock. The servitude road that will accompany the power line will be a twin spoor track that will only affect the immediate land surface and, as such, will only affect the Cenozoic regolith in almost all areas. The depth of any excavations required to construct the power station are unknown at this stage, but for the purposes of this report it is assumed that they may be up to 10 m deep; in this event the power station construction will directly impact upon both the regolith cover and the underlying bed rock. The infrastructure associated with the power plant (e.g., roads, car parks and out buildings) are expected to only impact upon the upper 1-2 m of the land surface. Thus, they will be expected to only impact upon the regolith cover in most areas.

The potential negative impacts of the proposed project on the palaeontological heritage of the area are:

- » Damage or destruction of fossil materials during the construction of project infrastructural elements to a maximum depth of those excavations. Many fossil taxa (particularly vertebrate taxa) are known from only a single fossil and, thus, any fossil material is potentially highly significant. Accordingly, the loss or damage to any single fossil can be potentially significant to the understanding of the fossil heritage of South Africa and to the understanding of the evolution of life on Earth in general. Where fossil material is present and will be directly affected by the building or construction of the projects infrastructural elements the result will potentially be the irreversible damage or destruction of the fossil(s).
- » Movement of fossil materials during the construction phase, such that they are no longer in situ when discovered. The fact that the fossils are not in situ would either significantly reduce or completely destroy their scientific significance.
- » The loss of access for scientific study to any fossil materials present beneath infrastructural elements for the life span of the existence of those constructions and facilities.

The construction of the power plant will affect the will definitely affect the Cenozoic regolith, with a reduced possibility of any effects occurring to the strata of the Karoo Supergroup. The associated infrastructure and out buildings are expected to have relatively shallow impacts (i.e., < 1-2 m) and should mostly affect the Cenozoic regolith. The power line pylons will impact upon the Cenozoic regolith as well as the upper-most 1-2 m of the underlying bedrock units. The servitude road associated with the power lines will only impact upon the Cenozoic regolith. Where the construction activities will impact upon the Cenozoic regolith or the Eendragtpan, Lisbon and Clarens Formations The probability of any negative impact upon the palaeontological heritage of these units is assessed as low. In those locations where the Swartrant Formation will be impacted the probability of any negative impact upon the palaeontological heritage is assessed as being medium. The rocks of the Mogalakwena and Letaba Formations are unfossiliferous and, as such, any disruption of these units will result in nil possibility of any negative impact upon their palaeontological heritage.

Despite the characterisation of the risk of a negative impact resulting upon the palaeontological heritage of the either the Cenozoic regolith or the Eendragtpan, Lisbon and Clarens Formations being assessed as low and that of the Swartrant Formation being assessed as medium any fossil materials that they may contain will potentially be of high scientific and cultural importance. No fossil materials were located during the site investigation undertaken for the project. However, this study has identified that the underlying strata of the Karoo Supergroup and the Cenozoic cover sequences are fossiliferous elsewhere

in South Africa. As such, fossils are potentially present beneath the planned construction projects (particularly in the Karoo Supergroup which is completely covered by the regolith and, as such, could not be directly investigated). Any damage, destruction or inadvertent movement of these fossils will result in permanent and irreversible damage. Similarly, any fossil materials that remain undiscovered after the construction of the project and which are located beneath the maximum depth of the anticipated excavations associated with the constructions will only be negatively affected in so far as they will be unavailable for scientific study for the life expectancy of the infrastructural elements that comprise the project.

3.3.1. Conclusions

The probability of a negative impact on the palaeontological heritage contained within the Swartrant Formation is categorised as medium and as low in the remainder of the Karoo Supergroup (the Eendragtpan, Lisbon and Clarens Formations). Similarly, the probability of a negative impact on the palaeontological heritage contained within the Cenozoic regolith underlying the project area is categorised as low, the significance of any negative impact posed by the project on the palaeontological heritage is categorised as potentially high if appropriate mitigation procedures are put into place.

It is recommended that thorough and regular examinations of all excavations that occur within the sediments of the Karoo Supergroup and Cenozoic regolith be made by a palaeontologist. Should scientifically or culturally significant fossil material be confirmed within the project area any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution.

The potential negative impact to the palaeontological heritage of the area can be minimised by the implementation of appropriate mitigation processes. It recommended that thorough and regular examination of all excavations that are conducted upon or within the Karoo Supergroup or Cenozoic regolith be made by a palaeontologist while they are occurring. Should any fossil materials be identified, the mining operations should be halted in that area and SAHRA informed of the discovery.

The social benefits of the project have been classified as beneficial, herein, as the project aims to facilitate the supply and delivery of electricity to an increasingly stressed national power grid. The project will also provide considerable employment during the construction phase as well as ongoing employment opportunities during the operational life of the power plant. As such, the study has not identified any palaeontological reason to prejudice the construction of either the power plant or a power transmission line, subject to adequate mitigation programs being put in place.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions and Recommendations from Climate Change Study

The operation of the 1 200 MW Thabametsi Power Station under the South African DoE's Coal Baseload IPP Programme will result in significant GHG emissions and therefore will have climate change impacts. The main findings of the climate change specialist study are described below.

- » The 1 200 MW Project's annual and cumulative GHG emissions are significant, estimated to be 9 879 522 t CO₂e per annum assuming a baseload supply scenario, and in the range of 296 Mt CO₂e over the project's 30-year lifetime.
- » The Project has a relatively high thermal efficiency compared to other coal-fired power plants using sub-critical steam conditions, but a relatively low thermal efficiency in comparison to coal-fired power plants using SC and USC steam conditions, and relative to IGCC power plants (noting that there are few IGCC coal plants in commercial operation).
- » The Project has relatively high emissions intensity (1.23 t CO₂e per MWh generated) compared to coal-fired power plants, and a high emissions intensity relative to that of Eskom's coal-fired fleet, estimated at 1.05 tCO₂e in 2021-22 including Kusile and Medupi. However, the emissions intensity of the plant is similar or lower compared to the projected 2021/22 estimates of the five Eskom coal-fired power plants that are due to be decommissioned before 2025: Camden (1.25 t CO₂e / MWh), Grootvlei (1.36 t CO₂e / MWh), Hendrina (1.33 t CO₂e / MWh), Kriel (1.24 t CO₂e / MWh) and Komati (1.27 tCO₂e / MWh). Specifically when comparing Camden, which will be the first power station to be decommissioned, and Thabametsi, CO₂e will be reduced. (1.23 CO₂e/MWh (Thabametsi) vs. 1.25 CO₂e/MWh (Camden).
- » The requirements of the Coal Baseload IPP Programme, primarily tariff cap and including the maximum net generating capacity of 600 MW, and the requirement for redundancy, placed within South Africa's energy context including the need for additional baseload power at a low cost, influence the choice of technology for the plant (notably the use of subcritical steam conditions and low-grade coal), which, in turn, affect the emissions performance of the Project.
- » Thabametsi's GHG emissions are estimated to comprise about 1.7 – 2.5% of South Africa's Peak, Plateau and Decline trajectory emissions in 2020/21, rising to 2.3 – 4.7% in 2050.
- » The greenhouse effect occurs on a global basis and the geographical source of GHG emissions is irrelevant when considering the future impact on the climate. Due to the global nature of the greenhouse effect, it is not possible to link emissions from a single source – such as the Thabametsi Power Station - to particular environmental and social impacts in the broader study area. Therefore, in line with international good practice such as that established by the IFC Performance Standards, this report: calculates the projected GHG emissions from the project across its lifetime; compares those emissions against appropriate comparators and reference benchmarks in South Africa and globally; and considers their relevance in the context of South Africa's national GHG emissions and policy.

Numerous GHG emissions management measures are proposed for inclusion in the Environmental Management Plan (EMP) with the objective to minimise GHG impact as far as possible by maintaining and maximising plant thermal efficiency over time. These include:

- » Develop and implement a GHG management policy and plan (combined with a thermal efficiency management plan as appropriate).

- » Measure and track GHG emissions and emissions intensity.
- » Develop a plan to minimise coal feed variability and implement coal drying wherever possible to enhance plant thermal efficiency and reduce GHG emissions.
- » Implement flue gas and cooling system heat recovery and recycling to enhance plant thermal efficiency and reduce GHG emissions.
- » Employ the use of 'smart' instrumentation and combustion controls to track key parameters such that combustion is optimised, and to allow thermal efficiency to be monitored over time.
- » Undertake scheduled maintenance to recover efficiency losses, including major maintenance re-hauls approximately every 5 years.
- » In the event of any future changes in plant operating philosophy, undertake a study to assess potential implications on thermal efficiency, GHG emissions intensity, and total GHG emissions per annum and identify and implement measures to mitigate any negative impacts.
- » Consider the use of co-firing of coal with low carbon, sustainable biomass to reduce GHG emissions and reduce the GHG intensity of the plant in future, if feedstock is available and costs are feasible.

These mitigation measures and recommendations have been added to the EMPr for the Thabametsi Power Station. The updated and the revised EMPr is being released along with this assessment report for public comment.

Based on the analysis of the magnitude of the Project's GHG emissions (Very Large), and informed by the findings from the benchmarking assessment and the impact on the national grid emissions factor, the overall significance rating for the Project is High (Negative). The emissions are of a similar but slightly lower magnitude per kWh generated than those from the Eskom coal-fired power plants which are scheduled to be decommissioned around the time of the Thabametsi plant's entry into service.

The choice of technology and specifications for this Project were informed by the technical requirements of the DoE as set out in the bid criteria under the Coal Baseload IPP Procurement Programme established under the IRP 2010, including the requirements for proven technology and tariff cap of ZAR0.82/KWh.

4.2. Conclusions and Recommendations from the Resilience Study

A number of high level risk mitigation (adaptation) options are proposed in order to help manage and reduce the risks identified. For some risks (e.g. risk of floods and high winds) additional, more focused studies are required in order to understand the level of risk posed. In a number of cases, an adaptive management approach can be followed such that risks are monitored over time, and adaptation plans can be tailored and implemented based on climate impacts 'on the ground'. In other cases, it may be prudent to integrate 'hard' adaptation measures into the project's design to mitigate against future risks; for example, integrating a 'buffer' into planned flood defences (e.g. additional raising of key infrastructure above ground level and/or additional drainage capacity at the site) and installing a cover for the raw water dam to reduce evaporative losses. The implementation of the various measures identified will help to increase the resilience of the project to future climatic changes.

It is recommended that the findings from the CRA are further investigated as the project progresses into more detailed design stages and that the risk assessment and risk register is continually revisited, updated and refined over time. Procedures (integrating with project-level risk management) should be put in place in order to track risks over time and a register of adaptation actions (relating to monitoring, management measures, and technical adaptation measures and projects) should be developed and maintained. This

process should be integrated into plant-level risk management procedures and risk registers that cover broader business/project risk (e.g. political, economic, social etc.). Finally, it will be important for someone or a team of individuals to have ownership of both the climate risk assessment process, and associated risk (and mitigation project) registers.

4.3. Conclusions and Recommendations from the Palaeontological Study

The paleontological study has not identified any palaeontological reason to prejudice the construction of the power plant, its associated infrastructure or any of the alternative routes for a power transmission line, subject to adequate mitigation programs being put in place.

It is recommended that thorough and regular examinations of all excavations that occur within the sediments of the Karoo Supergroup and Cenozoic regolith be made by a palaeontologist while they are occurring. Should any fossil materials be identified, the excavations in that area should be halted in that location and SAHRA informed of the discovery (see Section 3.4 above). A significant potential benefit of the examination of the excavations associated with the construction of the project is that currently unobservable fossils may be uncovered. As long as the construction process is closely monitored it is possible that potentially significant fossil material may be made available for scientific study.

Should scientifically or culturally significant fossil material exist within the project area any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality should be protected and the fossil site excluded from any further mining.

These mitigation measures and recommendations have also been added to the EMPr for the Thabametsi Power Station. The updated and the revised EMPr is being released along with this assessment report for public comment.

4.4. Overall Conclusions

The environmental impact assessment (EIA) for the proposed IPP Thabametsi Power Station was undertaken in accordance with the EIA Regulations of June 2010, in terms of Section 24(5) of the National Environmental Management Act (NEMA; Act No 107 of 1998).

From the conclusions of the specialist studies undertaken within the EIA, it was concluded that the impacts associated with the construction and operation of the power station and associated infrastructure are expected to be of Medium to Low significance with the implementation of appropriate mitigation measures. No environmental fatal flaws were identified to be associated with the proposed project. The findings of the additional studies undertaken do not alter this overall conclusion, although the impact rating associated with climate change impacts is rated as high.

No further recommendations or conditions are required to be included in the Environmental Authorisation for the project. However, the EMPr must be updated to include the mitigations and recommendations from the Palaeontology and Climate Change studies. The updated EMPr is included as Appendix G of this report.

