Bohlweki Environmental (Pty) Ltd

SCREENING STUDY FOR THE PROPOSED COMBINED CYCLE GAS TURBINE (CCGT) POWER PLANT IN THE AMERSFOORT AREA, MPUMALANGA

A PROJECT FOR ESKOM HOLDINGS LIMITED

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1. INTRODUCTION

Eskom Holdings Limited (Eskom) is mandated by the South African Government to ensure the provision of reliable and affordable power to South Africa. Eskom currently generates approximately 95% of the electricity used in South Africa. Electricity cannot be stored and must be used as it is generated. Therefore, electricity must be generated in accordance with supply-demand requirements. Eskom's core business is in the generation, transmission (transport), trading and retail of electricity. In terms of the Energy Policy of South Africa "energy is the life-blood of development". Therefore, the reliable provision of electricity by Eskom is critical for industrial development and related employment and sustainable development in South Africa.

1.1. The Need and Justification of the Proposed Project

The Department of Minerals and Energy has established a National Energy Policy and performs Integrated Energy Planning (IEP) to identify future energy demand and supply requirements. The National Energy Regulator of South Africa (NERSA) performs National Integrated Resource Planning (NIRP) to identify the future electricity demand and supply requirements. Similarly, Eskom continually assesses the projected electricity demand and supply through a process called the Integrated Strategic Electricity Plan (ISEP).

Through these assessment and planning processes, the most likely future electricity demand based on long-term Southern African economic scenarios is forecasted, and provides the framework for Eskom and South Africa to investigate a wide range of supply and demand-side technologies and options. Eskom's ISEP provides strategic projections of supply-side and demand-side options to be implemented in order to meet these long-term load forecasts. It provides the framework for Eskom to investigate a wide range of new supply-side and demand-side technologies, with a view to optimising investments and returns.

Based on the above planning processes, and in order to meet the projected 4% annual growth in demand for electricity, various projects are underway and are at various stages of implementation. These include base load technologies such as coal fired plants, combined cycle gas turbines and conventional nuclear as well as peaking technologies such as pumped storage schemes and open cycle gas turbines.

There are currently 38 projects in Eskom's "project funnel", which demonstrate the range of supply options being considered by Eskom to meet the increasing demand for electricity in the country. These projects are at different stages of development, ranging from research projects to new-build projects.

Eskom is committed to investigating and evaluating the options for the diversification of the energy mix over time (including renewable resources) and as part of an ongoing effort to evaluate the viability/feasibility of all supply-side options, a number of power generation technologies, not yet implemented in South Africa on a commercial basis, are being evaluated in terms of technical, socio-economic and environmental aspects. One such type of technology is Underground Coal Gasification (UCG), which has been successfully proven to be commercially viable, and Eskom plans to implement it as a fully commercially operating operation. In this project, it is proposed that a UCG-CCGT complex is operated, as explained below.

UCG is a gasification process carried out on "unminable" coal seams. These are coal seams that cannot be mined by using the conventional coal mining methods e.g. open cast or underground mining. UCG involves injecting steam and air (or oxygen) into a cavity created in an underground coal seam, to form a synthetic natural gas. The UCG plant on the farm Roodekopjes, Mpumalanga, has proven to be technically feasible for operation beyond the pilot plant level. Fuel from the UCG plant will be used as fuel for combined cycle gas turbine (CCGT) technology and potential co-firing with coal in the Majuba power station, thus the development of a UCG-CCGT power complex.

A **combined cycle** is characteristic of a power producing engine or plant that employs more than one thermodynamic cycle. Heat engines are only able to use a portion of the energy their fuel generates (usually less than 50%). The remaining heat from combustion is generally wasted. Combining two or more "cycles" such as the Brayton Cycle and Rankine Cycle results in improved overall efficiency.

In a **combined cycle** power plant (CCPP), or combined cycle gas turbine (CCGT) plant, a gas turbine generator generates electricity and the waste heat is used to make steam to generate additional electricity via a steam turbine; this last step enhances the efficiency of electricity generation. Most new gas power plants in North America and Europe are of this type. In a thermal power plant, high-temperature heat as input to the power plant, usually from burning of fuel, is converted to electricity as one of the outputs and low-temperature heat as another output. As a rule, in order to achieve high efficiency, the temperature difference between the input and output heat levels should be as high as possible (Carnot efficiency). This is achieved by combining the Rankine (steam) and Brayton (gas) thermodynamic cycles. Such an arrangement used for marine propulsion is called *Combined Gas (turbine) And Steam (turbine) (COGAS)*. The power plant combined cycle has a boiler called a Heat Recovery Steam Generator (HRSG) which produces steam using the exhaust gas at approximately 600 °C from an open cycle gas turbine. The steam is then used to drive the steam turbine which is also linked to the generator.

This study is only applicable to the CCGT component of the complex.

1.2. Overview of the Proposed Project

The project involves the proposed establishment of a CCGT plant and associated infrastructure in the Mpumalanga Province. A CCGT plant uses a cycle configuration of gas turbines, heat recovery system generators (HRSG) and steam turbines to generate electricity.

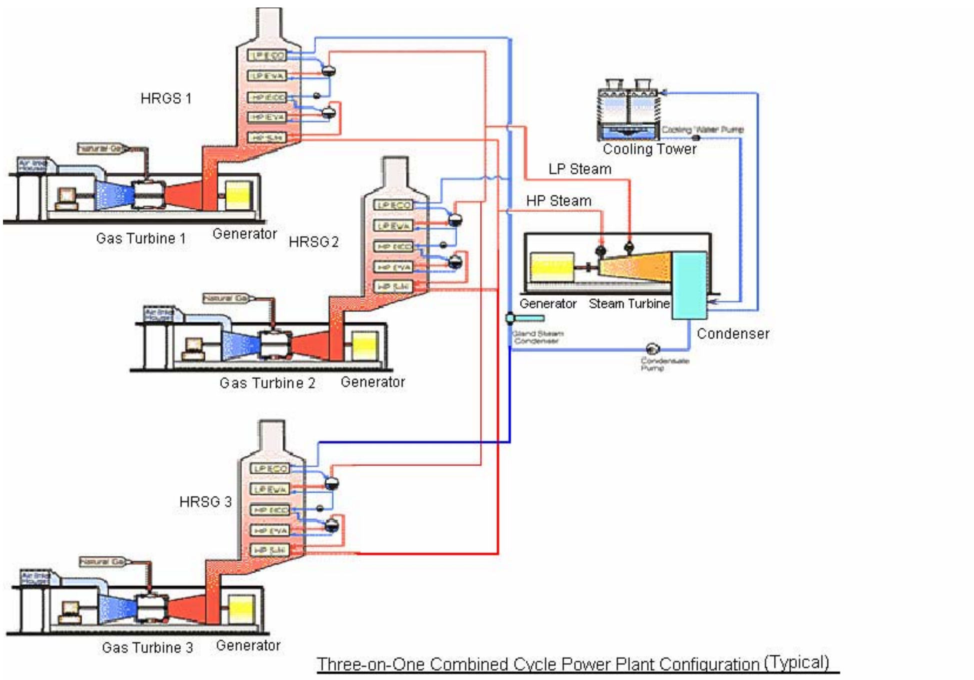

Figure 1.1 A typical 3-in-1 CCGT power plant configuration, in model form

The gas turbine is the first stage in the process of producing electricity through the CCGT plant. The gas turbine compressor draws in air from the environment via a filter. This air is compressed in the compressor, which means that it is elevated to a higher pressure, and then directed into the combustion chamber. Combustible gas is then mixed in and combustion takes place generating hot gases under high pressure. The energy that is released is converted into a mechanical rotation which powers the compressor and the generator.

When the hot gas exits the turbine as exhaust gas, it has a temperature of up to 600℃. This heat energy is transferred to the water in the heat recovery steam generator. The heat is used to generate water vapour, which powers the steam turbine. The resulting mechanical energy is transferred to the generator. In the generator mechanical energy from the steam turbine is converted into electricity. The condenser converts exhaust steam from the steam turbine back into water by means of cooling.

It is anticipated that the CCGT power plant will have approximately 2100 MW of installed capacity. The proposed project will consist of the following components:

- the CCGT power plant (comprising 6 units of approximately 350 MW each)
- a compressor plant
- a gas cleaning plant
- Ignition gas for unit start-up (using commercial propane)
- Weather and communication mast of up to 60 meters in height
- high voltage yard
- a gas pipeline from the UCG pant to the CCGT
- a water pipeline from the Rietpoort Balancing Dam
- a water treatment plant as well as ancillary works such as access roads, borrow pits and other associated infrastructure.
- Sewage treatment plant
- Borrow pits (limited to 1.5 ha each).

2. APPROACH TO SITE SELECTION

2.1. Introduction

A site selection process was initiated in the pre-screening study to identify potential ideal/preferred areas within the study area. The study area was demarcated using a 10 km radius around the UCG plant, off-coal resources. A sensitivity mapping exercise was undertaken for the study area in order to establish the best possible sites to evaluate during the scoping phase of the project. The purpose of such an exercise was to identify suitable areas within the study area that could accommodate the CCGT plant and associated infrastructure and to pro-actively identify sensitive areas that should ideally be avoided.

2.2. Sensitivity Mapping

The qualitative sensitivity mapping exercise divided the study area into three categories *viz.* ideal, acceptable and sensitive. A site sensitivity map for the study area, indicating sensitive areas, acceptable areas (areas with medium or average sensitivity) and ideal areas (least sensitive areas), was requested from each of the following specialist fields:

Biophysical

- Groundwater
- Surface Water
- Ecology

Social

- Air
- Noise
- Social
- Heritage
- Visual
- Risk
- Traffic

Table 2.1 provides a description of the various categories used in the sensitivity mapping.

Table 2.1 Description of the various categories used in the sensitivity mapping

Study Component	Category	Description
Hydrogeology	Sensitive	Shallow coal, average borehole yields > 0.8 l/s, average groundwater levels < 10 m.
	Acceptable	Deep coal, average borehole yields 0.3 to 0.8 l/s, average groundwater levels 10 -20 m.
	Ideal	Average borehole yields <0.3 l/s, average groundwater levels > 20 m.
Hydrology	Sensitive	Within 100 m of water bodies and on slopes steeper than 5%.
	Acceptable	Over 100 m from water bodies and on slopes of less than 5%.
	Ideal	Over 200 m from water bodies on slopes of less than 2%.
Ecology	Sensitive	Wetlands, rivers, streams, marshes, rocky outcrops, pristine grassland, Red Data habitat.
	Acceptable	Agricultural lands, degraded grassland.
	Ideal	Transformed habitat, areas of extensive degradation, existing infrastructure.
Air Quality	Sensitive	Zone containing potentially expanding and permanent residential settlements.
	Acceptable	Zone within wind dispersion field with potentially sensitive receptors but whose land if purchased by Eskom would be relocated and would no longer be considered sensitive.
	Ideal	Zone within wind dispersion field and with no potentially sensitive receptors.
Noise	Sensitive	Zone 3: • The new facility should be closer than 4 km to urban areas (the town of Amersfoort) and any informal settlement. • Areas east of National Road N11.

Study Component	Category	Description
	Less acceptable	Zone 2: Areas where construction is possible, as the Majuba power station is already the centre of a noise degraded area, but less desirable than in Zone 1.
	Most acceptable	Zone 1: Area at or within a 10 km radius of the Majuba Power Station. Subject to consideration of isolated noise sensitive sites. Proviso that if the CCGT power plant is at or within three (3) kilometers of the Majuba Power Station, special consideration is to be given to the acceptability of the cumulative affects at affected noise sensitive sites.
Social **a. Demographic**	Sensitive	Displacement and resettlement of people are necessary. Inhabitants of houses in close proximity to the proposed CCGT do not have the choice to resettle elsewhere (distance informed by visual, noise and risk specialist study).
	Acceptable	Visual, noise, air quality and traffic impacts on affected parties are highly significant during construction, but acceptable during operation (to be informed by the relevant specialists).
	Ideal	No displacement and resettlement of people are necessary. Houses are not in close proximity to the proposed CCGT (distance informed by visual, noise and risk specialist study).
b. Economic and Land Use	Sensitive	Land use is affected in such a way that those who are dependent on the land to make a living are affected, and mitigation measures cannot neutralise the impacts. Good agricultural land is lost. Potential mining land is lost.

Study Component	Category	Description
	Acceptable	Land use is affected in such a way that those who are dependent on the land to make a living are affected, but mitigation measures can neutralise the impacts. Land that was mined and which are stable, not potentially putting people's safety at risk.
	Ideal	Land use activities can carry on, and people who are dependent on the land to make a living can carry on with their activities. Good agricultural land is not affected. Potential mining land is not affected.
c. Socio-cultural	Sensitive	Socio-cultural activities cannot carry on, and sense of place is irrevocably changed.
	Acceptable	Socio-cultural activities and sense of place are affected but can be mitigated.
	Ideal	Socio-cultural activities are not affected and the sense of place is not disturbed.
d. Institutional	Sensitive	New services and infrastructure is necessary, and not clustered in the vicinity of similar activities.
	Acceptable	Although new services and infrastructure will be necessary, the proposed project is placed in the vicinity of similar activities.
	Ideal	As far as possible, link up with existing services and infrastructure.
Heritage	Sensitive	Heritage resources with qualities so exceptional that they are of special national significance.
	Acceptable	Heritage resources which, although forming part of the national state, can be considered to have special qualities which make them significant within the context of a province or a region.

Study Component	Category	Description
	Ideal	Other heritage resources worthy of conservation, and which prescribes heritage resources assessment criteria, consistent with the criteria set out in section 3(3) of the National Heritage Resources Act (Act No 25 of 1999), which must be used by a heritage resources authority or a local authority to assess the intrinsic, comparative and contextual significance of a heritage resource and the relative benefits and costs of its protection, so that the appropriate level of grading of the resource and the consequent responsibility for its management may be allocated in terms of section 8 of the said Act.
Visual	Sensitive	Areas within a 2 km buffer from populated places (Amersfoort, Vlakplaats and Daggakraal). Areas within a 500 m buffer zone of major roads. Areas that fall within elevated topographical units (e.g. ridges, crests, hills, etc.).
	Acceptable	Areas not falling within the *Ideal* or the *Sensitive* categories.
	Ideal	Areas within a 2 km buffer zone from already vertically disturbed industrial or mining land.
Risk **a. Toxics**	Sensitive	Not applicable
	Acceptable	Not applicable
	Ideal	1 % fatality
b. Flash Fires	Sensitive	½ Lower Flammable Limit
	Acceptable	Not applicable
	Ideal	Not applicable

3. GENERAL DESCRIPTION OF THE STUDY AREA

3.1. The Biophysical Environment

3.1.1. Geology

The majority of the study area is underlain by Karoo Supergroup sedimentary rocks of the Vryheid and Volksrust Formations of the Ecca Group. These are largely comprised of sandstone, mudstone, shale, siltstone, and coal seams.

The available geological maps covering the study area did not indicate any major structural features such as faults or fractures. Limited tectonic activity is recognised within the study area, and the only evidence of secondary processes is outcrops of intrusive younger dolerite sills mapped in the Karoo sediments.

Four generations of dolerite intrusions are recognised within the study area, based on olivine or plagioclase content, alteration, and texture. The intrusive dolerite has produced large-scale devolatilisation and structural displacement of the coal. These adverse geological conditions caused the closure of the Majuba Colliery in 1993.

Table 3.1 presents the lithostratigraphy of the study area.

Table 3.1 Lithostratigraphy of the study area

Age	Supergroup	Group	Subgroup	Formation	Lithology
Jurassic					Dolerite
[redacted]					
Permian	Karoo	Ecca		Volksrust	Mudstone, siltstone, shale
Permian	Karoo	Ecca		Vryheid	Sandstone, siltstone, shale, coal

3.1.2. Hydrogeology

The groundwater potential of the Karoo formations located in the study area is limited in their pristine state due to low permeability and storage capacity. Secondary processes, such as weathering, fracturing, etc., are required to enhance the groundwater potential.

Based on regional data, the hydrogeological resource maps, the following hydrogeological information is available for the formations within the study area: -

Volksrust Formation
- Upper and middle Ecca
- Predominantly argillaceous rocks
- Fractured aquifers
- Borehole yields 0.5 to 2.0 l/s

Vryheid Formation	-	Lower Ecca
	-	Intergranular and fractured aquifers
	-	Borehole yields 0.1 to 0.5 l/s

Groundwater hydrochemistry associated with the sediments is variable; the groundwater salinity associated with the formations in the study area can have electrical conductivity concentrations of < 250 up to 1000 mS/m.

The sandstones of the Vryheid Formation of the Ecca Group can be massive and dense and have limited permeability and storage. It thus offers only moderate groundwater yield, especially in the absence of dolerite intrusions.

Contacts between different rock lithologies and bedding planes within the sediments often yield groundwater. The contact zone between the dolerites and the sandstone lithologies can be high yielding. Fractured fault zones, especially if related to tensional stresses, are potentially rich targets for groundwater development.

Groundwater occurs within the joints, bedding planes, and along dolerite contacts within the sediments (as recognised across the study area).

3.1.3. Hydrology

The region in which the CCGT will be situated has a slope varying between from below 1 to above 100% and contains a number of streams and rivers. Most of these are small drainage lines that flow only periodically but a few are perennial rivers with a constant overview. The steeper slopes and the areas around the rivers are the most sensitive areas from a surface water point of view and hence a large area within the 12 km zone around the pilot UCG plant is sensitive from a hydrological point of view.

3.1.4. Biodiversity

The study area is situated in the Amersfoort Highveld Clay Grassland (Vegmap). This vegetation type comprises undulating grassland plains, with small scattered patches of dolerite outcrops in areas. The vegetation is comprised of short closed grassland cover, largely dominated by a dense *Themeda triandra* sward, often severely grazed to form a short lawn.

The conservation status of the study area is regarded as Vulnerable, with a target of 27%. The vulnerable status that is attributed to the vegetation of the area is determined by the VEGMAP database and is based on various targets as well as the regional status of this vegetation type. It must also be borne in mind that the Vulnerable status will, therefore, only be applicable to natural grasslands of the study area, not the entire study area.