



Environmental

REVISED 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 in large quantities 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 a number of 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 various options for the diversification of the energy mix over time (including renewable resources) and as part of an ongoing effort to assess 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 Combined Cycle Gas Turbine (CCGT) Power plant that uses gas from an Underground Coal Gasification (UCG) process as a primary energy, which has been successfully proven to be commercially viable. Eskom plans to use the gas from the UCG facility, which will be implemented as a full commercial operation, as a primary source of fuel for the CCGT power plant to be implemented as a full commercial operation. In this current project, it is proposed that an Underground Coal Gasification-Combined Cycle Gas Turbine (UCG-CCGT) complex is constructed and operated, as explained below.

UCG is a process carried out on coal seams that are not economically viable to mine through conventional mining methods, such as 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 burnable natural gas. The burnable natural gas from the UCG plant in the Majuba area will be used as fuel for combined cycle gas turbine (CCGT) technology thus the development of a UCG-CCGT power complex and co-firing with coal in the Majuba power station. The UCG plant on the farm Roodekopjes, Mpumalanga, has proven to be technically feasible for operation beyond the pilot plant level, and its area of operation will expand to identified nearby coal resources in the future.

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

1.2. Overview of the Proposed Project

A CCGT power plant uses a cycle configuration of gas turbines, heat recovery steam generators (HRSGs) and steam turbines to generate electricity (see Figure 1.1 below). 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%), with the remaining heat from combustion generally being wasted. The combination of two or more "cycles" such as the Brayton Cycle and Rankine Cycle results in improved overall efficiency as no/less heat is wasted.

In a CCGT power plant, a gas turbine generator generates electricity and the 'waste' heat is utilised to produce steam to generate additional electricity *via* a steam turbine cycle; this last step enhances the efficiency of overall electricity generation. 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. This is achieved by combining the Rankine (steam) and Brayton thermodynamic cycles.

The CCGT plant 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.

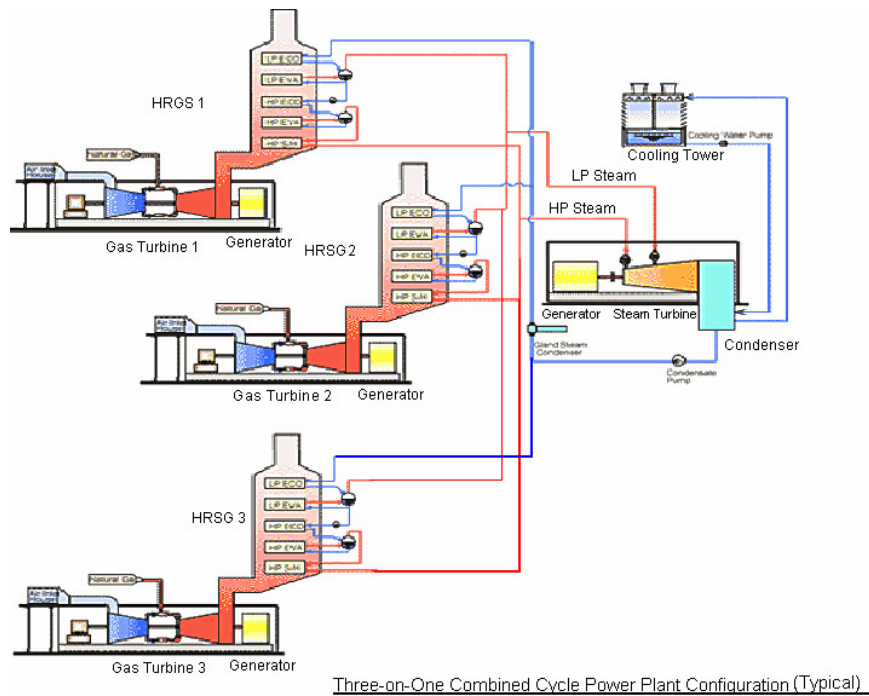


Figure 1.1 A typical 3-in-1 CCGT power plant configuration, in model form

1.2.1. How does a Combined Cycle Gas Turbine (CCGT) work?

The gas turbine (also called a combustion turbine or just the turbine element) is a rotary engine that extracts energy from a flow of combustion gas and is the first stage in the process of producing electricity through a CCGT plant. It has an upstream compressor coupled to a downstream turbine, and a combustion chamber in-between. Figure 1.2 is the schematic of a gas turbine used for the electrical power production. A typical gas turbine unit consists of three major parts:

- **Compressor** – which compresses the incoming air to high pressure;
- **Combustion area** – which burns the fuel and produces high-pressure, high-velocity gas; and
- **Turbine** – which extracts the energy from the high-pressure, high-velocity gas flowing from the combustion chamber

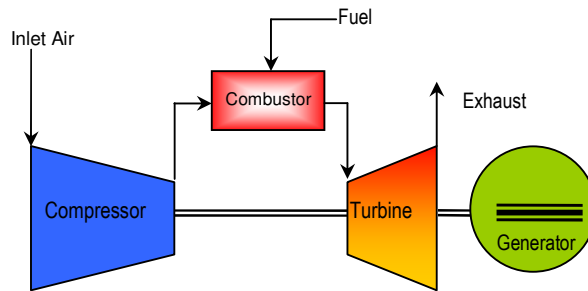


Figure 1.2 Schematic of a process of that a gas turbine undergoes in order to produce electricity.

The gas turbine compressor draws in air from the environment *via* a filter. This air is compressed in the compressor, thus being elevated to a higher pressure, and then directed into the combustion chamber. This combustible gas is then mixed in and combustion takes place generating hot gases under high pressure. The energy released is converted into a mechanical rotation which powers the compressor and the generator.

When used for power production, gas turbines can either be operated in an open cycle mode (exhaust to atmosphere) often referred to as an Open Cycle Gas Turbine (OCGT), or in a combined-cycle mode (CCGT – Combined Cycle Gas Turbine). A key feature of the thermodynamics of the gas turbine cycle is that the temperature of the turbine exhaust stream is typically in the range of 500°C – 600°C. 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 up to 6 units of approximately 350 MW each);
- a compressor plant;
- ignition gas plant, for unit start-up (using commercial propane);
- weather and communication mast of up to 60 meters in height and air quality monitoring station;
- high voltage yard;
- a gas pipeline from the adjacent gas cleaning plant to the CCGT;
- a water supply pipeline from the Majuba allocation or the Rietpoort Balancing Dam (for construction and operational water supply);

- electricity supply for construction;
- a water treatment plant as well as ancillary works such as other associated infrastructure;
- access roads (temporary and permanent);
- sewage treatment plant;
- storage facility for hazardous materials including cement, batching plants etc.;
- storage facility for waste (temporary and permanent storage of general and hazardous waste);
- construction village; and
- borrow pits.

2. APPROACH TO SITE SELECTION

2.1. Introduction

A site-selection process was initiated in the pre-screening study to identify feasible sites 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 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

The social specialist did not provide a map as their sensitivity map was largely informed by the presence of farmhouses and the visual sensitivity map. Furthermore, no sensitivity maps were received from the heritage and traffic specialist fields as it was indicated that the entire study was acceptable for the development of the CCGT power plant.

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 that would be affected by the proposed development.
	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	<p>Zone 3:</p> <ul style="list-style-type: none"> 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.
	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.

Study Component	Category	Description
	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 <i>Ideal</i> or the <i>Sensitive</i> categories.
	Ideal	Areas within a 2 km buffer zone from already vertically disturbed industrial or mining land.
Risk	Sensitive	Not applicable
a. Toxics	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 Eccca 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
Permian	Karoo	Eccca		Volksrust	Mudstone, siltstone, shale
Permian	Karoo	Eccca		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 Eccca

- 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 (Mucina and Rutherford, 2006). 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.

Some 25% of this unit is transformed, predominantly by cultivation (22%). The area is not suited to afforestation. Silver and black wattle and *Salix babylonica* invade drainage areas and the erosion potential is low.

Overgrazing leads to invasion of *Stoebe vulgaris*. Parts of this unit were once cultivated and now lie fallow and have been left to re-vegetate with pioneer grass species. These transformed areas are not picked up by satellite for transformation coverage and the percentage of grasslands still in a natural state may be underestimated.

3.2. The Social Environment

3.2.1. Air Quality

During the screening phase of the project, hourly meteorological data sourced from the UCG Pilot Plant Weather Station was used to determine the atmospheric dispersion potential of the area. The data set spanned the period from October 2006 to August of 2007. Figure 3.1 depicts the wind rose and wind class frequency distribution graphs that were extracted from the data provided. The dispersion potential of the area is briefly described by the wind rose and wind class frequency distribution graph presented in Figure 3.1. The Majuba UCG pilot plant is associated mostly with winds originating from a westerly and easterly direction as is depicted by the wind rose. The field flowing from the west is characterised by high wind speeds greater than 8 m/s, which suggests that pollution emanating from the proposed facility, could be dispersed for large distances eastward from the site. Winds from the east are also noted to occur for 33% of the time, which have a potential to distribute pollutants from the proposed facility in a westerly direction. Calm winds (winds less than 0.5 m/s) are noted to occur 0.6% of the time. Consequently the resultant flow field is from west to east.

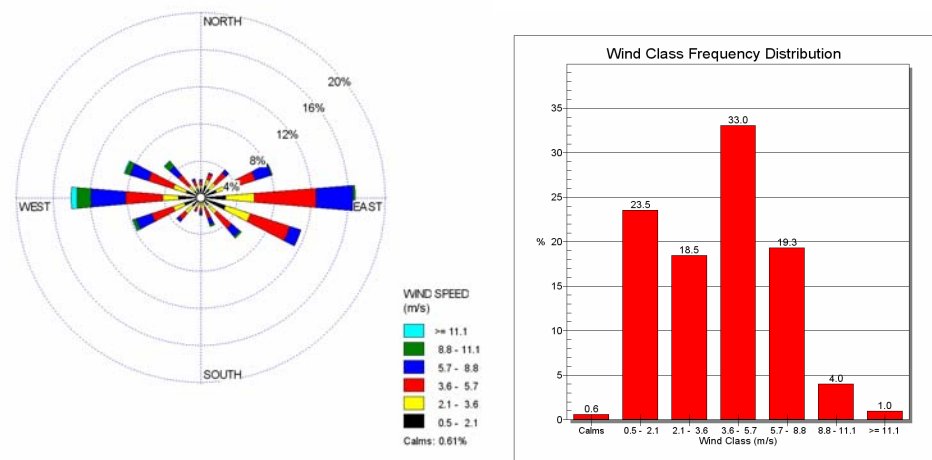


Figure 3.1 The period wind rose and wind frequency distribution for data taken at the Majuba UCG Pilot Plant.

The air quality study criteria used to undertake the sensitivity analysis are summarised as the proximity of the sensitive receptors in the area to other industrial operations in the area and the dispersion potential of the pollutants released into the study area.

The sensitive receptors can be defined as the farms and dwellings that are situated adjacent to (eastward of) the existing Majuba power station. The Amersfoort Town is also situated to the north of the Majuba power station.

The already existing Majuba power station is a potential source of emissions that is contributing to the background pollution levels in the area. This will need to be assessed along with the proposed operations to evaluate cumulative impacts. This will be done in the EIA phase.

3.2.2. Noise

The *noise climate* (ambient noise condition) in the Amersfoort area is quiet and is representative of a rural (farming) noise district (SANS 10103). There is, therefore, a potential for noise impact with the introduction of a new facility such as the CCGT power plant. There are a number of major noise sources in the area namely the existing Majuba power station, the traffic on the main roads and the coal supply railway line to the power station. The noise sensitive sites/areas are Amersfoort town and various farm houses and farm labourer residences in the surrounding area.

3.2.3. Social

The proposed project falls in the Mpumalanga Province in Ward 7 of the Pixley ka Seme Local Municipality (MP 304) within the Gert Sibande District Municipality (DC30).

The Pixley ka Seme Local Municipality lies on the eastern border between Mpumalanga and KwaZulu-Natal. A total of 80 737 people reside within the area in 16 726 households (average 4.8 people per household). Of these residents, 68% of the people live in urban areas, with the remaining 32% residing in largely rural areas. In 2001, just over half (51%) of the people were unemployed, which differs significantly with the unemployment rate of 1996 where it was estimated that only 33% of the population were unemployed. Of those employed, the majority (24%) are employed in the agriculture/forestry and fishing economic sector. This is closely followed by those employed in private households (20%).

According to the IDP of the Pixley ka Seme Local Municipality (2000 Demarcation Data and 2001 Census Data), the ward is characterised by:

- About 5% of the Local Municipality's population falls in this ward;
- One (1) in Five (5) inhabitants is Indian;
- The majority of the population falls within the 15-64 year old age bracket;
- Approximately three quarters of the population do not have a personal income;