Republic of South Africa
Eskom Holdings SOC Ltd.

Preparatory Survey
for
Flue Gas Desulfurization Retrofit Project
for
Medupi Thermal Power Plant
in
Republic of South Africa

Final Report

June 2019

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd.

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Abbreviation

ACC	Air-cooled Condenser
AEL	Atmospheric Emissions License
AfDB	African Development Bank
APH	Air Pre-Heater
ASME	American Society of Mechanical Engineer
BA	Basic Assessment
B-BBEE	Broad - Based Back Economic Empowerment
BD	Basic Design
C/P	Counterpart
CAPEX	Capital Expenditure
Cd	Cadmium
CIDB	Construction Industry Development Board
Co	Cobalt
COD	Commercial Operation Day
CS	Construction Stage
Cu	Copper
DAWF	Department of Water Affairs and Forestry
DEA	Department of Environmental Affairs
DEWA	Department of Water and Environmental Affairs
DoE	Department of Energy
DPE	Department of Public Enterprises
DT	Department of Transport
DTC	Design to Cost
DTI	Department of Trade and Industry
DWS	Department of Water and Sanitation
EAL	Eskom Academy of Learning
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EIRR	Economic Internal Rate of Return
ENPV	Expected Net Present Value
EPS	Engineering, Procurement and Construction
ERA	Execution Release Approval
F	Fluoride
FC	Foreign Currency
FGD	Flue Gas Desulfurization

FIDIC	Fédération Internationale Des Ingénieurs-Conseils (The International Federation of Consulting Engineers)
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
FSL	Full Supply Level
FSR	Final Scoping Report
GC	Gas Cooler
GKC	System Code name for Portable Water system in the Project
GN	Government Notice
GNG	System Code name for Zero Liquid Discharge system in the Project
GoS	Government of South Africa
GTG	General Terms and Conditions for ODA Loans
HTQ	System Code name for FGD Makeup Water Supply system in the Project
HTT	System Code name for Sumps system in the Project
H-V	Height - Volume
IDP	Internally Displaced Persons
IFC	International Finance Cooperation
IPPs	Independent Power Providers
IPS	Interconnected Power System
IRP	Integrated Resource Plan
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
JST	JICA Survey Team
LBG	System Code name for Auxiliary Steam system in the Project
LC	Local Currency
LN	Listing Notices
LWL	Low Water Level
MCWAP	Mokoro and Crocodile (West) Water Argumentation Project
MEIBC	Metal and Engineering Industries Bargaining Council
NEC	The New Engineering Contract
NEM	National Environmental Management
NEMAQA	National Environmental Management Air Quality Act
NEMWA	National Environmental Management Waste Act
NEMA	National Environmental Management Act
NERSA	National Energy Regulatory of South Africa
Ni	Nickel
NOx	Nitrogen oxides

NPV	Net Present Value
NT	National Treasury
NWA	National Water Act
O&M	Operation and Maintenance
O_3	Ozone
OPEX	Operating Expenditure
OHS Act	Occupational Health and Safety Act
OS	Operation Stage
Pb	Lead
PCS	Pre-Construction Stage
PED	Primary Energy Division
PGB	System Code name for Closed Cycle Cooling Water system in the Project
PM	Particulate Matter
PM10	Particulate Matter < 10 microns in diameter
PM2.5	Particulate Matter < 2.5 microns in diameter
ppb	Parts per billion
PPE	Personal Protective Equipment
QFB	System Code name for Compressed Air system in the Project
RBS	Revised Balanced Scenario
RCD	Rotary Car Dumper
South Africa	Republic of South Africa
SGA	System Code name for Fire Protection system in the Project
SIP	Special Infrastructure Programme
SO_2	Sulfur Dioxide
SOC	State-owned Company
SOP	Standard Operating Procedure
SO_x	Sulfur Oxide
TCTA	Trans-Caledon Tunnel Authority
TFR	Transnet Freight Rail
TNPA	Transnet National Ports Authority
TPL	Transnet Pipelines
TPP	Thermal Power Plant
TPT	Transnet Port Terminals
TRE	Transnet Rail Engineering
TRE	Transnet Rail Engineering
WA	Waste Act
WB	World Bank

WDR	Wind Direction
WLGS	Water Level Gauging Station
WUL	Water Use License
WVL	Wind Velocity
WWTW	Waste Water Treatment Works
Zn	Zinc

Chapter 1 Executive Summary

1.1. Necessity of FGD Project

1.1.1. Background and Objective of the Survey

In the Republic of South Africa (South Africa), power demand increased with economic growth according to a published material by NERSA, as shown in Figure 3.1-2, whereas the peak power demand was approximately 37,000 MW as of 2008. The total supply capacity was approximately 40,000 MW. It means that the power supply capacity margin was merely 7.5% exhibiting that the power supply and demand values were so close. Coal-fired thermal power generation accounts for 80% of main power source; however, no power station was equipped with the flue gas desulfurization (FGD) for the longest time. The Government of South Africa (GoS) amended the National Environmental Management Air Quality Act (NEMAQA) for air quality in March 2010. In NEMAQA, sulphur dioxide (SO_2) emissions for new coal-fired thermal PSs are set at less than 500 mg/Nm^3 and are required to be achieved by April 2020 (less than 3,500 mg/Nm^3 for the existing PSs by 2015). As a result, Medupi Thermal Power Station (TPS), the largest coal-fired TPS in the country which started its construction before the revision, must be equipped with an FGD. Unit Nos. 6, 5, and 4 of the Medupi TPS commenced commercial operations in August 2015, April 2017, and November 2017, respectively, and as of May 2019, the rest of the three units are planned to operate in January 2019, March 2019, and December 2019. After approval from the Department of Environmental Affairs (DEA) for postponement of the deadline, the deadline to install and commence operations of FGD for the six units is set in July 2025. Besides, the amendment of the NEMAQA in 2018 made it possible to request five years of postponement of the deadline. In addition, Eskom and the World Bank (WB), one of the co-supporters as funder of the TPS project, agreed that FGD will be installed within six years after the commencement of operations. In addition to the above, because Medupi TPS is located in Limpopo Province, Eskom shall comply with Atmospheric Emissions License (AEL) issued by the Limpopo provincial government.

Section 7.1.4 of the revised AEL requires the installation of FGD in each unit within six years after the first commissioning of each unit from the license holder, i.e., Eskom.

Thus, with this project, respect for emission regulation is an urgent and crucial concern. With this background, Eskom asked the Japan International Cooperation Agency (JICA) to consider providing a loan to construct the FGDs in Medupi TPS in order to have a diverse fund resource.

By reviewing the Basic Design (BD) Report issued by the implementation agency, Eskom, this preparatory survey (the Survey) aims to study the feasibility of the Project, including necessity, concept, preparation of optimum plan, project cost, implementation schedule and plan (including procurement and construction plan), operation and maintenance structure, environmental, and social consideration, aiming for the appraisal for the JICA loan project.

1.1.2. Minimum Emission Standards of NEMAQA

Table 1.1-1 provides a summary of the minimum emissions standards prescribed for solid fuel combustion installations. The SO2 emission requirements for Medupi TPS categorized as the Existing Plant in terms of the minimum emissions standards are as follows:

- 3,500 mg/Nm^3, to be achieved from 01 April 2015 (at 273K, 101.3 kPa, and 10% O_2)
  : Minimum emissions standards for the Existing Plant
- 500 mg/Nm^3, to be achieved from 01 April 2020 (at 273K, 101.3 kPa, and 10% O_2)
  : Minimum emissions standards for the New Plant

However, the compliance timeline with minimum emission standards (500 mg/Nm3) for new plant for the Medupi TPS was examined and revised in the process of issuing the AEL from Limpopo provincial government, as mentioned 3.2.4 of this report. Section 3 of Governmental Notice No.1207 dated 31 October 2018 regarding to the amendment to the limited activities and associated minimum emission standards identified in terms of section 21 of NEMAQA defines that the once-off postponement with the compliance timeframe for minimum emission standards for new plant may not exceed a period of five years from date of issue and no once-off postponement with the compliance time flames with minimum emission standards for new plant will be vailed beyond 31 March 2025. Medupi TPS is categorized as the Existing Plant. The Governmental Notice No.1207 defined that the existing plant to be decommissioned by 31 March 2030 may apply to the National Air Quality Officer for a once-off suspension of compliance timeframes for minimum emission standards for new plant.

Table 1.1-1 Minimum Emissions Standards Prescribed for Solid Fuel Combustion Installations

Application	All installations with design capacity equal to or greater than 50MW heat input per unit, based on the lower calorific value of the fuel used.		
Substance or mixture of substances		Plant status	mg/Nm^3 under normal conditions of 10% 0_2, 273 Kelvin, and 101.3kPa.
Common name	Chemical symbol		
Particulate matter	N/A	New	50
		Existing	100
Sulphur dioxide	SO_2	New	500
		Existing	3500
Oxides of nitrogen	NOx expressed as NO_2	New	750
		Existing	1100

Note: Compliance Time Frames
New Plant must comply with the new plant minimum emission standards from 01 April 2010
Existing Plant must comply with minimum emission standards for existing plant by 01 April 2015
Existing Plant must comply with minimum emission standards for new plant by 01 April 2020

Source: Government Notice No.248 (2010) of National Environmental Management: Air Quality Act (Act 39 of 2004)

1.1.3. Atmospheric Emissions License

Atmospheric Emissions License (AEL) provides categories of emissions standards with timelines for compliance. The TPS must currently comply with Category 1 of Government Notice No. 248 (Table 1.1-1): Combustion Installations for Existing Plant Status. Therefore, based on the compliance timeframe defined by Government Notice No.248, the plant must reduce SO_2 emissions to less than 500 mg/Nm^3.

1.2. Review of Basic Design Report

1.2.1. Performance Guarantee

Eskom had once intended to design the FGD system through consignment of basic and detailed design work to Black & Veatch, guaranteeing its performance in its own responsibility, obtaining an FGD system design license from Steinmuller Engineering GmbH in Germany. It is known that some power generation companies based in the United States of America (USA) try to take a guarantee in order to improve their capacity and decrease project cost. However, they stored adequate knowledge prior to such challenge. Even when Kusile FGD had already operated, the additional installation of FGD on the existing flue gas system requires higher technical capacity. The JICA Study Team recommends that Eskom avoid taking risk of performance guarantee, including keeping top performance of the existing flue gas system and achieving top performance of the FGD.

The JICA Study Team was informed that a similar contract configuration sample was available in an FGD plant of an electric power utility company in the USA licensed by a Japanese FGD engineering company. Such contract configuration may give Eskom advantages to obtain high technical potentials. However, Eskom shall take full responsibility on the technical performance and the completion period of the Project.

1.2.2. Recommendation of Gas Cooler

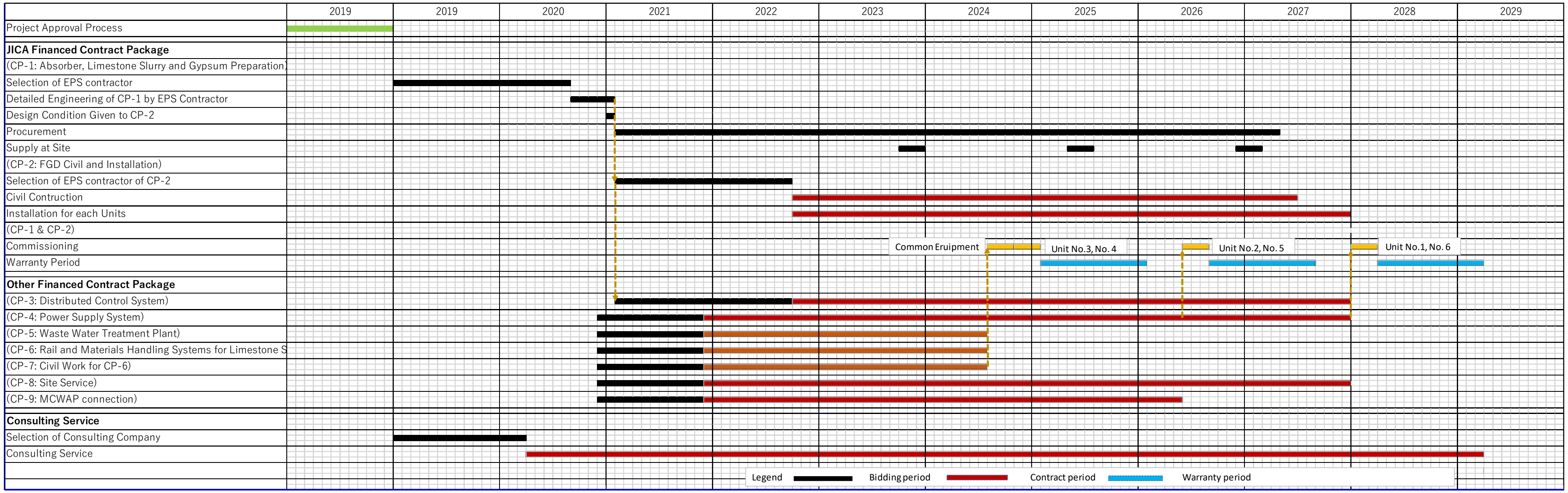
The JICA Study Team recommends adopting the introduction of a Gas Cooler (GC) in order to save water in FGD systems in the region, both in the economic and the ecological points of view.

Increasing draft loss through the introduction of GC in addition to the introduction of the FGD system will be in the draft margin of the existing Induced Draft Fan (IDF). Therefore, the introduction of GC does not require empowerment of draft capacity, e.g., addition of extra IDF and/or modification of existing IDF.

1.2.3. Recommendation of Schedule

The recommended schedule, taking the JICA official development assistance (ODA) loan scheme into account, is shown in Figure 1.2-1.

In the case of applying the JICA ODA loan, the JICA Study Team assumed that the loan agreement will be signed in the middle of 2019 and that the selection of the EPS contractor will start in the beginning of 2019. Selection of the EPS contractor takes at least 14 months in standard JICA procedures. Detailed engineering takes 1.5 years. The ESP contractor will complete the detailed design, providing the design condition in preparing bid documents for other related packages, within one year after the contract.



Source: Prepared by the JICA Study Team

Figure 1.2-1 Recommendation for Schedule

1.2.4. Applicable Standard

Medupi FGD BD described that "the design and specification of work shall be basically carried out under Eskom specific codes and South African codes. However, where no Eskom specific codes and South African codes are applicable, British standards and codes will be used. If British standards and codes are not available, American standards or international standards and codes will be used".

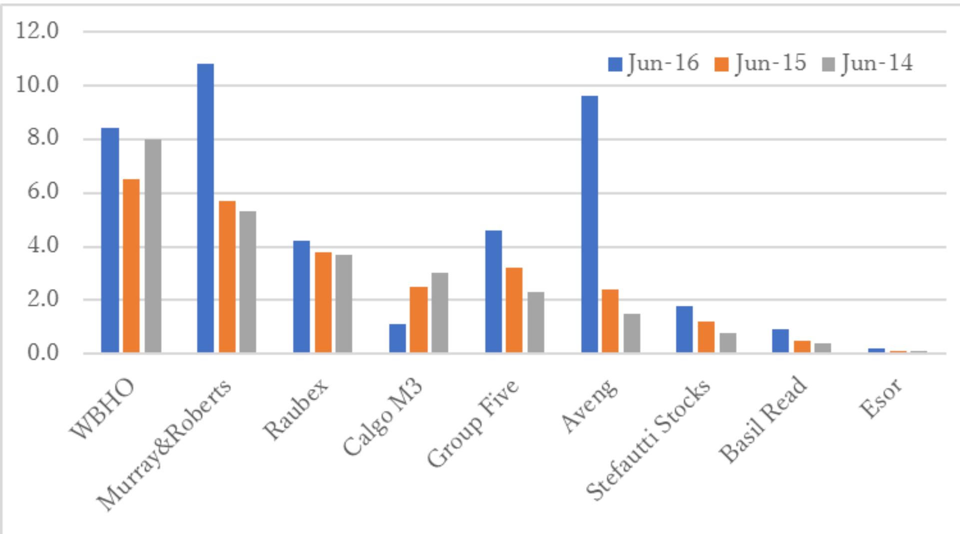
The BD indicates a series of available standards and codes. However, a standard for performance test procedures for FGD has not been specified. There would be no problem in case Eskom will be responsible in taking a performance guarantee for FGD. On the other hand, in the case of making a contractor take such responsibility, it is necessary to specify a standard of performance test procedure for FGD, e.g., ASME. The JICA Study Team recommends that PTC40-2017 from ASME as the standard of performance test procedure be added in the section of applicable standards for tender document.

1.3. Procurement and Construction Philosophy

1.3.1. Construction Market in South Africa

(1) General Information

The construction market in South Africa contributes to securing employment and economic growth despite the recession from 2009 in this field. Nine companies such as WBHO, Murray & Roberts, Raubex, Calgro M3, Group Five, Aveng, Stefautti Stocks, Basil Read, and Esor cover the main position in South Africa. Figure 1.3-1 shows the market value of the nine main companies in the construction market.



Source: SA Construction 4th Edition, PwC

Figure 1.3-1 Market Capitalization of the Top Nine Construction Companies (Unit: ZAR in Billion)

Table 1.3-1 shows the common risks identified by heavy construction companies.

Table 1.3-1 Common Risks Identified by Heavy Construction Companies

Challenges	Actions Required by Industry
B-BBEE and Transformation	
Transformation is a key challenge in South Africa. Despite significant progress since the establishment of a democratic government in 1994, South African society is characterized by income and social service inequalities.	Proactive monitoring of compliance with B-BBEE codes and employment equity targets as well as changes to legislation are imperative in the South African construction industry. Timely transformation strategies (or compliance planes) should follow in order to remain competitive and achieve transformation goals. The transformation commitment in the October 2016 settlement agreement clearly indicate the high importance attributed to transformation by both Government and the industry.
In 2007, the Department of Trade and Industry released original B-BBEE codes, and nine sectors, including construction, have their own codes and the Construction Sector Charter on Black Economic Empowerment was issued in June 2009. Compliance with the charter by the industry is seen as not only societally but also economically imperative.	Construction companies increased their participation in discussions about the new B-BBEE codes while adjusting business practices to be compliant with new codes.
In May 2015, the new B-BBEE codes were gazetted. Amendments to the codes significantly changed the manner in which companies' B-BBEE status is calculated, increasing the number of points required to achieve a particular level. On 4 March 2016, the Minister of Public Works, Thulas Nxesi, convened a high level meeting of construction industry captains and principals with the vies to mapping out an urgent way forward in the finalization of the gazette of the Construction Sector Code.	Other strategic responses included various empowerment programs, a focus on management control and skills development, other internal initiatives, and headhunting.
Non-compliance with employment equity could negatively impact companies in the following manner: Reduce their ability to win tenders; Increase the likelihood of client sanctions and sanctions from the Department of Labor; and Increase the possibilities of penalties being imposed on South African projects.	
Health, Safety, and Environmental Sustainability	
Construction is inherently a high-impact and dangerous industry. Any major incident, while a tragedy in its own right, also has implications for the reputation and ability of the entity involved to procure work in certain sectors. The construction industry has a less than 50 percent rate of compliance with health and safety standards.	Health, safety, and environmental statistics have improved in recent years. However, this needs to be monitored, as well as the reporting of statistics.
Industrial Action	
Ongoing industrial unrest in South Africa continues to cause project delays and disruptions, affecting safety, productivity, and profitability. It also adds a further hurdle to the decision-making process for investment in new capital projects.	In order to mitigate the risk of labor unrest and prevent significant project disruptions and delays, open communication between unions and construction companies to monitor and resolve potential labor issues is essential.
Strikes have reached a new level in terms of number, duration, and violence and have inflicted significant damage to the economy in both the short and medium term.	Strike mitigation plans must be put into place, proactive labor relations strategy with allowances in tenders for labor

	unrest.
This has had an impact on both project and business performance. The recent wide-scale and prolonged industrial action has placed pressure on the underlying contractual relationships.	Proactive engagement with communities prior to project commencement assists to manage expectations.
Liquidity Risk	
A lack of sufficient working capital increases exposure to liquidity risk. This may negatively impact credit, acquisitions, and growth opportunities.	It is essential that cash-flow requirements over the life of a contract be considered at the tendering stage, together with robust working capital cash-flow management.
The negative conditions experienced in the economy has contributed to liquidity problems experienced by construction companies as well as significant cash outlays required for new projects.	Close monitoring and management of outstanding claims and project overheads and tougher debt collection measures are also essential to mitigate liquidity risk.
Talent Management and Staff Retention	
People are an entity's most important asset, and various specialist skills are required to deliver projects successfully. South Africa's construction industry has grown significantly over the last decade, resulting in a skills shortage in the industry at all grades. Loss of skills and expertise affects the ability of companies to successfully complete contracts and undermines expansion. Growth strategies place high demands on companies to maintain appropriate leadership capacity, and this has been a continued focus of 2016.	A remuneration policy focusing on performance and the retention of key talent is essential for the sustainability of business. Regular succession reviews to identify potential talent retention risks and career planning strategies should be undertaken, as should in-house training, promotion from within, and development initiatives.
Growth, Expansion, and Operational Performance	
Growth in the South African construction industry has declined in recent years due to: · The decline in business confidence and the volatile labor market; · Government's reduced spending on infrastructure projects; · Competition in the industry, which has continued to drive down margins; and · Limited expansion into new markets, which has been hampered by volatile commodity prices and exchange rates.	In order to address the risks posed to growth and expansion, companies need to: · Focus on effective contract negotiation on equitable terms, and efficient contract management; · Align capacity with planned with SA Government spend; · Focus on gaining a competitive edge in the market; and · Explore growth options in new and emerging markets
Poor performance has also been a concern. Due to the competitive nature of the market, combined with skills shortages, there is pressure on companies to deliver on projects.	The implementation and monitoring of project management procedures and policies over the life cycle of a project and the assignment of accountability are imperative in mitigating the risks posed to project execution.
Poor execution of contracts results in margin erosion and losses. This includes the risk of poor quality control on site, which results in rework, increased costs, and delayed delivery of contracts.	Increased focus on closing out loss-making projects, improving efficiencies, and productivity.
Macro-Economic Environment	
Continued poor economic performance by the South African economy has had a negative financial impact on business and their operations. This affects business and investor confidence and limits for capital projects and infrastructure.	Maintaining key stakeholder relationships in order to assist in winning of new work in this depressed cycle.
Tender Risk	
There is inherent risk in the tendering process as it requires educated and highly judgmental views to be taken on pricing, mark-up, geological conditions, and the quality and availability of materials.	To mitigate tender risk, extensive tender risk assessment procedures need to be undertaken at the tendering stage of each project.
There is a risk of bidding for and winning contracts on	Experienced estimators should be

onerous terms or under unacceptable commercial conditions.	involved in contract pricing, which is to be subject to review by senior management.
Legislation and Regulatory Compliance	
Non-compliance with applicable legal and regulatory requirements may lead to reputational damage, penalties and fines and may impact the entities operations. The increasingly complex regulatory landscape requires entities to meet new regulatory requirements and stakeholder expectations while supporting performance objectives, sustaining value and protecting the brand.	Compliance with regulatory and legislative requirements is imperative in preventing loss to a business and maintaining a company's reputation in the industry.

Source: SA Construction 4th Edition, PwC

(2) CIDB of Company

South Africa has a Construction Industry Development Board (CIDB). The role of CIDB is facilitating and promoting the improved contribution of the construction industry to South Africa's economy and society. CIDB must promote uniformity of construction procurement, efficient and effective infrastructure delivery, construction industry performance improvement, development of the emerging sector, industry transformation, and skills development.

Home building is not included in the activity of CIDB because it is regulated by the National Home Builders Regulatory Council (NHBRC). Accordingly, contractors undertaking housing projects for the public sector do not need to be registered in the CIDB Register of Contractors. However, the client is only required to register the construction projects on the CIDB Register of Projects. Projects that are above ZAR 200,000 in value, in the public sector and above ZAR 10 million for the private sector and state-owned entities, are registered. The CIDB Register of Contractors was established through Section 5 (1) (d) of the Construction Industry Development Board Act (Act 38 of 2000). It requires CIDB to establish a registry system that categorizes contractors in a manner that facilitates public sector procurement and that promotes the development of construction companies. It is the sole registration and grading system for construction companies in South Africa, and all construction companies seeking to participate in public sector work must be registered on the CIDB Register with the exception of home builders and subcontractors only with labor. The CIDB Register classifies construction companies in nine grades, 1st to 9th, based on their capability to undertake projects.

(3) Construction Availability of Local Construction Company for FGD Project

The construction availability of local construction company FGD project is shown in Table 1.3-2. Based on own experience, the JICA Study Team infers that the construction works regarding FGD are divided into twelve categories, i.e., construction IT and communication, permanent plant IT and communication, FGD absorber construction, duct construction, piping construction, structure construction, electrical construction, superstructure construction, mechanical construction, C&I installation based on own experience, rail road construction and substation construction. All of the local construction companies do not have capability for construction IT and communication and permanent plant IT and communication. AVENGE, GROUP FIVE, and Stefanutti Stocks Civils can cover most of the other construction works.

Table 1.3-2 Construction Availability of Local Construction Company FGD Project

Item	AVENG	GROUP FIVE	Stefanutti Stocks Civils	WBHO
Construction IT & Communication	N/A	N/A	N/A	N/A
Permanent Plant IT & Communication	N/A	N/A	N/A	N/A
FGD Absorber Construction	N/A	Capable	Capable	Capable
Duct Construction	Capable	Capable	Capable	Capable
Piping Construction	Capable	Capable	Capable	Capable
Structure Construction	Capable	Capable	Capable	Capable
Electrical Construction	Capable	Capable	Capable	N/A
Superstructure Construction	Capable	Capable	Capable	Capable
Mechanical Construction	Capable	Capable	Capable	N/A
C&I Installation	Capable	Capable	Capable	N/A
Rail Road Construction	Capable	Capable	Capable	Capable
Substation Construction	Capable	Capable	Capable	N/A

N/A: Not Available

Source: Prepared by the JICA Study Team based on interview with local construction companies

1.3.2. Limestone Market in South Africa

(1) Limestone Procurement

1) IDWALA

IDWALA is one of the biggest limestone manufacturers in South Africa. IDWALA is currently supplying 10,000 tons/month per unit of diameter 20-8 mm limestone for Kusile TPS. IDWALA has the capacity to supply 1.3 million tons per year.

Currently, IDWALA transports limestone from its mine in Danielskuil by rail and off-load to its Vereeniging Plant. IDWALA transports limestone by road using tipper trucks from Vereeniging to Kusile TPS.

IDWALA specializes in limestone with 95% or higher purity and there is no mine that produces lower purity limestone.

2) PPC

PPC is one of the biggest limestone manufacturers in South Africa. PPC is currently not transporting limestone to Medupi TPS and Kusile TPS.

PPC is transporting limestone from its mine in Lime Acres by road to Botswana Power Corporation (BPC) (for Morupule Power Stations) for its FGD plant. PPC provides limestone that is 96% calcium carbonate. There is no mine that produces lower purity of limestone.

3) Afri-Roads

Afri-Roads is a company that deals limestone and gypsum products.

Afri-Roads does not have its own trucks, thus, Afri-Roads hires trucks to deliver limestone. In addition, Afri-Roads has been engaging with Transnet regarding transportation of limestone by rail. Afri-Roads has five limestone suppliers who have distributor licenses.

Afri-Roads also deals with natural and synthetic gypsum. According to Afri-Roads, currently, gypsum in South Africa is in short supply. As of October 2017, Afri-Roads is importing natural gypsum from Middle East. Afri-Roads thinks that the South African market requires around 400,000 tons/month of gypsum at the moment. On the other hand, currently, Afri-Roads is supplying gypsum at 22,000 tons/month. Most of the gypsum is in powder and paste states.

(2) Study on the Specification of Limestone for FGD

1) Purity

As of January 2018, the mines that can supply the necessary quantity of the Medupi TPS are only PPC or IDWALA, both of which produce limestone with a purity of 95% or more.

In case 85% limestone is adopted, it is necessary to develop limestone companies' mines in accordance with the Petroleum Resources Development Law. Considering the smooth and reliable progress of the construction of FGD with the deadline for completion, rather than accepting new risk factors involving consultation with the mining development business, premise utilizing already developed mines is at low risk.

For that reason, it is reasonable to exclude the mines of 85% purity because they are not developed as of January 2018, although the FGD basic design mentioned about limestone with purity of 85%.

2) Grain Size

As previously explained, the limestone company will crush and sift the large lime and then deliver it to the Medupi TPS. Limestone in fine particle size requires much time and labor for processing on the limestone company side, resulting in high cost. Also, limestone in fine particle size may cause dissipation during transportation.

Limestone (IDWALA) to be delivered to the Kusile TPS is 8 mm to 20 mm in diameter; thus, limestone of the same size is proposed for the Medupi TPS by the JICA Study Team.

In FGD, it is grinded into powder form by a mill with limestone preparation equipment. Therefore, the FGD mill should meet the specification that it can process limestone into 8 m to 20 mm diameter.

(3) Unit Price for Limestone

According to an interview with a limestone company, as of January 2018, it is ZAR 196.43/ton (PPC) with the limestone specification described above.

(4) Transportation of Limestone

Mines that produce the limestone specified above are Danielskuil (IDWALA) and Lime Acres (PPC) located in Northern Cape province. The possibility of transportation and its costs are examined in Section 8.2.

1.3.3. Gypsum Disposal

(1) Gypsum Generation at Medupi TPS

In the basic design (BD) for the FGD of Medupi TPS, the amount of gypsum generated from the FGD is estimated as shown in Figure 7.1 6. In the BD, two cases of limestone with purity of 85% and 96% were studied. In the largest cases, it is estimated that the amount of gypsum generated is 248,354.42 kg/h (2.18 M ton/year) with 85% purity of limestone and 233,768.97 kg/h (2.05 M ton/year) with 96% purity of limestone. However, as discussed in Section 7.1.4 "Limestone Market in South Africa", as of January 2018 there is no limestone mine developed with 85% purity that is capable of the required quantity of the Medupi TPS. Thus, it is reasonable to study only the case of 96% purity.

(2) Interview with Local Company

The JICA Study Team had an interview with a local company to investigate the gypsum market in South Africa. The JICA Study Team requested interviews to Gyproc and Marley, but only Marley accepted the offer.

Marley is dealing gypsum products as architectural material. Marley obtains its gypsum (synthetic and natural gypsum) from various mines because Marley's mine was closed and being rehabilitated. Marley is familiar with the Department of Mineral Resources - DMR Act of South Africa and the United States Standards.

Natural gypsum is sourced from Moscow and Spain. The acceptable quality is from 93% with an average of 95% of purity. As for synthetic gypsum, the accepted quality is from 85% to 100% and an average of 92% of purity. Natural gypsum is crushed and mixed with synthetic gypsum to achieve the required volumes for production. Marley produces 15 million squares of boards per year.

Marley buys gypsum with following prices:

- FGD synthetic gypsum –ZAR 300/ton
- OMV (Uranium Plant gypsum) – ZAR 200 to 250/ton
- Water Treatment Plant (gypsum with more magnesium) – ZAR 90 to 200/ton
- Natural gypsum (from Moscow) – ZAR 450 to 550/ton
- Natural gypsum (from Spain) – ZAR 400 to 500/ton

(3) Possibility of Gypsum Disposal

1) Domestic Market

Generated FGD gypsum will have around 88% purity if Eskom adopts a purity of 85%; thus, marketability will be low. On the other hand, if Eskom will adopt a purity of 95%, marketability for plasterboard will be high. However, the demand in Gauteng state will be fulfilled with FGD gypsum supply from Kusile TPS. As a result, the possibility to dispose will be small. Cape Province, another large consumption area of gypsum, will also have low marketability because of higher transportation cost.

2) Foreign Market

Medupi TPS is located far from the shore, so transportation of gypsum to the international port will be more than 1,000 km. This results to high transportation cost, so foreign marketability is assumed to be very low.

(4) Proposal for Gypsum Handling and Exclusion of Exporting Facility

It was assumed to sell the 20% of generated gypsum in the basic design for FGD, but the marketability is deemed very low with the above considerations. Thus, the JICA Study Team suggests not to sell the gypsum.

This change will result in cost reduction because of the omission of exporting facility and its initial cost. On the other hand, 20% of the generated gypsum originally assumed to be exported will be landfilled; thus, the cycle for consolidation of land for landfill will be faster than the original plan.

1.3.4. B-BBEE

(1) Outline of B-BBEE

Broad-Based Black Economic Empowerment Act (B-BBEE Act) was issued in 2003 and amended in 2015. The Black Economic Empowerment (BEE) Advisory Council was founded in 2009, and it consists of the President, Ministers, and representatives from enterprises, the trade union, and the local government.

(2) Classification of Enterprises

Classification of enterprises is shown in Table 1.3-3. Under the B-BBEE Act, enterprises are categorized into three groups, i.e., Exempted Micro-Enterprises (EME), Qualifying Small Enterprises (QSE), and Generic Enterprises. EME is an entity with an annual turnover of ZAR 10 million or less. This group is only required to obtain “a worn affidavit” on an annual basis to indicate black ownership and annual turnover. EME enterprise can automatically get B-BBEE Level 4 or better, depending on their black ownership. QSE is an entity with an annual turnover of ZAR 10 million or more but less than ZAR 50 million. This group is required to comply with all five BEE elements but less onerous than Generic

Enterprises. Generic Enterprises are entities with an annual turnover of ZAR 50 million or more.

Table 1.3-3 Classification of Enterprises

Classification	Annual Turnover	Duty of compliance with BBE element
Exempted Micro-Enterprises (EME)	ZAR10 million or less	No
Qualifying Small Enterprises (QSE)	ZAR10 million or more but less than ZAR 50 million	All
Generic Enterprise	ZAR 50 million or more	All

Source: Prepared by the JICA Study Team based on amended Codes of Good Practice

(3) BEE Elements and Points

In order to measure BEE compliance for entities, Generic Enterprises and QSE scorecards are prepared. Requirements and Points per BEE elements on Generic Enterprise scorecard is shown in Table 1.3-4. Five elements, namely ownership, management control, skills development, enterprise and supplier development, and socio-economic development, are set for measurement of BEE compliance. The Ownership element measures the effective ownership, voting rights, and net economic interest of black people in the enterprise. The management control element measures the effective representation of black people in the board, top, senior, middle, and junior management levels of the enterprise. The skills development element measures the extent to which employers implement initiatives of designers to promote the development of job-related core competencies of their black employees. The enterprise and supplier development element measures the extent to which an enterprise implements initiatives to assist and accelerate the development of Black Empowered Small, Medium, and Micro Enterprises (SMME), including referential procurement. The socio-economic development element refers to specific measures that enterprises and industries undertake to uplift majority of South Africans through socio-economic development programs or organization.

Table 1.3-4 Requirements and Points per BEE elements on Generic Enterprise Scorecard

BEE Element	Requirements	Points
Ownership	25% + 1 vote to black shareholders	25
Management Control	Participation on junior to executive level management by black, black women, black disabled	19
Skills Development	6% of payroll on programmes for black employees 0.3% of payroll on programmes for disabled black employees 2.5% of learnerships for black employees	20 + 5
Enterprise and Supplier Development	80% Procurement from B-BBEE supplier 15% to 40% Procurement from QSE, 50% black owned and more than 30% black women owned supplier 3% of net profit after tax on Enterprisse and Supplier development Initiatives	40 + 4
Socio-Economic Development	1% of NPAT	5
Total		109 + 9

Source: Prepared by the JICA Study Team based on amended Codes of Good Practice

(4) BEE level

The score achieved on the scorecard can be translated to Broad Based BEE status level and BEE procurement recognition level. The matrix for translation to BEE level is shown in Table 1.3-5.

Table 1.3-5 Requirements and Points per BEE elements on Generic Enterprise scorecard

Range of Total Points by Scorecard	Broad Based BEE status level	BEE procurement recognition level
100 or more	1	135%
95 or more but less than 100	2	125%
90 or more but less than 95	3	110%
80 or more but less than 90	4	100%
75 or more but less than 80	5	80%
70 or more but less than 75	6	60%
55 or more but less than 70	7	50%
40 or more but less than 55	8	10%
less than 40	Non-compliant contributor	0%

Source: Prepared by the JICA Study Team based on amended Codes of Good Practice

(5) Priority Element

Three priority elements, i.e., ownership, skills development and enterprise and supplier development, are specified as the principal effect and are set 40% sub-minimum requirement to be complied. If an enterprise cannot comply with the 40% sub-minimum requirements of any the priority element, the broad-based BEE status level of the enterprise will be discounted.

(6) BEE Legislation Requirements for Public Sector

In order to maximize its governmental commitments, to improve local supplier development, and to streamline its procedures, public sector entities have implemented Supplier Development and Localization (SD&L) to their procurement policies. Accordingly, these entities are required to set local content, B-BBEE, and skills development targets as key evaluation criteria in the tenders awarded. These requirements are set on each tender awarded and targets measured as the contract is serviced. Suppliers are subject to penalties in the event of breach of these targets.

(7) Construction Sector Charter

In 2007, the Department of Trade and Industry released the original B-BBEE codes. Nine sectors, including construction, have their own codes and the Construction Sector Charter on Black Economic Empowerment was issued in June 2009.

On 02 November 2015, the DTI released communications on the repeal of sector codes: -

"Sector Charter Councils have until the 15 November 2015 to submit aligned Sector Codes for approval to the Minister of Trade and Industry, Dr. Rob Davies. All existing Sector Codes that have not submitted application for approval to the Minister to be aligned with

Broad-Based Black Economic Empowerment Codes of Good Practice will be repealed. Once sector codes are repealed, entities operating in the affected sectors will use the Amended B-BBEE Codes of Good Practice for measurement.

The background to this action by Minister Davies is that on 15 May 2015, all the existing Sector Codes, which were not aligned to the Amended Broad Based Black Economic Empowerment (B-BBEE) Codes of Good Practice, were given further extension to complete the alignment process by 30 October 2015. The extension was given through a notice, Government Gazette No. 38799, which further stated that consideration shall be made to repeal sector codes that are not aligned and ready for gazetting by 30 October 2015."

The Construction Sector Charter Council (CSCC) was established. CSCC is an executive authority responsible for overseeing and monitoring of the implementation of the Construction Sector Codes (CSC) of Good Practice, which is the legal and mandatory empowerment measurement tool for the construction industry.

Table 1.3-6 Total Amount of Gypsum Generated from FGD

		Crocodile West Water		Mokolo Water	
		Gypsum Production kg/h	Gypsum Purity %	Gypsum Production kg/h	Gypsum Purity %
85% Limestone	Design Coal	145,512.91	88.90	145,697.63	88.85
	Worst Coal	247,536.96	88.48	247,758.45	88.44
	Worst Coal + Attempt	248,111.61	88.48	**248,354.42**	88.43
96% Limestone	Design Coal	139,214.95	96.56	139,281.70	96.54
	Worst Coal	233,249.68	96.49	233,330.49	96.47
	Worst Coal + Attempt	233,680.45	96.49	**233,768.97**	96.47

Source：Basic Design Report/Eskom

1.3.5. Procurement and Construction Philosophy

(1) Procurement of FGD

The composition equipment of FGD are to be classified onshore and offshore as shown in Table 1.3-7. There is a checkmark on both onshore and offshore procurements for the raw materials or some parts that cannot be procured within the country but can be manufactured by imported raw materials and parts. Those with high proportions of materials in FGD are carbon steel materials, plates, and pipes, so many materials can be procured within the country. However, the items for instrumentation control relationships (DSC, etc.) boost up fans and GGH cannot be procured in South Africa, so the proportion of overseas procurement will increase.

Table 1.3-7 Procurement Material Information

No.	Items	Localization	
		Onshore	Offshore
1	Valves	✓	✓
2	Spray Nozzle	✓	✓
3	Pumps (Water)	✓	✓
4	Pumps (Slurry)	✓	✓
5	Agitator	✓	✓
6	Lining of Rubber	✓	
	Lining of FRP	✓	✓
7	Limestone Feeder	✓	
8	Oxidation Air Blower	✓	✓
9	Mist Eliminator	✓	✓
10	Spray Header	✓	
11	Tanks (Metal)	✓	
12	Tanks (Plastic)	✓	
13	Piping (Metal)	✓	✓
14	Piping (Plastic)	✓	
15	Absorber	✓	
16	Duct	✓	
17	Limestone Silo	✓	
18	Structural Steel	✓	
19	Expansion Joint	✓	✓
20	Damper	✓	
21	Insulation	✓	
22	Gypsum Conveyor	✓	
23	Elevator	✓	✓
24	HVAC	✓	
25	Lighting	✓	
26	Gypsum Dewatering System	✓	
27	Limestone Ball Mill	✓	
28	DCS	✓	✓
29	Electrical	✓	
30	Boost Up Fan	✓	✓
31	Gas to Gas Heater (with fine tube)	✓	✓

Source: Prepared by the JICA Study Team based on interview with local material companies

(2) Transport Route for Procurement of Offshore

According to the Eskom Basic Design 03 Construction Execution Plan, offshore procurement items are discharged from one of the following three ports in South Africa.

1) Durban
2) Port Elizabeth
3) Cape Town

The calculation of transportation time should take into consideration the effects of taking heavy equipment transportation by trailer. If one travels on the general road at a speed of 60 km/h to 80 km/h, including break time, the total transportation time is estimated to be the indicated times above. The transport route is shown in Figure 1.3-2. In addition, this driving route has dropped the route based on basic design of Eskom into Google Maps.

Source: Taken by the JICA Study Team using Google Maps (taken in November 2017)

Figure 1.3-2 Transport Route Map

(3) Construction of FGD

The large heavy machinery to be used for FGD construction can be procured in South Africa. There are four main construction companies that own large heavy machineries, namely Mammoet, Liebherr, Sarens, and Tubular. Among these, Tubular has actual performance of producing and installing FGD at Kusile TPS. The man lift (Telescopic Diesel Booms) can be rented from two companies, Eazi Access and Total Access Hire, near the Medupi TPS.

(4) Ability for Workers

In the welding technology and alignment work, more than Category 4 is needed in the process of steel structure manufacturing.

1.3.6. Risk Analysis

(1) Risk of Stakeholder

Delay of the start of operations may occur due to delay of water resource development.

In case the gas heat exchanger will be installed to the FGD, the total water consumption saved at Medupi TPS will be from 13.4 mil. m^3/year to 11.0 mil. m^3/year. Existing water rights from Mokolo and Crocodile River Water Augmentation Project (MCWAP1) is 9.4 mil. m^3/year. Thus, water supply from Mokolo and Crocodile River Water Augmentation Project Phase 2 (MCWAP2) is needed in order to operate all of the FGD.

MCWAP2 is in the design stage and is seeking a source of funding. If some issues, i.e., delay of purchasing fund, land acquisition, or approval of EIA rises, the commencement of water supply will be delayed. The JICA Study Team assumes that the possibility is at a middle level and impact of risk is at a middle level as well.

(2) Risk of Implementation Organization

1) Incapability of the Project Executing Agency

Delay of the project implementation may rise due to the incapability of the project executing agency.

If the executing agency is not capable enough for appropriate process of daily works, timely decision making or coordination with relevant authorities, the project implementation may be seriously delayed. Such an incapability may also lead to a dispute with the project management consultant (PMC) or the contractor regarding contractual or payment issues.

Eskom has experienced controlling and coordinate approximately 30 packages with boiler, turbine, generator, and auxiliary machinery construction work on original Medupi TPS construction.

The JICA Study Team assumes that the possibility is at low level and impact of risk is at middle level.

2) Corruption in the Procurement Procedures of the PIU or the Contractor

Generally, corruption in the procurement processes of the PIU or the contractor may rise in the projects, which may involve huge amounts of money. If this rises, corruption at any process of the project, such as procurement procedures of the PIU or the contractor, would prevent implementation of the project.

If this rises and is exposed, the Project may not proceed. The JICA Study Team assumes that the possibility is at low level and impact of risk is at high level.

(3) Risk of the Project

1) Labor Strike

Delay and overbudget of the project may rise due to labor strikes. In South Africa, labor unions have great power, and they select to go on a long strike frequently. It can be a serious cause of both overbudget and delay of construction work. Usually, the contractor is exempted from responsibilities with risk involving labor strikes as one of force majeure, in the case of project under FIDIC contract. However, Eskom does not accept such exemption in the event that the sub-contractor participates in a labor strike. It means that the contractor may be burdened by all of the risks related to labor strikes.

There is a high possibility of strike occurring, judging from the original Medupi TPS construction work. The JICA Study Team assumes that the possibility of this risk is at a high level, and the impact of this risk is at a high level.

2) No Achievement of Intended Performance

No achievement of intended performance may occur due to many reasons, e.g., construction defects. Unlike the EPC scheme, each of the EPS contractors and the construction contractors have limited liability.

There are some practices of separate EPS and construction contracts in the USA, so an experienced manufacturer as EPS contractor can make an appropriate construction manual. The JICA Study Team assumes that the possibility of this risk is at low level, and the impact of this risk is at middle level.

3) Imperfect Repossession of Installation Cost

Bad debt may occur due to delay of permission for power tariff revision based on the investment to FGD, i.e., environmental measure. FGD does not produce financing benefit, but a huge amount of capital cost and operational cost will be spent. In case permission for power tariff revision will be delayed, Eskom will receive a negative financial impact.

National Energy Regulatory of South Africa (NERSA) does not understand the necessity of the power tariff revision accounted into expenditure for FGD. The JICA Study Team assumes that the possibility of this risk is at a low level, and the impact of this risk is at a high level.

4) Negative Impact on Existing Flue Gas System

Negative impact on the existing flue gas system may occur due to lack of experience and/or capacity of the engineering company. Incapability of engineering (design) works may lead to erosion and lack of pressure.

The existing (under construction) Medupi TPS has a high quality. The equipment for FGD shall also be designed and supplied by well-experienced manufacturers. By doing this, it will make Medupi TPS keep high reliability even after FGD retrofit. The JICA Study Team assumes that the possibility of this risk is at a middle level and impact of this risk is at a high level respectively.

(4) Risk Management Framework

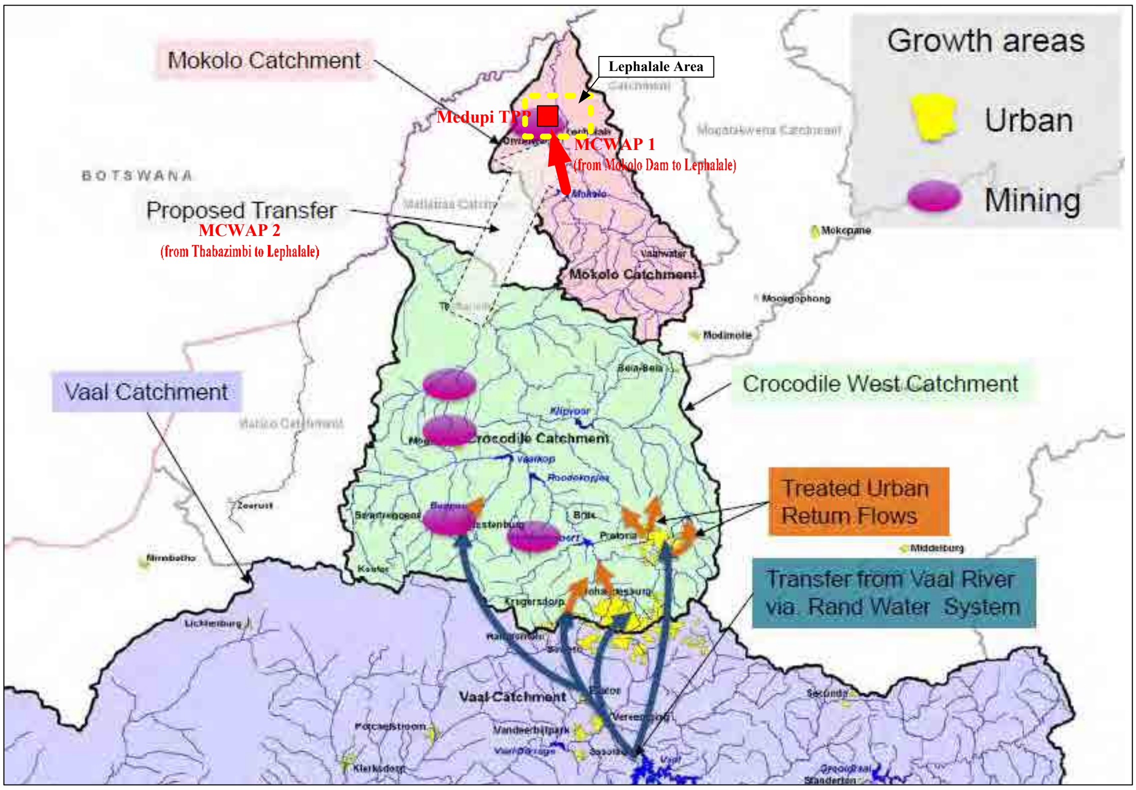
The JICA Study Team prepared draft Risk Management Framework (RMF) sheet as Appendix 7.1.

1.4. Water Resource and Limestone Transportation

1.4.1. Water Resource

The existing water resources of the Mokoro and Crocodile River catchments those supply to the Lephalale area cannot satisfy the future water demand of the Lephalale area. Therefore, DWS plan to increase water supply volume from Vaal River catchment to Lephalale area from current water supply volume through Mokolo and Crocodile (West) Water Argumentation Project Phase 2 (MCWAP2).

Figure 1.4-1 shows the location of Lephalale area, Mokolo River catchment, Crocodile River catchment, Vaal River catchment, existing Mokolo and Crocodile (West) Water Argumentation Project Phase 1 (MCWAP1) pipeline, and planned MCWAP2 pipeline.



Source: Presentation Material of Water Resources Assessments, DWS, 30 Nov.2017

Figure 1.4-1 Location Map of Study Area

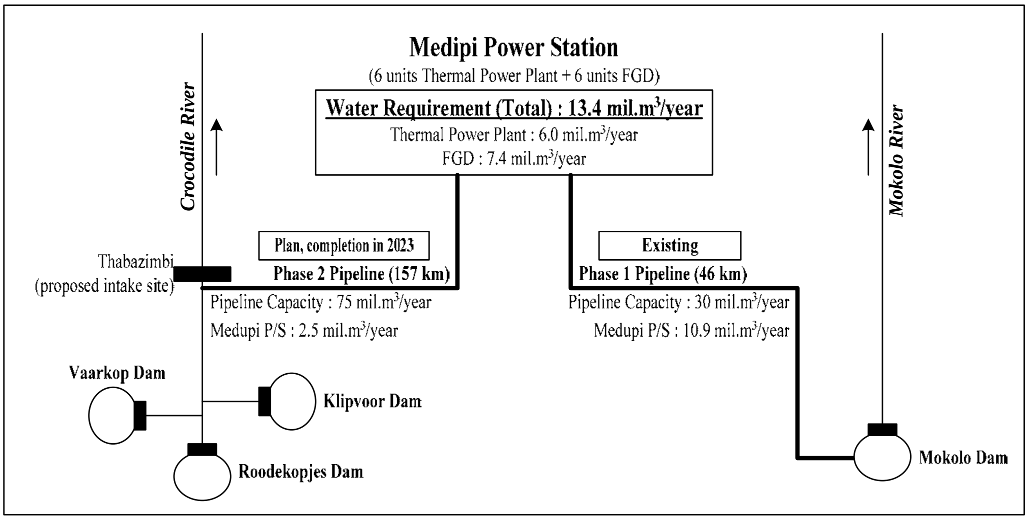
Supply water from the Mokolo River and the Crocodile River catchments is insufficient for future water requirement in the Lephalale area. Therefore, it is necessary to supplement the shortage of water supply through increasing the water supply from the Vaal River catchment. Regarding mentioned shortage of water, it is expected to be dissolved through both expansion of the existing waste water treatment plant and construct a new waste water treatment plant those the DWS are in planning.

(1) Water Resources Plan

According to Eskom and TCTA, the total water uses of 6 units TPS and FGD is 13.4 million m^3/year. The breakdown of TPS and FGD are 6.0 million m^3/year and 7.4 million m^3/year, respectively.

In case that gas cooler will be attached with FGD in purpose of water saving, the water use decreases from 7.4 million m^3/year to 5.0 million m^3/year for FGD 6 units. As mentioned at the Chapter 8, future demand for water use is increased in this area.

The schematic diagram of the water supply plan to Medupi TPS is shown in Figure 1.4-2.



Source: Prepared by JICA Study Team

Figure 1.4-2 Schematic Diagram of Water Supply Plan for Medupi TPS

(2) Water Balance Calculation

1) Water Supply from Mokolo dam

Water supply from Mokolo Dam to the Lephalale area is 30 million m^3/year (2.50 million m^3/month) through the MCWAP1 pipeline. On the other hand, the inflow discharge to Mokolo Dam is 156 million m^3/year (12.98 million m^3/month) It means that there is enough margin for water use in Lephalale area.

2) Water Supply from Crocodile West Catchment

a) Comparison between downstream water use of the dams and inflow discharge to the dams

As of 2016, the downstream water use of the dams is 212 million m^3/year (17.67 million m^3/month). On the other hand, the inflow discharges to the dams both of from the dam own basin and from the WWTW in Gauteng province are 129 million m^3/year (10.75 million

m^3/month) and 250 million m^3/year (20.83 million m^3/month) respectively. It means that total inflow discharge is 379 million m^3/year (31.58 million m^3/month).

Therefore, there is a water volume that is acceptable for the water use of 75 million m^3/year (6.25 million m^3/month) by MCWAP2 on a monthly and annual basis. Actual data regarding the inflow discharge from WWTW shows its monthly fluctuation is not much.

b) Consideration of dry season risk

Inflow discharge of dams from the dam own basin decreases by zero m^3/month in months when has little amount of rainfall during the dry season. In this case, the inflow discharge to the dam is 250 million m^3/year (20.83 million m^3/month) from the WWTW in Gauteng province. On the other hand, because water use 287 million m^3/year (23.92 million m^3/month=17.67 million m^3/month +6.25 million m^3/month), water supply to MCWAP2 falls in a shortage of 37 million m^3/year (3.09 million m^3/month).

c) Risk mitigation through extension and expansion of WWTW

In Gauteng province, the extension and expansion of WWTW is ahead in stages. Inflow discharge from WWTW is expected from 250 million m^3/year (20.83 mil.m^3/month) as of 2016 to at least 485 million m^3/year (40.41 million m^3/month) as of 2030. In case the growth rate of WWTW is constant, it is assumed that the shortfall of 37 million m^3/year (3.09 million m^3/month) will be resolved as early as 2019.

In addition, downstream water uses of the dam as of 2016 is 212 million m^3/month (17.67 million m^3/month). EIA of MCWAP2 describes no mention regarding increasing water for irrigation, which accounts for the majority of water use. It is speculated that there will be no significant increase in irrigation in the future.

3) Conclusion

As for the inflow as of 2016, there will be a shortage of water supply to MCWAP2 in the dry season, however it will be dissolved in 2019 due to the expansion of the WWTW in Gauteng province.

1.4.2. Limestone/ Gypsum Transportation

(1) Introduction

In this sub clause, Medupi FGD BD and Medupi Yard Concept Report Volume 1 are reviewed in view of the transportation by railway. A transportation plan will be proposed based on those reports.

(2) Railway Service Overview in South Africa

Freight railway service is performed in a remarkably large scale, and the service is well known as the highest length of the freight train in the world. The current transport volume reached 219 million tons in 2017. The freight rail network is owned by Transnet and is operated and maintained by the TFR division.

(3) Review of Medupi FGD Basic Design (BD)

The total timeline of railroad construction is assumed at 45 months in total, and the basic idea of limestone handling and the storage in the Medupi FGD FS of the project are in the design manual. However, the origin of the limestone to be procured is not mentioned in the report. The destination of the gypsum needs to be examined in a further study and the transport route shall be set accordingly.

(4) Review of Medupi Rail Yard and Off/Loading Facility Concept Report

The main key concepts are listed in the Medupi Yard Concept Report as follows; all the points-sets in the yard is automatically controlled and signaled with a Central Traffic Control.

- Transnet freight rail operating a drop-off pick-up type of mainline service
- 342 operational days
- Max. number of train-consists to be accommodated within the Medupi Rail Yard is four.
- The railway yard consists six lines for limestone and gypsum handling.

As for limestone transportation, the JICA Study Team estimated that the sum of total limestone handling time is at 360 minutes (six hours). As for gypsum transportation, the sum of total gypsum handling time is estimated at 370 minutes (approx. six hours). In the Medupi Yard Concept Report, there is a *12-hour train handling time applicable within the yard*[1], and the estimated time is acceptable. It shall be noted that all the figures are for reference only, and the detailed estimation of time is required for implementation.

(5) Operation Plan

In this study, 143,556 kg/h is used as the required limestone volume for railway transportation subject to be the FDG introduced to all six units of Medupi TPS. In this condition, the volume of limestone is 1.3 million tons/year. The operation days is estimated at a conservative 300 days, and the type of wagon is assumed is a hopper wagon or Rotary Car Dumper (RCD) for limestone and gypsum transportation. The payload is assumed at 50 tons/wagon since the axle load along the route is 20 tons/axle with four axles by RCD.

1) Operation Plan

The total distance between Lime Acer as an origin and Medupi FGD site as a destination is approx. 1,050 km. It takes three days via railway transportation according to Transnet.

The number of wagons needed per day and the number of trains per day are as follows:

- number of wagons needed to be carried: 84 wagons
- applied number of trains per day: 2

Two trains per day is proposed in the project subject to be FGD introduced to all six units of Medupi TPS. The number of wagons was calculated as follows:

- Number of wagon set per train: 42 = 84 wagons/day /2 trains/day

[1] Medupi Yard Concept Report (2015), pp.13, ESKOM

So far, the line capacity has not reached the limit along the route, and there is room to allocate some trains for lime transportation according to TFR. In addition to that, there are several alternative routes between Lime Acers and Medupi FGD site. The alternative route can be set if the line capacity is not enough to transport limestone.

(6) Site Condition

1) Medupi FGD Site

The area is located inside the RoW in ESKOM and the foundation shall be arranged by ground cutting/excavation for railway yard use, but it can be said that the area is appropriate for railway yard in the engineering point of view.

2) Limestone Loading Site (Lime Acers, PPC)

It was confirmed that the limestone loaded wagon, coupled with 20 wagons and 60 wagons, would be done by attaching three 20-wagons set in threes at the yard owned by PPC. The current maximum loading capacity is 2~3 trains per day, and by observation, the loading facility and the yard is good enough to serve limestone.

(7) Project Cost in Railway Yard in Medupi FGD Site

In the Medupi FDG BD, the total railroad construction cost is ZAR 127 million (USD 12.2 million equivalent). The total costing of CAPEX and OPEX are ZAR 233 million and ZAR 4.3 million, respectively, according to the concept report.

1.5. Technical Features and Design Consideration

1.5.1. FGD System Performance

The FGD system performance is the same as FGD BD Report.

The performance design condition that the engineering company should comply with is shown in Table 1.5-1.

Table 1.5-1 Performance Design Basis (100% BMCR)

Parameter	unit	Design Basis Design Fuel	Design Basis Worst Fuel (L/G Dimensioning)	Design Worst Fuel with Tempering Air (Absorber Dimensioning)
Maximum Inlet Flue Gas Temp	°C	200	200	200
Inlet Flue Gas Rate	Nm^3/hr, wet	2,427,840	2,495,520	2,814,610
Inlet Flue Gas Temperature	°C	137	137	137
Inlet Flue gas Pressure range	kPa	91.62	91.64	91.71
Max Inlet SO2	kg/h	8.262	13.32	13.32
	mg/Nm^3 (dry, mg/Nm^3 at 6% O_2)	3.406	5.339	5.378
Max Inlet PM	kg/h	121.3	124.7	123.85

	mg/Nm^3 (dry, mg/Nm^3 at 6% O_2)	50	50	50
Max Inlet HCl	kg/h	388.3	399.2	396.3

Source: FGD BD Report, Project Design Manual

1.5.2. Code and Standard

The design and specification of work shall be in accordance with applicable South African codes, local codes and ordinances, Eskom specific codes, or international codes. Where no South African or Eskom specific codes are available, British standard codes will be used. If British standard codes are not available, American or international codes will be used.

PTC40-2017 of ASME is available as a standard of performance test procedure for FGD.

Available South African codes and Eskom specific codes regarding engineering, procurement, and supply of FGD are shown in Appendix 9.1.

1.6. Organizational Structure for the Project

1.6.1. Project Organization Set-up

It is required that all stakeholders of the Project gather and confirm the progress, share issues, and take necessary actions in a coordinated manner to solve them. The JICA Study Team recommends Eskom to consider the establishment of a Project Steering Committee (PSC) consisting of Eskom, JICA, African Development Bank (AfDB), New Development Bank (NDB), and Arab Bank for Economic Development in Africa (BADEA). Hiring of external consultants to support the project management led by Eskom Team should also be considered.

1.6.2. Organization Set-up during the Design and Construction Stage

It is assumed that the Project will be executed by a team led by Eskom and that the actual design and construction works will be supplemented by external contractors that are to be determined prior to the commencement of the Project. Since many stakeholders will be engaged in the Project, it is important to develop an appropriate project management system, including information sharing and task management among stakeholders. Also, since FGD is a new technology for Eskom, Eskom engineers' active participation in the Project should be considered for them to be able to accumulate experience and knowledge on FGD in Eskom internally.

1.6.3. Organization Set-up for Operation and Maintenance of FGD

FGD is operated by Eskom internally, and maintenance is outsourced to external contractors in principle. As the installation of FGD is held at the Kusile TPS, organization set-up and staffing for operation and maintenance at Kusile Power Station should be of consideration for the organization and staffing set-up for the Medupi TPS. In the initial operation stage, operators and maintenance personnel (including external contractors) should have technical guidance from a technician of an FGD manufacturer. Regarding the maintenance of FGD, utilizing the subsidiary of Eskom that provides maintenance service for operation and maintenance at the Medupi TPS is one option, and this is also in order to accumulate technology and knowledge on FGD inside Eskom.

1.6.4. Recruitment and Human Resource Development for Operation and Maintenance of FGD

Though the new recruitment of additional personnel for the operation and maintenance of FGD is not necessarily planned by Eskom, the consideration for the organization set-up, staffing, terms of reference (TOR) for each personal, shifting schedule, and necessary human resource development plan should be started as soon as the design of FGD is confirmed. With the cooperation from an FGD manufacturer, the development of a comprehensive training course for FGD operation and maintenance should be considered. It should also be considered that the operation and maintenance personnel team at the Kusile TPS and Medupi TPS be instructors and teach knowledge and skills on FGD operation and maintenance to the junior staff of Eskom.

1.7. Environmental and Social Consideration

1.7.1. Baseline of Environmental and Social Condition

(1) Environmental Condition in Lephalale

Lephalale is influenced by the local steppe climate. In 2016, the total amount of annual rainfall is 310 mm. The driest months are July, August, and September with 0 mm of rainfall. In February, precipitation reaches its peak. The annual average temperature in Lephalale is 24.1°C. The topography of the area is flat. Medupi TPS is placed 580 km from the nearest coast. The nearest tributary of Limpopo River flows about 19 km west from the TPS. Water source, including groundwater, is limited. The Lephalale Municipal economy is largely dependent on mining and electricity generation as primary economic sectors.

(2) Project Location and Surrounding Condition

Medupi TPS is located about 15 km west of the town of Lephalale in the Limpopo Province. The FGD system will be designed into the vacant space of the Medupi TPS footprint. Therefore, there is no possibility of a new large-scale development, land acquisition, and resettlement. Marapong Village is placed about 7 km north east from the Medupi TPS, and it is the nearest residential area. There is no residence adjoining the Medupi TPS.

1.7.2. Environmental Law and Regulations

(1) Air Quality Management

Atmospheric Emissions License (AEL) for Medupi TPS was issued by the Limpopo provincial government, as contemplated on 01 April 2015 in terms of the National Environmental Management: Air Quality Act (NEMAQA), 2004.

In the process of issuing AEL above, the postponement for compliance time line for the minimum emission standards for new solid fuel combustion plant defined by Section 21 of the NEMAQA (Act 39 of 2004) was granted by Department of Environmental Affairs (DEA) from April 2020 to April 2025 in consideration of the timing of installation and operation of the FGD system.

(2) EIA, Water Use, and Waste Management

The Medupi FGD project may require the following Licenses and Environmental Authorizations:

- Environmental Authorization for a Full Scoping and Environmental Impact Assessment (EIA) in Terms of the National Environmental Management Act, 1998 (Act No.107 of 1998) (NEMA) and the Environmental Impact Assessment Regulations of 2017;
- Water Use Licensee (WUL) in terms of Section 21 of the National Water Act, 1998 (Act No 36 of 1998) (NWA); and
- Waste Management License (WML) as per the National Environmental Management Waste Act, 2008 (Act No. 59 of 2008) (NEM: WA).

1.7.3. Agreement with World Bank

The funding for Medupi TPS construction came partly from a WB loan, for which the loan agreement is dated 16 April 2010. The agreement sets out the terms of the loan and includes a section on environmental and social safeguards. This section requires the installation of FGD at Medupi TPS.

1.7.4. Environmental Impact Assessment on FGD project

(1) Scoping

The project proponent prepared the final scoring report on the Medupi FGD project in June 2015 through public participation and stakeholder meeting in accordance with the EIA regulations. Considering the project characteristic and the regional environmental and social conditions, there are possibilities of potential negative impact on air quality, noise, waste, water usage, working condition, and accident, due to the implementation of the FGD project activities.

(2) Environmental Impact Assessment and Environmental Management Program

Draft EIA report including EMP was disclosed from February 2018 to April 2018. A series of public meetings on draft EIA report were held in March 2018. The final EIA was submitted to DEA on May 2018, and DEA has granted Environmental Authorization (EA) for the Medupi FGD project on September 2018 (Amendment of EA on October 2018).

1.7.5. Indivisible Project and Associated Project

(1) Medupi Power Station Development Project

In case the next three conditions are satisfied, the associated facilities are defined as the indivisible project, and it is required to examine their impact carefully in accordance with JICA Environmental Guidelines, which are:

i) the associated facilities are not funded as part of the JICA project, ii) the associated facilities would not have been constructed or expanded if the JICA project did not exist, and iii) the JICA project would not be viable without the associated facilities. Therefore, the Medupi TPS Project is considered as an indivisible project from the FGD project. The EIA report on Medupi TPS was prepared in line with South African EIA regulations and with World Bank's safeguard policy because the funding for Medupi TPS construction came partly from a World Bank loan. Granting of conditional authorization for the Medupi TPS project was issued on 21 September 2006. The status of environmental and social considerations was confirmed from the point of view of the JICA Environmental Guidelines requirement, thoroughly reviewing the existing environmental documents and interviewing the Eskom Environmental Team experts. In compliance with the conditions that come with the environmental authorization, environmental management and environmental monitoring are carried out appropriately.

In line with World Bank's Inspection Panel process, the request for inspection of the Eskom Investment Support Project was submitted in April 2010. World Bank has already reported the analysis and findings of the Inspection Panel on all issues raised by the request for inspection, and the process has been closed.

(2) Water Supply Project (MCWAP2)

The MCWAP2 by DWS is addressing the water needs of the Lephalale area. Water users are not only thermal power stations but also urban domestic users, industrial users, irrigation users, and rural area farm users. Therefore, MCWAP2 is not considered as an indivisible project from the FGD project. As for the EIA progress on MCWAP2, the final scoping reports was accepted by DEA in May 2018, and the draft EIA was submitted to DEA in September 2018. The final EIA Report was submitted to the DEA in November 2018, and DEA granted environmental authorization (EA) at the end of March 2019. Through the application process of appeals in line with the EIA regulations, several appeals to EA were submitted to DEA, as of April 2019.

Regarding the construction of the water pipeline from the off-take point on the MCWAP2 to the Medupi FGD Plant, Eskom will be the project proponent. Eskom expects that the BA process for the water pipeline will be concluded on or before December 2019, as of December 2018.

1.8. Implementation Plan

1.8.1. Project Package

The proposed packaging is shown in Table 1.8-1. Originally, Eskom had a project packaging idea that consists of seven separate packages composed of the absorber, a set of limestone slurry and gypsum dewatering, and another five elements. However, the JICA Study Team proposed the unification of the absorber, limestone slurry preparation, and gypsum dewatering, with further separation of "Engineering & Procurement" and "Construction (erection)". The reason for the combination of absorber, limestone slurry preparation, and gypsum dewatering is to secure the performance guarantee of the FGD. These three systems should be unified into a single package. The reason for the separation of the "Engineering & Procurement" and "Construction (erection)" is that international bidders that have a lot of experience can participate in the bid where they can be free from construction risk in case "construction" element is excluded from the scope of the contract. If they are separated, international bidders will release the construction risk with a characteristic legal framework. Through this Eskom can secure the local contents of a construction package.

Table 1.8-1 Proposed Packaging

	Package	Contracting Arrangement
CP-1	Supply of Equipment Absorber, Limestone Slurry Preparation and Gypsum Dewatering	EPS
CP-2	Civil Work and Installation for CP-1	C
CP-3	Distributed Control System	EPC
CP-4	Power Supply System	EPC
CP-5	Waste Water Treatment Plant	EPC
CP-6	Rail and Materials Handling Systems for Limestone Supply and Gypsum Disposal	EPC
CP-7	Civil Work for CP-6	C
CP-8	Site Service	Service providing
CP-9	MCWAP connection	EPC

EPS: Engineering, Procurement and Supply
EPC: Engineering, Procurement and Construction
C: Construction (Civil Work and/or Installation)
Source: Prepared by JICA Study Team

1.8.2. Estimated Project Implementation Cost

The project cost was estimated through FGD BD by design company who was outsourced by Eskom. The cost that is adjusted due to change of estimation condition is adopted.

Cost estimation for the project implementation includes:

- ✓ Capital Cost (spare parts inclusive)
- ✓ Financing Cost
- ✓ Administrative Cost (owner's fee)
- ✓ Taxes and Fees

- ✓ Contingency
- ✓ Cost for EIA
- ✓ Cost regarding Obtaining Permission from local government

The capital cost is approximately JPY 299,000 million as mentioned above.

The financing cost is estimated as shown in the latter chapter on "Economic/Financial Analysis".

The spare parts cost should be included in the capital cost, as spare parts are supplied during the construction period. Recommendable items and the number for spare parts are the same as the items and the number specified in the coal TPS model case of "Cost and Performance Baseline for Fossil Energy Plants" that is published by the Department of Energy (DOE). The summary of the number of spare parts is shown in Table 1.8-2. In case of adoption with high quality equipment and implementation of maintenance with the recommended methodology by their manufacturer, the life cycle of facilities is expected to be at least seven to ten years without using spare parts. However, spare parts should be provided in the event of accidents up to their expected lifetime from commencement of operation. Spare parts will remain with their own capability in the long term, if spare parts will be used.

The project cost for the application for Medupi FGD Retrofit Project is shown in Table 1.8-3. Cost estimation for project implementation is assumed for the application for Japanese ODA Loan. Price escalation was set at 1.7% for foreign cost (FC) and 1.0% for local cost (LC). Interest rate applied was for Japanese Yen Loan (construction: 1.5%, consultant: 0.01%).

The eligible cost, interest during construction, and commitment charge in Table 1.8-3 correspond to the JICA-financed portion.

Table 1.8-2 Summary of Number of Spare Parts

	Spare Item	Number
Sorbent Preparation and Feed	Limestone Weigh Feeder	1
	Limestone Ball Mill	1
	Auxiliaries	1
Flue Gas Clean up FGD and ESP	Pumps	1 respectively
	Belts	1
	Blower	1

Source: Prepared by the JICA Study Team based on "Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity", DOE

Table 1.8-3 Project Implementation Cost (FC and Total: JPY in Million, LC: ZAR in Million)

Item		Total		
		FC	LC	Total
A. ELIGIBLE PORTION				
Ⅰ)	Procurement / Construction	72,651	2,716	95,055
	CP-1 Supply of Equipment Absorber, Limestone Slurry Preparation and Gypsum Dewatering (EPS)	63,953	0	63,953
	CP-2 Civil Work and Installation for CP-1 (C)	0	2,471	20,385
	Base cost for JICA financing	63,953	2,471	84,339
	Price escalation	5,238	115	6,190
	Physical contingency	3,460	129	4,526
Ⅱ)	Consulting Services	1,256	44	1,621
	Base cost	1,092	40	1,422
	Price escalation	104	2	122
	Physical contingency	60	2	77
Total (Ⅰ + Ⅱ)		73,907	2,760	96,676
B. NON-ELIGIBLE PORTION				
a	Procurement / Construction	625	7,823	65,164
	CP-6 Rail and materials handling systems for Limestone Supply and Gypsum Disposal (EPC)	550	87	1,268
	CP-3 Distributed Control System (EPC)	0	434	3,583
	CP-4 Power Supply System (EPC)	0	1,806	14,897
	CP-5 Waste Water Treatment Plant (EPC)	0	2,097	17,303
	CP-7 Civil Work for CP-3, CP-4, CP-5, and CP-6 (C)	0	2,690	22,197
	Base cost	550	7,115	59,247
	Price escalation	44	336	2,814
	Physical contingency	30	373	3,103
b	Land Acquisition	0	0	0
	Base cost	0	0	0
	Price escalation	0	0	0
	Physical contingency	0	0	0
c	Administration cost	0	1,260	10,398
d	VAT	0	2,746	22,658
e	Import Tax	0	444	3,664
Total (a+b+c+d+e)		625	12,274	101,884
TOTAL (A+B)		74,531	15,034	198,560
C. Interest during Construction		4,861	0	4,861
	Interest during Construction (Const.)	4,860	0	4,860
	Interest during Construction (Consul.)	1	0	1
D. Front End Fee		198	0	198
GRAND TOTAL (A+B+C+D)		79,591	15,034	203,620
E. JICA-finance portion incl. IDC (A + C)		78,768	2,760	101,538

Source: JICA Study Team

1.8.3. Disbursement Schedule

The disbursement schedule including all packages is shown in Table 1.8-4. Payment for 2019 will be about 4.9% of the total cost since construction will start in this year. This consists of the construction cost mainly for advance payment. Payment for the total amount from 2020 to 2024 will be approximately 20.6%, 18.2%, 20.6%, 17.1%, and 10.0% of the total cost, respectively. Payment for 2025 will be approximately 4.9% of the total cost after approval of completion of construction, while that for 2026 will be about 3.9% of the total cost after the warranty period is mainly completed during this year. The payment is composed of the construction cost for payment, installation cost, and consultant fee for the construction stage.

Table 1.8-4 Medupi FGD Retrofit Cash Disbursement Schedule including All Packages

Schedule	Payments	
Year	USD in Million	In %
FY2019 (Construction 1st)	170	9.4%
FY2020 (Construction 2nd)	91	5.0%
FY2021 (Construction 3rd)	716	39.7%
FY2022 (Construction 4th)	283	15.7%
FY2023 (Construction 5th)	293	16.3%
FY2024 (Construction 6th)	147	8.1%
FY2025 (Warranty)	103	5.7%
Total	1,802	100.00%

Source: JICA Study Team

Note: Including consultant fee for construction supervision

1.9. Financial and Economic Analysis

1.9.1. Objectives and Methodology of the Financial and Economic Analysis

The financial and economic analyses aim to examine the financial and economic viability of the Project by calculating the Internal Rate of Return (IRR) and the Net Present Value (NPV).

Financial analysis is conducted to evaluate the profitability of the Project from the viewpoint of the project executing organization (i.e., Eskom). To obtain the Financial Internal Rate of Return (FIRR) and the Financial Net Present Value (FNPV), the net benefit of the Project is calculated considering 1) the benefits, i.e., incremental revenue of tariff from the Project, and 2) the cost based on the market price.

Economic analysis is conducted to evaluate the viability of the Project from the viewpoint of the national economy. To obtain the Economic Internal Rate of Return (EIRR) and the Economic Net Present Value (ENPV), the net benefit of the Project is calculated considering 1) the environmental levy, one of the components in the standard tariff, and 2) the economic costs.

1.9.2. Financial Analysis

Financial analysis is divided into two cases. Case 1 is conducted based on the combined cost of 1) coal-fired TPS and 2) FGD and the benefit based on electricity tariff, while Case 2 is based on the cost of FGD alone and the benefit of the tariff that is equivalent to the FGD related cost.

Benefit and cost are compiled and calculated considering the 2017 prices in order to obtain the FIRR. Moreover, 2.97% is used as the discount rate for calculating the FNPV. The FNPV of Case 1 turns positive.

Table 1.9-1 FIRR and FNPV (Case 1: With TPS Cost)

FIRR	FNPV (Million ZAR)	FNPV (Million USD)
10.77%	252,058	17,876

Source: JICA Study Team

On the other hand, the FNPV of Case 2 becomes slightly positive, simply because the tariff applied to the calculation for Case 2 is determined to make the FNPV nearly zero.

Table 1.9-2 FIRR and FNPV (Case 2: Without TPS Cost)

FIRR	FNPV (Million ZAR)	FNPV (Million USD)
2.97%	4	0

Source: JICA Study Team

Sensitivity analysis is conducted for Case 1 and 2 as the actual condition may be different from that assumed for the base case. In the sensitivity analysis, 1) cost increase (+10%), 2) delay in construction (1 year), and 3) the hurdle rate (8.4%) are considered.

The FNPV of Case 1 remains positive in all cases of the sensitivity analysis. Even when a hurdle rate of 8.4% is applied, the FNPV remains still positive. Cost increase and delay in construction could have a small negative impact on the FIRR and FNPV.

Table 1.9-3 Sensitivity Analysis for Financial Analysis (Case 1: With TPS Cost)

Case	Benefit	Cost	FIRR	FNPV	
			(%)	(Mil ZAR)	(Mil USD)
Base case	No change	No change	10.77%	252,058	17,876
Cost increase (+10%)	No change	+10%	10.51%	247,796	17,574
Delay in construction (1 year)	No change	No change	9.98%	240,049	17,025
Hurdle rate (8.4%)	No change	No change	10.77%	36,325	2,576

Source: JICA Study Team

The FNPV of Case 2 (without TPS cost) turns negative except the base case. This leads to the conclusion that careful management for the implementation of the Project is required, though the tariff assumed for Case 2 is rather hypothetical.

Table 1.9-4 Sensitivity Analysis for Financial Analysis (Case 2: Without TPS Cost)

Case	Benefit	Cost	FIRR	FNPV	
			(%)	(Mil R)	(Mil USD)
Base case	No change	No change	2.97%	4	0
Cost increase (+10%)	No change	+10%	2.47%	(2,965)	(210)
Delay in construction (1 year)	No change	No change	2.91%	(323)	(23)
Hurdle rate (8.4%)	No change	No change	2.97%	(12,972)	(920)

Source: JICA Study Team

1.9.3. Economic Analysis

The economic benefit and cost are compiled and calculated in order to obtain the EIRR and are discounted using the social discount rate (2%) for attaining the ENPV. The EIRR is -3.25% and the ENPV turns into a negative value. However, if a higher environmental levy (ZAR 0.05904/kWh) is applied, the EIRR becomes 2.0%, which is equal to the hurdle rate, and the ENPV becomes a small positive value.

Table 1.9-5 EIRR and ENPV

EIRR	ENPV (Million R)	ENPV (Million $)
-3.25%	(18,650)	(1,323)

Source: JICA Study Team

Sensitivity analysis is conducted for economic analysis. The cost increase, delay in construction, and lower hurdle rate (1%) are considered.

Table 1.9-6 Sensitivity Analysis for Economic Analysis

Case	Benefit	Cost	EIRR	ENPV	
			(%)	(Mil R)	(Mil USD)
Base case	No change	No change	-3.25%	(18,650)	(1,323)
Cost increase (+10%)	No change	+10%	-3.57%	(21,208)	(1,504)
Delay in construction (1 year)	No change	No change	-3.40%	(18,382)	(1,304)
Lower hurdle rate (1%)	No change	No change	-3.25%	(17,850)	(1,266)

Source: JICA Study Team

The ENPV of cost increase, delay in construction, and lower hurdle rate remain negative.

1.9.4. Financial Situation and Governance Issues of Eskom

The recent financial statement of Eskom reveals that the revenue has been steadily increasing by around 7% to 9% per year in the last three fiscal years. However, the net finance cost significantly increased, which led to the loss before tax in 2015 and 2017, although Eskom could make net profit after income tax in the consolidated income statement.

The outstanding balance of 1) the non-current asset (property, plant, and equipment) and 2) debt securities and borrowings has been increasing at a rate of 10% to 13% per year due to the implementation of the large-scale capital programs. The increasing balance of debt is likely to impose additional financial burden on Eskom in the future.

The recent cash flow of Eskom clearly shows that the cash generated by operating activities is not enough to cover the required amount of cash for investment activities including the capital programs such as the Medupi and Kusile projects.

Governance is one important factor that influences the operational and financial performance of Eskom. However, there seems to be a weakness in the governance of Eskom, specifically regarding the management team, procurement, and expenditure management. Weak governance seems to have negatively contributed to the financial management.

Eskom has been taking measures to tackle the difficulties on financial and governance issues and to solve these issues. The measures focus on 1) revenue increase, 2) cost management, 3) cash flow management, and 4) strengthening of governance.

1.9.5. Expected Impact of the Project (Operation and Effect Indicators)

Operation indicators are intended to evaluate the operational condition of the Project, which quantitatively check whether the Project is being operated properly.

Table 1.9-7 Operation Indicators

Indicator	Formula	Target
SOx Emission Concentration at Rated Output (Ppm or Mg/M_3)	As shown by the name of the indicator	500 mg/Nm^3
SOx Removal Efficiency (%)	= (1 - amount emitted from the funnel / amount emitted from the boiler) × 100	90%
Desulfurization Availability to Generator Operation Hours (%)	= (Operating hours per year/hours per year) × 100	100%

Source: Prepared by JICA Study Team based on JICA, "JICA Operational Indicator and Effect Indicator Reference in ODA Loan Projects", July 2014

Effect indicators are intended to evaluate the outcome of the Project.

Table 1.9-8 Effect Indicators

Indicator	Formula	Target
Amount of SOx Reduction (Ton/Year)	= Amount emitted from the boiler-amount emitted from the funnel	271 Ton/Year（= 45.297 ton × 6 unit） (3,405 - 500) x 2,225 x 8,760 x 0.8 / 1,000,000,000 =45.297ton/unit

Source: Prepared by JICA Study Team based on JICA, "JICA Operational Indicator and Effect Indicator Reference in ODA Loan Projects", July 2014

Chapter 2 Introduction

2.1. Basic Policy for Implementation of Survey

2.1.1. Background and Objective of Survey

(1) Background and Objective of the Survey

In the Republic of South Africa (South Africa), power demand increased with its economic growth, according to published material by NERSA as shown in Figure 3.1-2, whereas the peak power demand was approximately 37,000 MW as of 2008. The total supply capacity was approximately 40,000 MW. This means that the power supply capacity margin was merely 7.5%, exhibiting that the margin of power supply and demand were so close. The Medium Term System Adequacy Outlook (MTSAO) states that approximately 5,700 MW capacity of the thermal power station (TPS) will shut down in 2023. In fact, 1,800 MW of the capacity of the TPS had already shutdown in September 2018. It obviously shows that the tightening of electric supply and demand remains as a severe issue in South Africa. Coal-fired thermal power generation accounts for 80% of main power source; however, there was no power station equipped with FGD since the 2000s. Therefore, the Government of South Africa (GoS) amended the National Environmental Management Air Quality Act (NEMAQA) for air quality in March 2010. In NEMAQA, Sulphur Dioxide (SO_2) emissions for the new coal-fired TPS is set at less than 500 mg/Nm^3 and is required to be achieved by April 2020 (less than 3,500 mg/Nm^3 for the existing TPSs by 2015). As a result, Medupi Thermal Power Station (TPS), the largest coal-fired TPS in the country, which started construction before the revision, is required to be equipped with FGDs. Besides Unit Nos. 6, 5, and 4 of the Medupi TPS commencing commercial operations in August 2015, April 2017, and November 2017 respectively, the rest of the three units are planned to operate in June 2019, December 2019, and May 2020, as of May 2019. It means that the first FGD should be completed by August 2021. After the approval from the Department of Environmental Affairs (DEA), the deadline to install and commence the operation of FGD for the six units is postponed to July 2025. In addition, Eskom and the World Bank (WB), one of the donors of the TPS project, agreed that the FGD will be installed within six years after the operation's commencement (by the end of March 2025). In addition to the above, because Medupi TPS is located in Limpopo Province, Eskom shall comply with the Atmospheric Emissions License (AEL) issued by the Limpopo provincial government.

Section 7.1.4 of the revised AEL requires the installation of FGD in each unit within six years after the first commissioning of each unit from the license holder, i.e., Eskom.

Thus, with this project, to respect the emission regulation is an urgent and crucial concern. With this background, Eskom asked Japan International Cooperation Agency (JICA) to consider providing a loan for the FGD retrofit at Medupi TPS in order to have a diverse fund resource.

By reviewing the Basic Design (BD) Report issued by the implementation agency, Eskom, this preparatory survey (the Survey) aims to study the feasibility of the Project including necessity, concept, preparation of the optimum plan, project cost, implementation schedule and plan (including procurement and construction plan), operation and maintenance structure, and environmental and social consideration, aiming for the appraisal of the JICA loan project.

(2) Objective Site

Limpopo Province

(3) Objective Survey Organization

The objective survey organizations are as follows:

1) Government of South Africa

- Department of Public Enterprises (DPE)
- Department of Energy (DoE)
- Department of Environmental Affairs (DEA)
- Department of Water and Environmental Affairs (DWEA)
- Department of Water and Sanitary (DWS)
- Department of Transport (DT)
- Department of Trade and Industry (DTI)
- National Treasury (NT)
- National Energy Regulator of South Africa (NERSA)

2) Counterpart (C/P)

- South African electricity public utility "Eskom"

(4) Available Surveys for the Objective Project

The currently available surveys for the objective project are as follows:

1) FGD design

- Basic Design Study, Black and Veatch, 2014, funded by Eskom

2) Water resource investigation around Lephalale

- Mokolo Crocodile (West) Water Augmentation Project Feasibility Study, Africon, 2009, funded by DWS

3) Transport survey

- Basic and Detailed Design of Medupi Rail Yard and Offloading Facility, Bosch Holdings Consortium, 2015, funded by Eskom

(5) Related Laws and Regulations in South Africa

The related laws and regulations for the objective project are as follows:

1) Related to Procurement and Purchasing in South Africa

- Preferential Procurement Policy Framework Act (PPPFA), supervised by NT
- Public Finance Management Act (PFMA), supervised by NT
- Nation Industry Participation Program (NIPP), supervised by DTI
- Competitive Supplier Development Program (CSDP), supervised by DPE

2) Eskom Purchasing Policy

- Application of the Broad-Based Black Economic Empowerment (B-BBEE) Codes of Good Practice within Eskom
- Implementation of Eskom's Black Economic Empowerment Strategy
- Primary Energy Division (PED) contracting requirements for coal
- Eskom Supply Chain Management Policy
- Eskom Supply Chain Management Procedure

3) Power Sector Regulation

- National Energy Regulatory Act (NERA)

4) Environmental and Social Consideration

- National Environmental Management Air Quality Act (NEMAQA)
- National Environmental Management Act
- Agreement with World Bank regarding pollution abatement
- License from Limpopo Province

5) Civil Works

- National Building Regulations and Building Standards Act
- Construction Industry Development Regulations

6) Site Condition and Working Condition

- Construction regulation
- Labor Relations Act

2.1.2. Relevant Standards

(1) Japanese Standards Concerning the Objective Project

Related Japanese standards for the objective project are as follows:

- Standard Bidding Documents Under Japanese ODA Loan
- General Terms and Conditions for ODA Loans (GTG)
- JICA guidelines for Environmental and Social Consideration (April 2010)
- Guidance for the Management of Safety for Construction Works in Japanese ODA Projects

(2) Other Standards Concerning Objective Project

- Health and Safety Guideline for Thermal Power Plants, 2008, IFC

2.1.3. Outline of FGD

(1) Objective of the Introduction of FGD

FGD is a type of technology used to abate sulphur dioxide from flue gas.

Generally, coal includes some sulfur, and sulphur dioxide is generated from coal burning. At a TPS without FGD, the generated sulphur dioxide is emitted through stack then dropped around the TPS. However, sulphur dioxide is a popular pollutant and causes various negative impact such as damage to human and wild animal health, and corrosion to steel and concrete.

(2) Types of FGD

There are many types of FGD systems produced worldwide, which include lime-gypsum system, magnesium hydroxide system, spray-dryer system, circulation system, and utilizing fly ash system. The characteristics of each of the different FGD systems are shown below. All types of FDG systems require supply of water as well as procurement of chemicals and disposal of by-products.

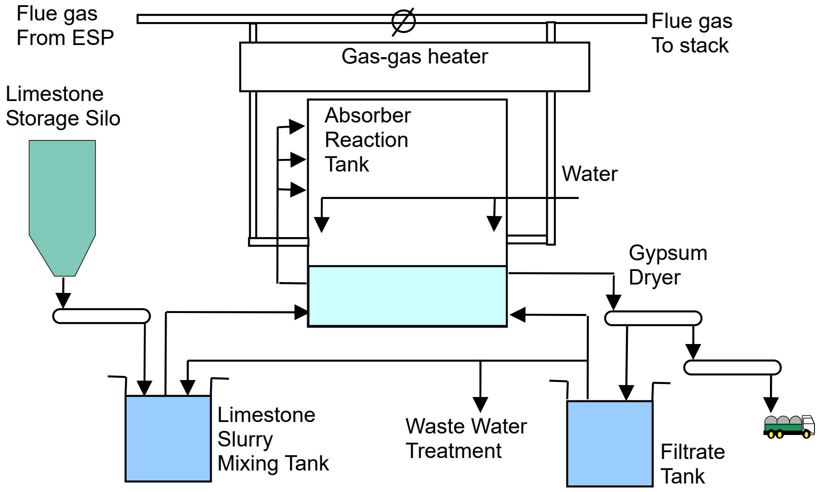
1) Lime-gypsum Type FGD (Wet Type)

Lime-gypsum type FGD is classified into wet type. A typical flow a lime-gypsum system is illustrated in Figure 2.1-1.

The system is installed between the precipitator outlet and the stack. In the absorber reaction tank, the reaction is activated to absorb SO_2, then SO_2 and $CaCO_3$ react mutually and change to gypsum, water, and CO_2.

Installation of wastewater treatment is also needed because a lot of wastewater is discharged.

When trouble occurs in the absorber reaction tank, the flue gas from the precipitator can flow directly to the stack through the bypass vane. During that process, the flue gases go through the bypass vane, and SO_2 is not abated. When trouble occurs in the absorber reaction tank, flue gas from ESP can flow directly to the stack through the bypass valve.



Source: Prepared by the JICA Study Team

Figure 2.1-1 Image of Lime-Gypsum Type FGD

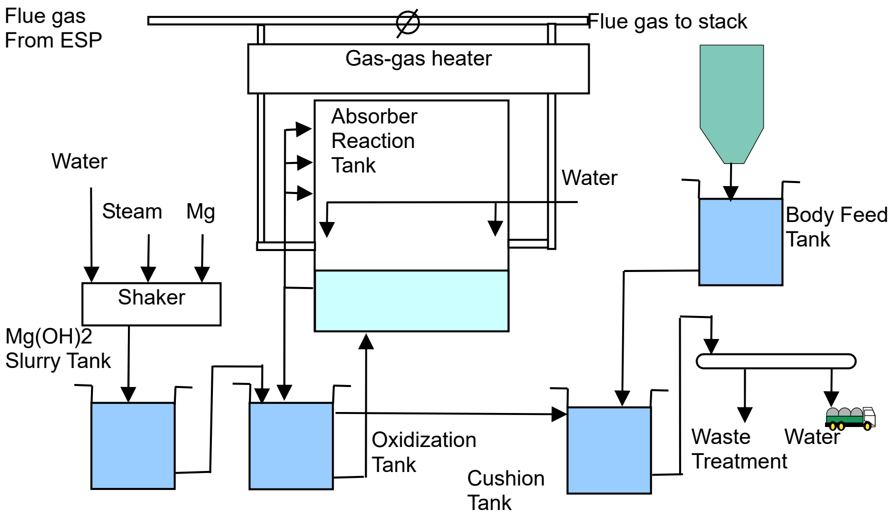
2) Magnesium Hydroxide Type FGD (Wet Type)

The magnesium hydroxide-type FGD is classified as a wet type. The typical flow of a magnesium hydroxide-type FGD is illustrated in Figure 2.1-2.

This type of FGD is installed between the precipitator outlet and the stack. Flue gas from the precipitator passes through the gas-gas heater first, then it flows into the absorber reaction tank. The gas-gas heater cools the inlet gas to reduce the evaporation of water in the absorber reaction tank. Then, the flue gas goes to the gas-gas heater to heat the gas in order to avoid corrosion inside the duct or the stack. In the absorber reaction tank, the reaction is activated to absorb SO_2, then SO_2 and magnesium hydroxide react mutually and change to $MgSO_4$.

Installation of wastewater treatment is also necessary because a lot of wastewater is discharged.

Where trouble occurs in the absorber reaction tank, the flue gas from the ESP can flow directly to the stack through the bypass valve.



Source: Prepared by JICA Study Team

Figure 2.1-2 Image of Magnesium Hydroxide Type FGD

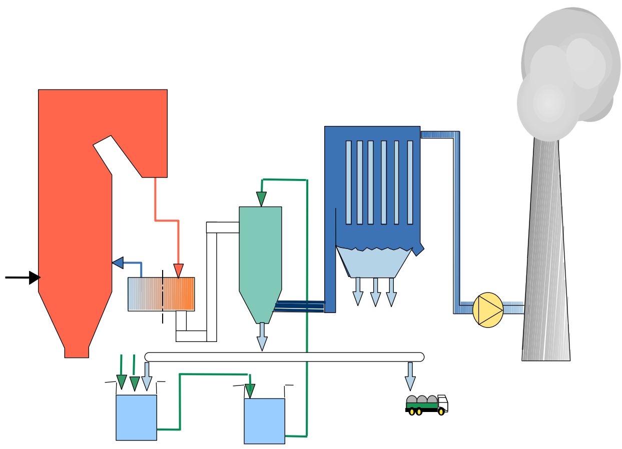
3) Spray-dryer Type FGD (Semi dry type)

The spray-dryer-type FGD is categorized into the semi-dry type. The typical flow of a spray-dryer-type FGD is illustrated in Figure 2.1-3.

The spray-dryer-type FGD is installed between the air heater, the AH outlet, and the precipitator. The flue gas goes into the spray dryer. In the spray dryer, the reaction is activated to absorb SO_2, then SO_2 and calcium hydroxide react mutually to change into gypsum.

Installation of wastewater treatment is not necessary because not much wastewater is discharged.

When trouble occurs in the spray dryer, the unit should be stopped.



Source: Prepared by JICA Study Team

Figure 2.1-3 Image of Spray-dryer Type FGD

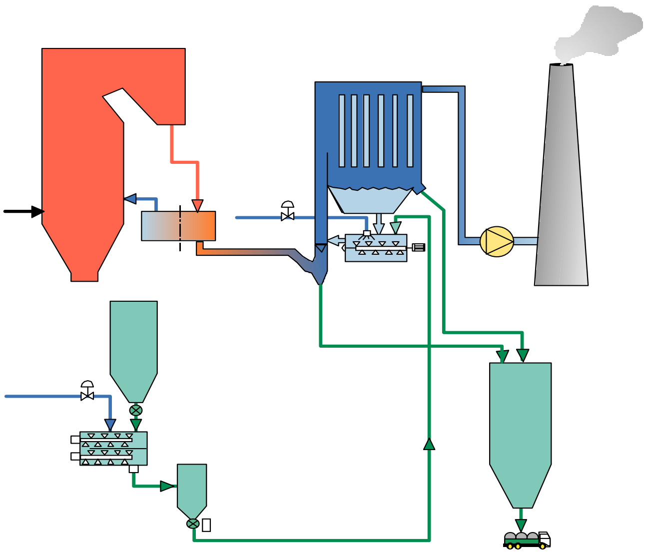
4) Circulation Type FGD (Semi-Dry Type)

The circulation type of FGD is classified into the semi-dry type. A typical flow of a circulation type FGD is shown in Figure 2.1-4.

This type of FGD is installed between the AH outlet and the precipitator. Flue gas is sprayed in the flue gas duct, then goes into precipitator where it is also used as a reaction tower. In the flue gas duct and the precipitator, the reaction is activated to absorb SO_2, then SO_2 and calcium hydroxide react mutually and change to gypsum.

The installation of wastewater treatment is not necessary because not much wastewater is discharged.

Where the existing precipitator is used, the efficiency of the precipitator downtime after FGD installation will be reduced because the reaction is being activated in the precipitator.



Source: Prepared by JICA Study Team

Figure 2.1-4 Image of Circulation Type FGD

5) Utilizing Fly Ash Type FGD (Dry Type)

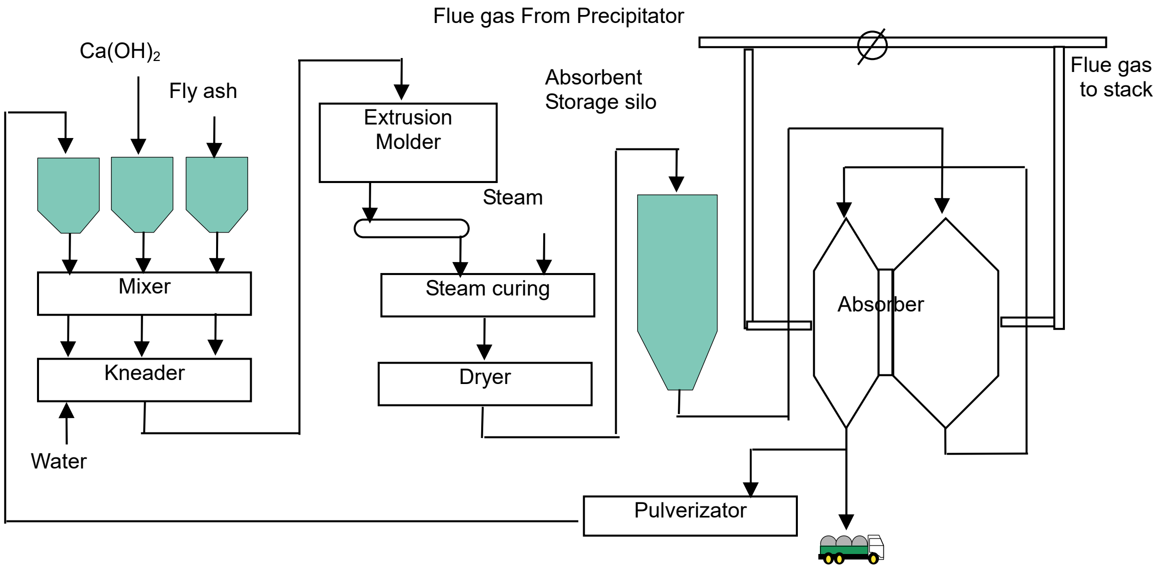
The utilizing fly ash system is classified into the dry type. A typical flow of the utilizing fly ash type FGD is illustrated in Figure 2.1-5.

Some water is consumed in the mixture process for preparation of the solid pellet that is utilized for absorption of the SO_2 in the fly ash type FGD; however, its volume is much less than a wet type FGD.

This type of FGD is installed between the precipitator outlet and the stack. Flue gas goes into the absorber, in which the solid pellets are contained. The pellet is made by mixing the fly ash, quick lime, and used pellets supplying less water to kneading. In the absorber, the reaction is activated to absorb SO_2, then SO_2 and calcium hydroxide react mutually and change into gypsum.

Installation of wastewater treatment is not necessary because not much wastewater is discharged.

Where trouble occurs in the absorber reaction tank, the flue gas from the precipitator can flow directly to the stack through the bypass valve.



Source: Prepared by the JICA Study Team

Figure 2.1-5 Image of Utilizing Fly Ash Type FGD

(3) Comparison of Some Types of FGD System

Comparison for Some Types of FGD is shown in Table 2.1-1. The JICA Study Team recommends applying the lime-gypsum system because of its low initial cost and operation cost and because it is widely used.

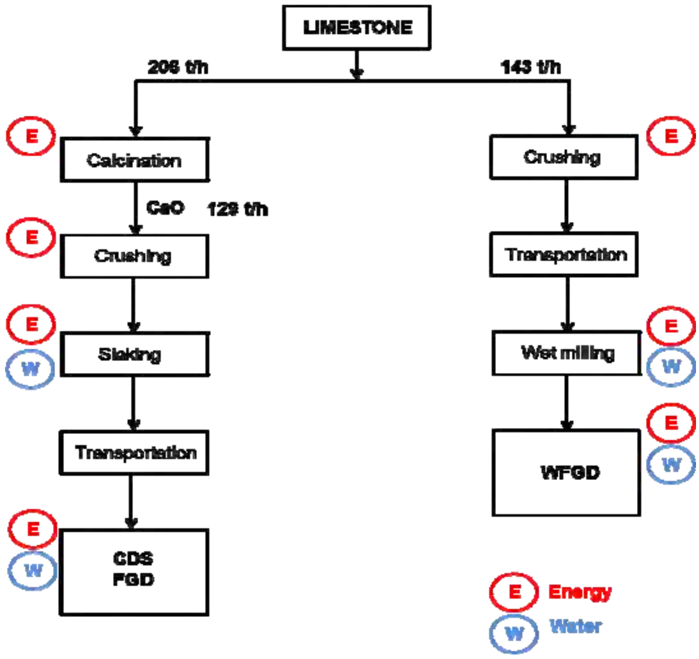
(4) Selection of FGD Type by Eskom

Eskom already selected the lime-gypsum system as of June 2017, which is the commencement of this survey, based on its own considerations. Eskom drew a comparison between the lime-gypsum type and the Circulating Dry Scrubbing (CDS) from the aspect of electric power consumption and water consumption. Comparison of CDS FGD and lime-gypsum type by Eskom is shown in Figure 2.1-6. In this comparison, the electric power reduction is converted to water reduction with coefficient of 0.1997 m^3/MWh. Besides, the CDS FGD case consumes almost the same amount of water compared to the lime-gypsum type with gas cooler of 90°C. However, the CDS FGD requires a huge amount of capital expenditure compared with the lime-gypsum type.

Table 2.1-1 Comparison for Types of FGD

Items	Lime-gypsum (Wet) (Water Saving Type)	Magnesium hydroxide (Wet)	Spray-dryer (Semi dry)	Circulation (Semi dry)	Utilizing fly ash (Dry)
Initial Cost	USD 982 mil. – USD 1,122 mil.	USD 912 mil – USD 1,157 mil.	USD 1,132 mil. – USD 1,412 mil.	USD 1,483 mil. – USD 1,623 mil.	USD 1,438 mil. - USD 1,823 mil.
Operational Cost (annual)	USD 87.3 mil.	USD 109.1 mil.	USD 109.1 mil.	USD 109.1 mil.	USD 100.0 mil.
Efficiency	> 95% Highest efficiency	> 90%	> 70% Low efficiency	> 90%	> 90%
Necessary Water (annual)	7.4 mil. m^3 (5.0 mil. m^3)	10.4 mil. m^3	7.4 mil. m^3	7.4 mil. m^3	1.0 mil. m^3
Kind of Chemicals (Toxicity)	Limestone (Calcium hydroxide invades membrane and the skin, especially eyes)	Magnesium hydroxide (No problem)	Quicklime (Calcium hydroxide invades membrane and the skin, especially eyes)	Quick lime (Calcium hydroxide invades membrane and the skin, especially eyes)	Slaked lime (No problem)
By-products	Gypsum	$MgSO_4$	Gypsum	Gypsum + Ash + Quick lime	Gypsum + Ash+ Slaked Lime
Utilization of By-products	Gypsum can be reused for wall or ceiling materials for building.	$MgSO_4$ can be reused as desulfurization agent.	Gypsum can be reused for wall or ceiling building materials.	By-product cannot be reused, as it becomes cocktail.	By-product cannot be reused, as it becomes cocktail.
Space for Installation	Large area is needed.	Large area is needed.	Necessary to remove existing ESP.	Necessary to remove existing ESP.	Large area is needed.
Abating Dust (PM)	Dust is expected to be abated by FGD.	Dust is expected to be abated by FGD.	Efficiency of abating dust is decreased.	Efficiency of abating dust is decreased.	
Conclusion	Wet type is widely used. To apply the water saving type, the usage water can be minimized, same as semi-dry. Existing FGD can be used.	As the water consumption is high, the type cannot be applied.	The initial cost and operation cost are too expensive. The efficacy is low, and much augmentation is necessary between boiler and stack.	The initial cost and operation cost are too expensive.	The initial cost is too high. There are few supply records.
Recommendation	Recommended to be applied				

Source: Prepared by JICA Study Team



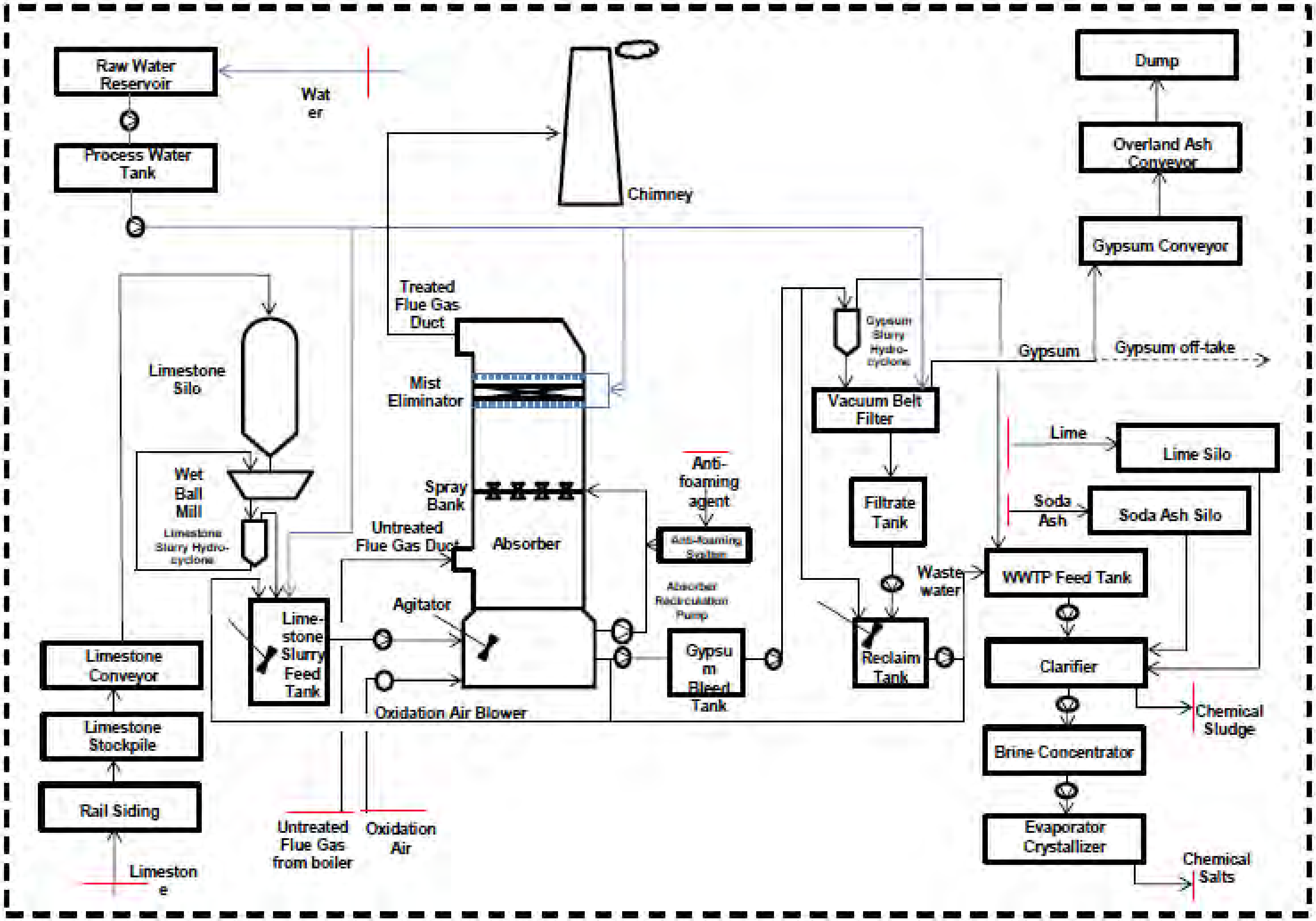
	WFGD	WFGD (with Cooler 100°C)	WFGD (with Cooler 90°C)	CFB-FGD
Total Water (m^3/annum)	6,498,402	4,638,100	4,135,883	3,707,546
Total Power (MWh/annum)	247,642	254,533	254,533	1,015,367
Power to Water (m^3/annum)	49,450	50,826	50,826	202,752
Total Water (m^3/annum)	6,547,852	4,688,927	4,186,709	3,910,298

Source: Power Point Document "Medupi Power Station Flue Gas Desulphurization Project" prepared by Eskom

Figure 2.1-6 Comparison of CDS FGD and Wet FGD by Eskom

(5) Scope of FGD Project

The scope of the Medupi FGD project is shown in Figure 2.1-7. The Medupi FGD project includes not only the FGD system, but also the rail siding for limestone and water supply equipment and waste disposal.



Source: Prepared by Eskom

Figure 2.1-7 Scope of FGD Project

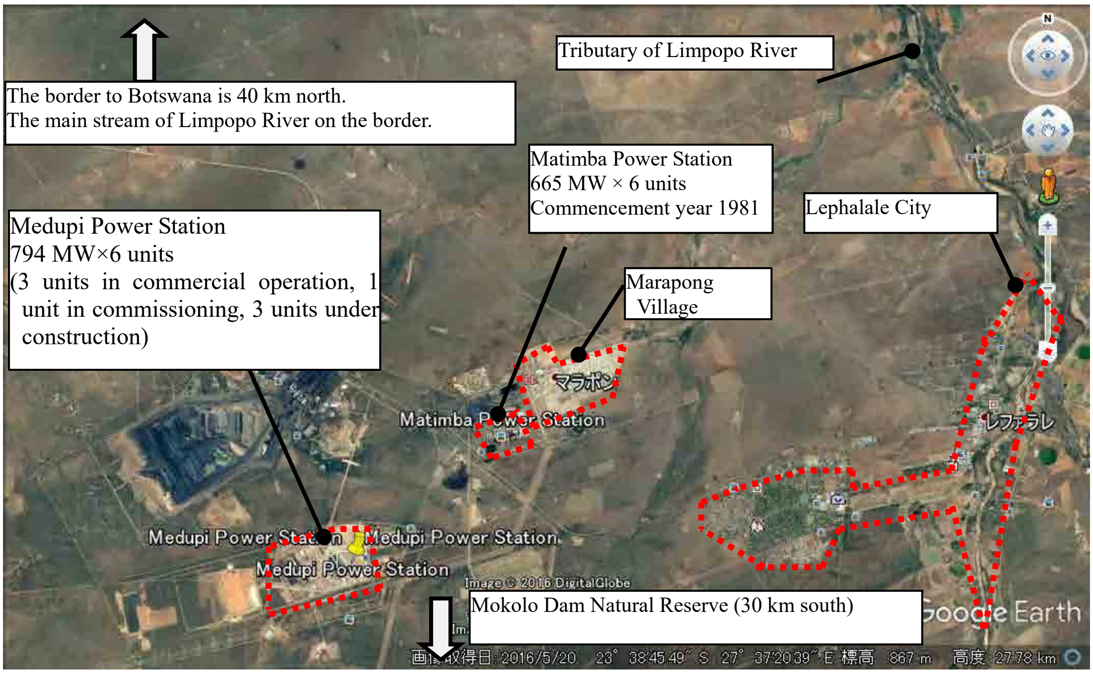
2.1.4. Current Situation and Issue of the Site and Objective Survey

(1) Review of the Planned Construction Site and Objective Survey

The Medupi TPS is located at the border of the Limpopo Province, near the Limpopo River, Botswana, and Zimbabwe. The total area of the province is 123,910 km^2, and the population is 5.4 million. The Medupi TPS is 290 km away from Johannesburg and is situated 580 km away from the nearest port in Maputo, Mozambique. Thus, water is secured from the river or from underground water. The nearest tributary of Limpopo River flows about 19 km west from the TPS, and the main stream of the river is approximately 40 km away. In terms of the water rights of Limpopo River, the river flows on the borders of Botswana, Mozambique, and Zimbabwe. There may be issues in securing the amount of water for utilization at the TPS in terms of the water rights that are for negotiation.

The surrounding area of Medupi TPS is shown in Figure 2.1-8. The fuel supply, coal field, and mining sites are located near the site so that there will be no problem. The surrounding area of the TPS is grassland, and the nearest city, Lephalale, is about 12 to 13 km east from the TPS. Lephalale is located on the tributary of Limpopo River. In addition, the Marapong Village is the nearest residential area to the TPS.

Enumerating the natural reserves near the TPS, there are three sites: D'nyala Natural Reserve (near Lephalale), Thiane Wildlife Sanctuary (30 km south from the TPS), and Mokolo Dam Natural Reserve.



Source: Prepared by the JICA Study Team using Google Earth (taken in May 2016)

Figure 2.1-8 Surrounding Area of Medupi TPS

(2) Basic Design Report to be Reviewed

The documents of Medupi FGD BD is listed in Table 2.1-2. Eskom had once intended to design the FGD system through consignment of basic and detailed design work to Black & Veatch, which is a global EPC contractor based in the United States of America (USA), and taking guarantee of its performance in its own responsibility, obtaining an FGD system design license from Steinmuller Engineering GmbH of Germany, which is an engineering service company based in Germany and wholly owned subsidiary company by IHI of Japan. The limestone-gypsum process was adopted in the conducted study. The lime-gypsum process is a typical process for desulfurization, entailing gypsum as a byproduct of chemical reaction with limestone, sprayed as an aqueous solution, and SO_2 included in the boiler flue gas. In the BD Report, emission factors including the composition of SO_2 in flue gas, the consumption of limestone and water, and the amount of effluent water are estimated in six cases in which coal specification and purification of limestone are varied.

Table 2.1-3 shows the outline of the estimation. According to the result, the consumption of water and limestone for 794 MW x 6 units are approximately 1,200 m^3/h and 150,000 kg/h, respectively. About 20% of the byproduct, gypsum will be sold as construction material via railway transportation. The rest is planned to be disposed for landfill at the TPS yard.

Table 2.1-2 List of Documents in the Basic Design Report

	Basic Design Report	Outline
1	Design Basis Documents	Design Condition, Design Policy, Summary of Design
2	Process Flow Diagram	Estimation with varieties of limestone-gypsum process in six cases (with/without gas-gas heater, range of specification of coal and purification of limestone) (1) PFD Design Coal, 85% $CaCO_3$ (2) PFD Worst Coal, 85 % $CaCO_3$ (3) PFD Worst Coal, Attemperated Air, 85% $CaCO_3$ (4) PFD Design Coal, 96% $CaCO_3$ (5) PFD Worst Coal, 96% $CaCO_3$ (6) PFD Worst Coal, Attemperated Air, 96% $CaCO_3$ (7) FGD Design Controlling Cases
3	Studies	There are 22 sub-study regarding BoP of FGD: (1) Chimney Analysis (2) Induced Draft Fan Analysis (3) Byproduct Disposal Study (4) Water Supply / Waste Water Disposal (5) Absorber Sizing Design Report (6) FGD Redundancy & Size Evaluation (7) Balance & Plant System Sizing Criteria Study (8) Support of Bypass Tie-In with Hitachi Duct Design Study (9) Rubber Lining vs Rubber Lining with Insulation Study Cost Estimation (10) Wet Oxidation Cooling Study (11) Operability Study (12) Limestone Quality Range Study (13) FGD Startup and Shutdown Concept (14) FGD Oxidation Air Blower Optimize Energy Consumption Study (15) Definition of Pipe Material (16) Stackwater Collection Study (17) Material Concept for the Inlet Duct (18) Technical Evaluation of Flue Gas Cooling Options (19) Five Protection / Detection Assessment Report (20) RAM Analysis (21) FMECA Analysis (22) HAZOP Analysis
4	Arrangement Design	12 drawings. Two of the important drawings are the following: (1) FGD Retrofit Plot Pan (2) FGD Retrofit Site Arrangement
5	Process System Design	Process design and drawings of FGD. They are composed of eight parts: (1) System Description, FGD Plant General System Description, FGD Process (2) Absorber (8 Reports, 32 Drawings) (3) Flue Gas (4 Reports, 12 Drawings) (4) Limestone Preparation (3 Reports, 6 Drawings) (5) Limestone Slurry Feed (3 Reports, 1 Drawing) (6) Bleed and Drain System (4 Reports, 2 Drawings) (7) Gypsum Dewatering (10 Reports, 10 Drawings) (8) Process Water (3 Reports, 3 Drawings)
6	Mechanical System Design	Report and drawing underlined are not shared. (1) P&ID Index (1 Drawing) (2) P&ID Legend (1 Drawing) (3) Auxiliary Steam (LBG) (1 Report, 1 Drawing) (4) Compressed Air (QFB) (1 Report, 1 Drawing) (5) Closed Cycle Cooling Water (PGB) (1 Report, 1 Drawing) (6) Fire Protection (SGA) (1 Report, 2 Drawings)

	Basic Design Report	Outline
		(7) Zero Liquid Discharge (GNG) (1 Report, 1 Drawing) (8) Portable Water (GKC) (1 Report, 1 Drawing) (9) FGD Makeup Water Supply (HTQ) (1 Report, 2 Drawings) (10) Sumps (HTT) (1 Report, 15 Drawings) (11) Material Handling System Design (2 Report, 16 Drawings)
7	Electrical System Design	There are seven sub-study and 12 drawings regarding Electrical System Design: (1) Medupi FGD Retrofit Evaluation (2) AC Power Supply (400 V) System Description (3) AC Power Supply (6,600 V) System Description (4) 24 V DC Power Supply System Description (5) DC Switchgear (110-220 V) System Description (6) Essential Service AC System Description (7) Emergency Generation System Description (8) Index FGD MV & LV Single Line Diagrams (9) Single Line Diagram Unit 1 Absorber MV & LV Board (10) Single Line Diagram Unit 2 Absorber MV & LV Board (11) Single Line Diagram Unit 3 Absorber MV & LV Board (12) Single Line Diagram Unit 4 Absorber MV & LV Board (13) Single Line Diagram Unit 5 Absorber MV & LV Board (14) Single Line Diagram Unit 6 Absorber MV & LV Board (15) Single Line Diagram FGD Common MV & LV Board (16) Single Line Diagram ZLD Treatment MV & LV Board (17) Single Line Diagram Essential MV & LV Board (18) Single Line Diagram Limestone & Gypsum Handling MV & LV Board (19) Single Line Diagram FGD Common Back-Up MV Board
8	Control System Design	(1) Distributed Control System Description (2) Local Control Philosophy (3) DCS Architecture Diagram (4) Hook Ups (5) Process Control System Philosophy
9	Building Design	(1) Interface List (2) FGD BOP Equipment List (3) Pipeline List (4) FGD In-Line Components List (5) FGD Instrument List (6) FGD Valve List (7) FGD Relief Valve List (8) Equipment List (9) Piping List (10) Valve List (11) Equipment Load List Absorber (12) Equipment Load List Dewatering (13) Equipment Load List Limestone Preparation (14) FGD Electrical Load List (15) Electrical Load List Absorber 1-6 (16) Electrical Load List Limestone Preparation (17) Electrical Load List Gypsum Dewatering (18) Electrical Load List Drain & Bleed Tank (19) Electrical Load List Process Water (20) Measuring Point List
10	Lists	(1) Interface List (2) FGD BOP Equipment List (3) Pipeline List (4) FGD In-Line Components List (5) FGD Instrument List (6) FGD Valve List (7) FGD Relief Valve List

	Basic Design Report	Outline
		(8) Equipment List (9) Piping List (10) Valve List (11) Equipment Load List Absorber (12) Equipment Load List Dewatering (13) Equipment Load List Limestone Preparation (14) Equipment Load List Limestone Preparation (15) Electrical Load List Absorber 1-6 (16) Electrical Load List Limestone Preparation (17) Electrical Load List Gypsum Dewatering (18) Electrical Load List Drain & Bleed Tank (19) Electrical Load List Process Water (20) Measuring Point List
1)	Operation and Maintenance Planning	(1) Maintenance & Access Diagram FGD Medupi (2) Maintenance & Access Drawing Pump house (3) Maintenance Staffing Plan (4) M&A Drawing Gypsum Dewatering Building +0.000 M (5) M&A Drawing Gypsum Dewatering Building +9.000 M (6) M&A Drawing Gypsum Dewatering Building +16.000 M (7) M&A Drawing Limestone Building 0.00 M (8) M&A Drawing Limestone Building +20.0 M (9) Maintenance & Access Drawing Gypsum Bleed Tank Area (10) Evaluation of Access Equipment for Maintenance of Top Entry Agitators (11) Mobile Equipment Plan
12	Project Execution Planning	(1) Project Execution Plan (2) Project Procurement Plan (3) Construction Execution Plan (4) FGD Plant Construction Facilities (5) FGD Absorber Erection Manual (6) Medupi FGD Level 1 Schedule (7) Medupi FGD ERA Schedule Level 2 (8) Capital and O&M Cost Estimates

Source: Prepared by JICA Study Team Based on the data in Basic Design Study

Table 2.1-3 Summary of Six Cases for the Lime-Gypsum Process

Purification of Limestone	Spec. of Coal with/ without Gas-Gas heater	Case no.	SO_2 at FGD outlet	SO_2 removal rate	Consumption of Limestone	Crocodile West Water		Mokolo Water	
						Water flow	Effluent	Water flow	Effluent
			mg/Nm^3	%	kg/h	m^3/h	m^3/h	m^3/h	m^3/h
85%	Design Coal	Case 1	384.27	89.22	85,202.38	929.20	72.28	926.34	69.47
	Worst Coal	Case 2	396.22	92.95	143,235.88	1,030.31	74.20	1,027.15	71.09
	Worst Coal/Gas-Gas Heater	Case 3	389.67	93.14	143,556.27	1,128.50	73.99	1,125.04	70.59
96%	Design Coal	Case 4	300.18	91.63	75,328.76	933.49	73.24	930.54	70.39
	Worst Coal	Case 5	295.32	94.78	125,735.02	1,034.74	75.25	1,031.48	72.09
	Worst Coal/Gas-Gas Heater	Case 6	289.08	94.94	125,964.87	1,132.82	75.04	1,129.25	71.59

*Yellow hatched boxes stand for the most consumption in six cases.

Source: Prepared by JICA Study Team based on the data in the Basic Design Study

2.1.5. Technical Basic Policy for the Survey

(1) Medupi FGD BD

Eskom carried out the Medupi FGD BD using its own budget while utilizing the international consultant, Steinmüller Engineering (and Black & Veatch), on 2014 and is continuously considered until now.

The JICA Study Team reviewed the Medupi FGD BD after a series of discussions with Eskom and expressed some points to be amended with respect to the system configuration, packaging, and specification.

(2) Domestic Legal Framework

Eskom is imposed to keep the domestic preferential procurement policy as one of the public enterprises with social accountability.

(3) Consensus of JICA Environmental Social Consideration and Labor Safety Control

Eskom carried out an Environmental Impact Assessment (EIA) using its own budget and considered the safety countermeasures for the Medupi FGD BD.

However, JICA has done a loan examination based on "JICA guideline for Environmental and Social Consideration (April 2010)"

The JICA Study Team clarified mutual gaps between the EIA and the mentioned JICA guidelines and confirmed the progress to dissolve gaps.

2.2. Survey Implementation Method

2.2.1. Project Implementation Flow

The Survey started in June 2017 and completed in June 2019. The JICA Study Team carried out site finding, collecting information from Eskom and related organization and discussion with mentioned organizations, and supported meeting between JICA and Eskom through four times field survey from June 2017 to February 2018. Final report is submitted in June 2019.

2.2.2. Project Implementation Method for the Survey

(1) Confirmation of the Necessity and Background of the Project

- Confirmation of importance and necessity of the Project
- Survey on the laws about environmental operation of coal-fired TPS
- Understanding the previous survey and provision
- Summarization of the plan for the FGD installation for the coal-fired TPS in South Africa

(2) Verification of the Current State

- Review on the natural condition of Medupi FGD BD

(3) Review of the BD Report and Proposal of Optimal Plan

- Confirmation of scope and financing of the project
- Review of Medupi FGD BD and proposal of suitable plan

(4) Planning for Procurement and Construction

- Review of procurement and construction plan
- Proposal of O&M System for FGD and related facilities
- Study and proposal on necessity of technical support
- Study on construction method (specific method and impact on the procurement)

(5) Project Implementation Schedule

- Study of implementation method
- Study of project implementation schedule

(6) Project Implementation Organization

- Survey of implementation organization of similar project in South Africa
- Study of required system for the project

(7) Environmental and Social Considerations

(8) Cost Estimation of the Project

(9) Scope for Yen Loan Project

- Scope for the Yen Loan Project
- Consulting service for construction stage

(10) Support for Operational and Effective Indicators

- Financial and economic analyses
- Operational and effective indicators

(11) Preparation and Conduction of Holding Workshop and Visiting Power Station in Japan

(12) Assistance for Project Promotion

- Confirmation of process and document for project promotion
- Assistance for documentation to board meeting for approval

(13) Preparation of Risk Management Framework

Chapter 3 Necessity of FGD Project

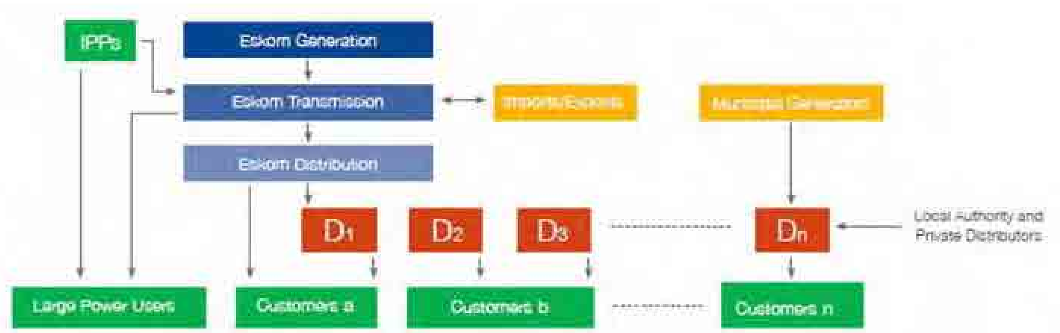
3.1. Current Status of the Power Sector

3.1.1. Structure of Power Sector and Power Demand

(1) Structure of the Electric Supply Industry of South Africa

The structure of the electric supply industry of South Africa is shown in Figure 3.1-1. All of the players in the electric supply industry should be licensed by the National Energy Regulatory of South Africa (NERSA). The electricity market is regulated by NERSA in terms of the National Energy Regulatory Act, 2004. NERSA has the power to issue licenses regarding generation, transmission, and distribution; to regulate all tariff increases; and to provide national grid codes and so on. The main player in the power generation sector is Eskom, which is a state-owned company (SOC). However, there are some Independent Power Providers (IPPs) apart from Eskom. Eskom is a monopoly enterprise in the power transmission sector. There are two licensees apart from Eskom; however, their service area is small. For that reason, NERSA currently collects transmission data only from Eskom. The main player in the power distribution sector is also Eskom; however, 178 municipal distributors and 12 distributors participate apart from Eskom as of 2012.

Licensed and operational power stations in 2012 is shown in Table 3.1-1. The net maximum power produce in South Africa is 49,717.32 MW in 2012, and coal-fired TPS accounts for approximately 70% (34,926.33 MW). It obviously shows that the coal-fired TPS is a key resource in power generation in South Africa.



Source: Electricity Supply Statistics for South Africa 2012, NERSA

Figure 3.1-1 Structure of Electric Supply Industry of South Africa

Table 3.1-1 Licensed and Operational Power Stations in 2012

Power Station Name	License Type	Licensed Capacity (MW)	Net Maximum Power Produces (MW)	Energy Generated (MWh)
Bagasse and Coal		149.50	84.80	344,742.25
Umfolozi	Private	16.00	4.00	
Bagasse		16.00	4.00	0.00
Komati Mill	Private	20.00	18.00	86,880.00
Malelane Mill	Private	19.00	16.00	92,226.00
Amatikulu Sugar Mill	Private	12.00	11.80	36,999.25
Darnall Sugar Mill	Private	12.00	7.00	17,957.00
Felixton Sugar Mill	Private	32.00	24.00	71,360.00
Maidstone Sugar Mill	Private	22.50	-	39,320.00
Coal		37,247.00	34,926.33	238,059,245.14
Arnot	Eskom	2,232.00	2,012.00	13,026,226.03
Camden	Eskom	1,450.00	1,451.00	8,902,148.00
Duvha	Eskom	3,450.00	2,645.00	18,131,754.00
Grootvlei	Eskom	1,090.00	1,077.00	6,232,252.89
Hentrina	Eskom	1,865.00	1,596.00	10,695,691.49
Kendal	Eskom	3,840.00	3,949.00	28,855,844.90
Komati	Eskom	791.00	757.00	3,963,569.04
Kriel	Eskom	2,850.00	2,580.00	16,944,768.72
Lethabo	Eskom	3,558.00	3,575.00	24,333,573.60
Majuba	Eskom	3,843.00	3,814.00	27,647,993.22
Matimba	Eskom	3,690.00	3,723.00	29,865,255.36
Matla	Eskom	3,450.00	3,388.00	22,765,429.29
Tutuka	Eskom	3,510.00	3,378.00	20,747,557.00
Rooiwal Power Station	Municipality	300.00	76.26	328,683.10
Kelvin Power Station	Private	600.00	250.00	1,624,950.00
Sasol Chemical Industries	Private	128.00	116.07	848,970.33
Sasol Synfuels Stream Power Station	Private	600.00	539.00	3,144,578.17
Coal and Gas		180.00	0.00	0.00
Pretoria West Power Station	Municipality	180.00	-	-
Gas		2,816.44	10,295.50	3,163,684.64
Acacia	Eskom	171.00	172.00	6,837.00
Ankerlig	Eskom	1,327.00	1,367.00	833,192.00
Gouikwa	Eskom	740.00	726.00	499,235.33
Port Rex	Eskom	171.00	171.00	7,828.00
Athlone Gas Turbine	Municipality	40.00	37.00	520.54
Roggebaai Gas Turbine	Municipality	42.00	19.80	201.87
Nelson Mandela Metropolitan	Municipality	40.00	38.00	-
Sasol Synfuels Gas Power Station	Private	252.00	232.00	1,761,971.97
Power Alt Middleburg	Private	10.70	10.70	3,222.83
Cogeneration Plant Methcap Petro SA	Private	4.24	3,151.00	4,163.60
Newcastle Cogeneration	Private	18.50	4,371.00	46,511.50
Hydro		643.10	646.31	990,462.70
Gariep	Eskom	360.00	365.00	432,397.00
Vanderkloof	Eskom	270.00	270.00	495,644.00
Lyndenburg Hydro	Municipality	2.10	2.10	7,980.84
Friedenheim Hydroelectric Power Station	Private	2.50	1.90	12,588.46
Sol Plaatja	Private	3.00	2.23	15,346.13
Marino	Private	4.00	3.58	20,156.13
Clanwillian Dam Hydro Power Station	Private	1.50	1.50	6,350.14
Nuclear		1,860.00	1,865.00	12,967,435.00
Koeberg	Eskom	1,860.00	1,865.00	12,967,435.00
Pumped Storage		1,580.00	1,615.00	3,038,882.29
Drakensberg	Eskom	1,000.00	1,021.00	2,047,041.00
Palmiet	Eskom	400.00	427.00	865,522.00
Steenbras Pumped Storage Scheme	Municipality	180.00	167.00	126,319.29
Spent liquor and Coal		5.10	5.10	7,094.30

Power Station Name	License Type	Licensed Capacity (MW)	Net Maximum Power Produces (MW)	Energy Generated (MWh)
Mpact, Piet Retief	Private	5.10	5.10	7,094.30
Spent pulping liquor and Coal		190.00	270.08	1,701,459.78
Sappi Saiccor	Private	46.00	36.08	225,356.25
Sappi Tugela	Private	10.00	20.00	29,022.64
Sappi Ngodwana	Private	117.00	117.00	771,736.59
Mondi Richards Bay Mill	Private	17.00	97.00	675,344.30
Wind		5.30	5.20	7,498.61
Darling Wind Power		5.30	5.20	7,498.61
Total		44,692.44	49,717.32	260,280,504.71

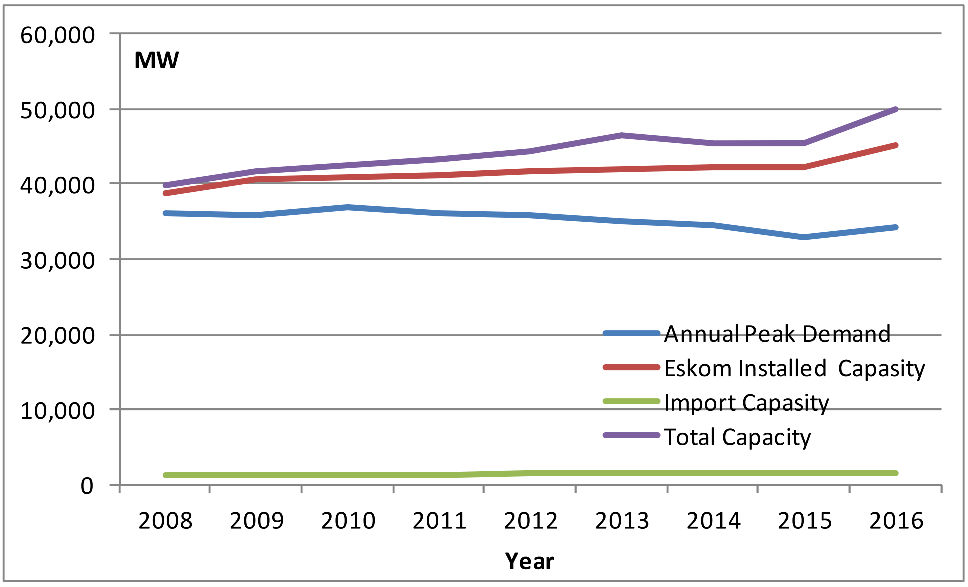
Source: Electricity Supply Statistics for South Africa 2012, NERSA

(2) Peak Demand and Supply Capacity

The peak demand and supply capacity is shown in Figure 3.1-2. From 2008 to 2016, the peak demand stays between 37,000 MW and 33,000 MW. The total supply capacity is in an upward trend and is increasing from approximately 40,000 MW to 50,000 MW during the same period. It seems that South Africa escaped its tight supply and demand of power. However, power supply will drop because of the large amount of capacity shutdown of the planned coal TPS.

Eskom revenue application shows the power supply and demand situation as “Eskom is moving from a period of a severely constrained environment to one of adequate or even excess capacity. The reasons for this include improved generating plant availability, low demand growth and the introduction of new capacity, both from Eskom and IPPs”.

On the other hand, tight power supply and demand is predicted in the future because the Draft IRP 2018 Upgraded published in August 2018 estimates a sharp increase of power demand as shown in a later mentioned Figure 3.1-6. Furthermore, the power stations that have been operational for 50 years or more since their commercial operation date (COD) will be decommissioned in South Africa. Therefore, six power stations, i.e., Kriel, Arnot, Hendrina, Camden, Groovlei, Komati, or a total of 10,976 MW of power, will be out of the grid by 2029. It means that the balance of peak demand and supply capacity is still a severe issue in medium-term and long-term perspectives.



Source: System Adequacy Outlook Issue 12, NERSA

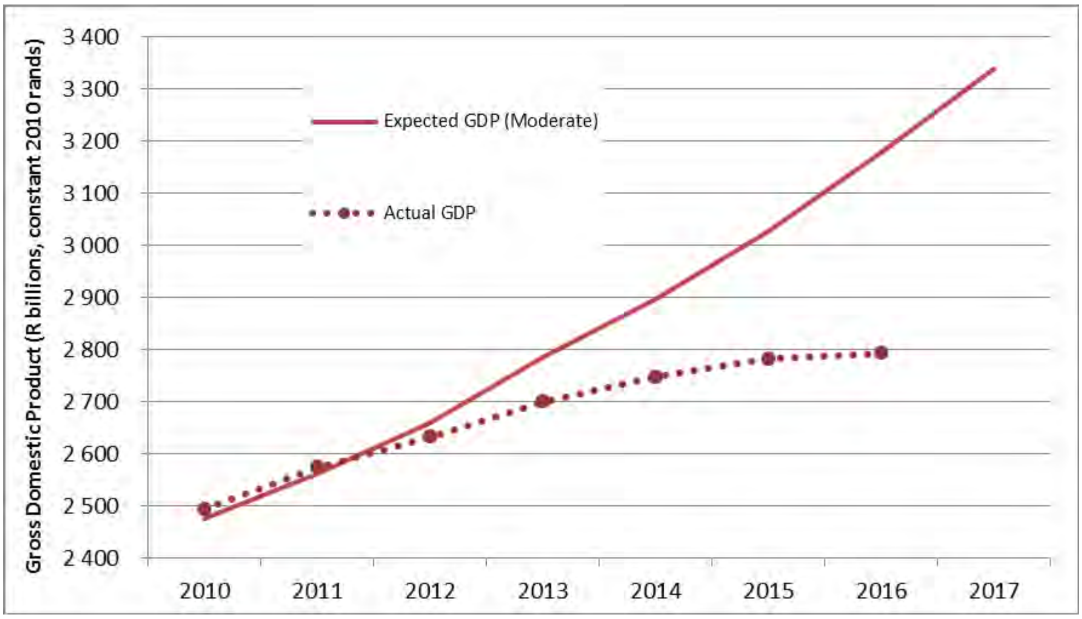
Figure 3.1-2 Peak Demand and Supply Capacity (2008 to 2016)

(3) Power Consumption

The GDP prediction as of 2010 and the actual record is shown in Figure 3.1-3. GDP in South Africa was approximately ZAR 2,500 million as of 2010, and an increase to approximately ZAR 3,200 million by 2016 was predicted. However, the actual record shows that it stayed at approximately ZAR 2,800 million in 2016.

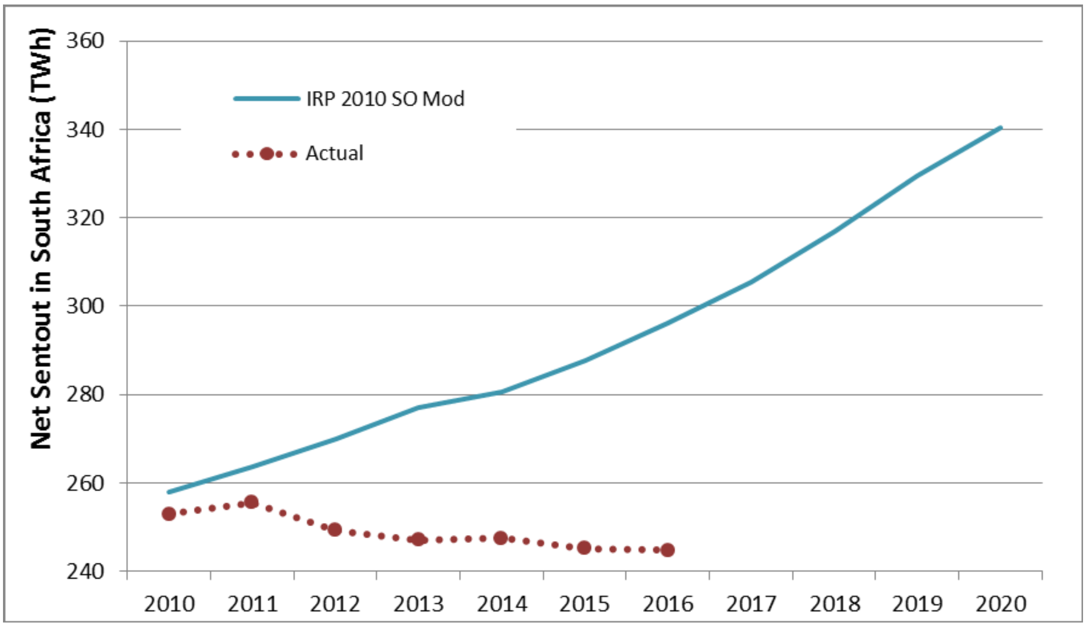
The power consumption prediction as of 2010 and the actual record is shown in Figure 3.1-4. Although the GDP grew from 2010 to 2016 despite it being lower than predicted, the energy consumption was in a downward trend during the same period.

The trend of electricity intensity from 1990 to 2016 is shown in Figure 3.1-5. Energy Intensity (EI) had a downward trend from 1997 as its peak, so the indicator calculated in annual energy consumption is divided by the GDP. This shows that the energy consumption in economic activity was more efficient than past years. The IRP Upgrade 2018 states the causes of improvement of energy efficiency with increasing power tariff, energy source change from electric power to gas, and proceeding introduction of roof top type solar power generation.



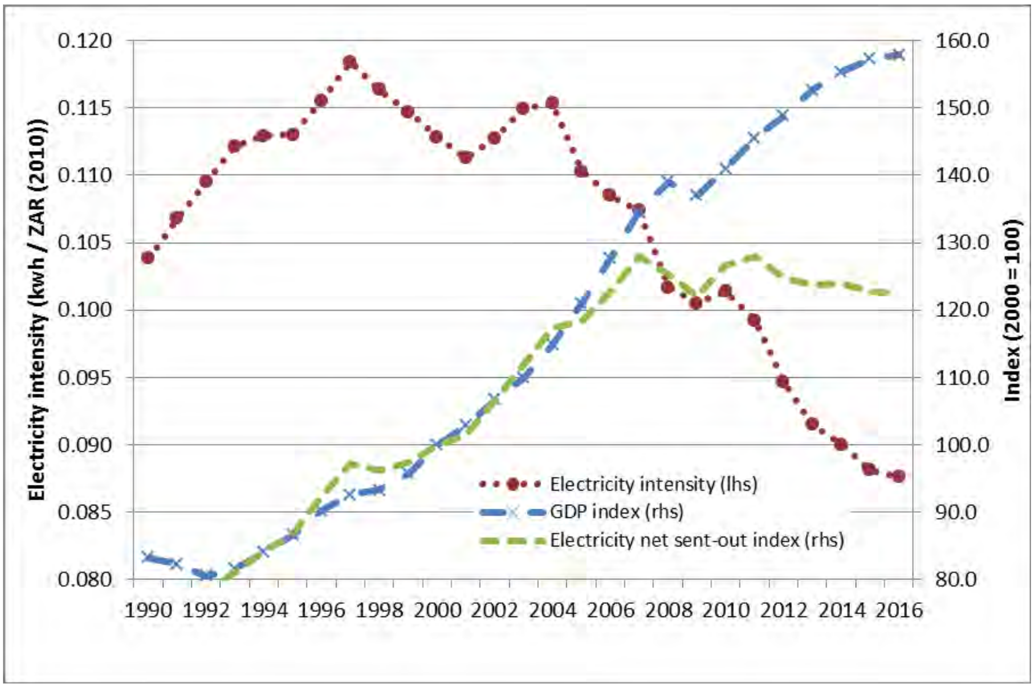
Source: Draft Integrated Resource Plan 2018 Updated, August 2018, Department of Energy

Figure 3.1-3 GDP Prediction as of 2010 and Actual Record



Source: Draft Integrated Resource Plan 2018 Updated, August 2018, Department of Energy

Figure 3.1-4 Power Consumption Prediction as of 2010 and Actual Record

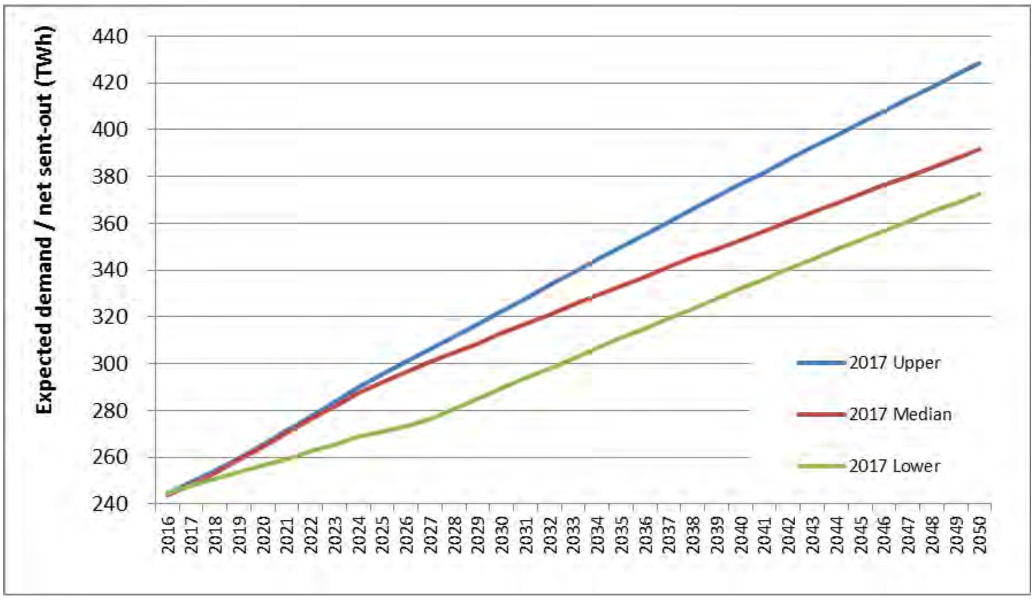


Source: Draft Integrated Resource Plan 2018 Updated, August 2018, Department of Energy

Figure 3.1-5 Trend of Electricity Intensity from 1990 to 2016

(4) Energy Demand Forecast

The energy demand forecast is shown in Figure 3.1-6. There are three scenarios, i.e., low, middle, and high forecast under each precondition. Power demand increasing in each case are set as 1.21%, 1.8%, and 2.0%, up to 2030 respectively, then 1.24%, 1.4%, and 1.66 % up to 2050 respectively. Draft IRP 2018 Upgrade does not state influential scenario.



Source: Integrated Resource Plan 2010 -2030 Updated, November 2016, Department of Energy

Figure 3.1-6 Energy Demand Forecast

(5) Status of Power Station Construction Project

Draft IRP 2018 Updated shows the status of that TPS construction project that is planned in South Africa as shown in Table 3.1-2. As of September 2017, a total of 39,830 MW worth of TPS construction projects was listed. However, a total of 18,576 MW worth of TPS construction project equivalent to almost half of the original plan, is still not in progress.

Table 3.1-2 Status of Power Station Construction Project

Type	Scale (MW)	Ministerial Determination date	Status (As of September 2017)
RE	3,725	11 August 2011	3,772.04 MW in commercial operation
RE	3,200	19 December 2012	
RE	6,300	18 August 2015	
CHP	800	19 December 2012	11.5 MW procured. No contract signed.
CHP	1,000	18 August 2015	
Nuclear	9,600	17 December 2013, Revised 5 December 2016	Not yet implemented
Gas/Diesel peaking plants	1,020	25 May 2012	1,005 MW in commercial operation
Coal Baseload IPP	2,500	19 December 2012	900 MW procured. No contract signed.
Coal Baseload IPP	3,750	20 April 2016	Not yet implemented
Gas and OCGT/diesel	3,126	18 August 2015	Not yet implemented
Additional gas	600	27 May 2016	Not yet implemented
Hydro	2,609	19 December 2012	Treaty signed with DRC for 2,500 MW
Solar	1,500	27 May 2016	Not yet implemented
Diesel	100	27May 2016	Construction not started
Total	39,830		

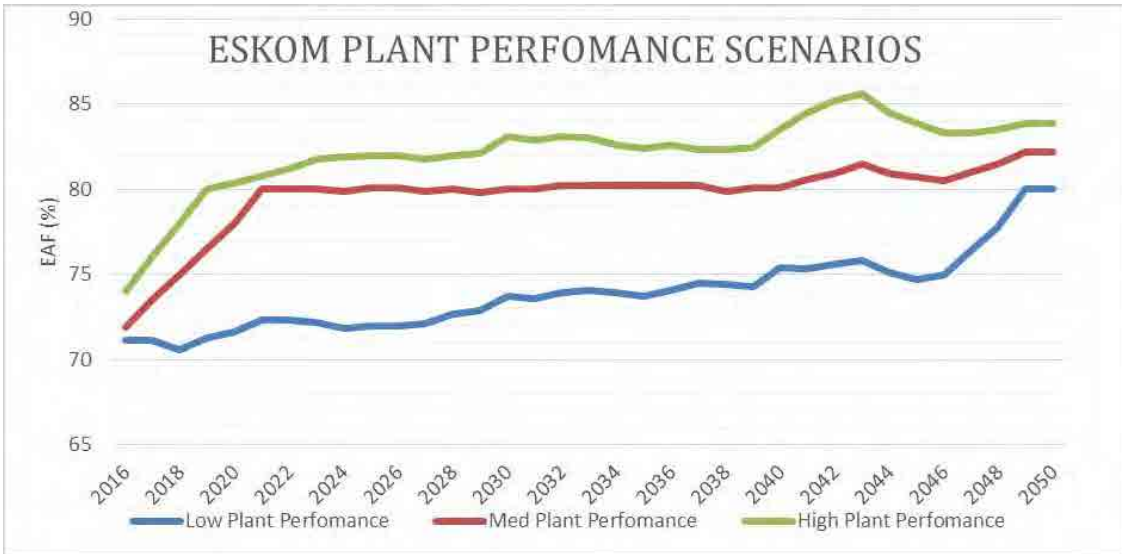
RE: Renewable Energy, Co-gen: Combined Heat and Power,

Source: Prepared by JICA Study Team based on Draft Integrated Resource Plan 2018 Updated, August 2018, Department of Energy

(6) Eskom Plant Performance

In a previous IRP, i.e., Draft IRP 2016 Updated November 2016, the average plant performance owned by Eskom was assumed at 86% compared to its actual performance in the time of preparation which was 85%. However, the Draft IRP 2018 Updated describes the actual performance in 2016 and 2017, which are approximately 71% and 77%, respectively.

The Eskom plant performance scenarios are shown in Figure 3.1-7. There are three plant performance scenarios by Eskom, i.e., high, med, and low plant performance. High plant performance is the design to cost (DTC) case, wherein the energy availability factor (EAF) is restored to the acceptable level. The medium plant performance is the business as usual case, wherein the EAF is restored to the level that complies with Eskom's Shareholder Compact 2017 and the corporate plan target. The low plant performance is a progressive case.



Source: Draft Integrated Resource Plan 2018 Updated, August 2018, Department of Energy

Figure 3.1-7 Eskom Plant Performance Scenario

3.1.2. Coal Thermal Plant of Eskom

The list of power station capacities owned by Eskom and its locations are shown in Figure 3.1-8 and Figure 3.1-9, respectively.

As of May 2019, Eskom has 16 base load stations (coal-fired power and nuclear), nine peaking load power stations (gas liquid power, pump storage power, and hydro power), one renewable and four hydroelectric, for a total of 30 stations of 48,039 MW installed capacity. The total installed capacity of 14 coal fired power station is 40,180 MW, which accounts for 84% (= 40,180 MW/48,039 MW) of the whole installed capacity.

Medupi TPS is under construction/commissioning, and only three units (No. 4 to 6, 794 MW x 3 units) are included in the above figure. After the six units of the Medupi TPS start their operations, a 2,382 MW (794 MW x 3 units) will be added.

Name of station	Location	Years commissioned: first to last unit	Number and installed capacity of generator sets MW	Total installed capacity MW	Total nominal capacity MW
Base-load stations					
Coal-fired (15)				**40 180**	**37 868**
Arnot	Middelburg	Sep 1971 to Aug 1975	1x370; 1x390; 2x396; 2x400	2 352	2 232
Camden[1,3]	Ermelo	Mar 2005 to Jun 2008	3x200; 1x196; 2x195; 1x190; 1x185	1 561	1 481
Duvha[2]	Emalahleni	Aug 1980 to Feb 1984	5x600	3 000	2 875
Grootvlei[1]	Balfour	Apr 2008 to Mar 2011	4x200; 2x190	1 180	1 120
Hendrina[1,4]	Middelburg	May 1970 to Dec 1976	1x210; 4x200; 2x195; 1x170; 1x165	1 738	1 638
Kendal[2]	Emalahleni	Oct 1988 to Dec 1992	6x686	4 116	3 840
Komati[1,3]	Middelburg	Mar 2009 to Oct 2013	4x100; 4x125; 1x90	990	904
Kriel	Bethal	May 1976 to Mar 1979	6x500	3 000	2 850
Kusile[2,4]	Ogies	Aug 2017	1x799	799	720
		Under construction	5x800		
Lethabo	Vereeniging	Dec 1985 to Dec 1990	6x618	3 708	3 558
Majuba[2]	Volksrust	Apr 1996 to Apr 2001	3x657; 3x713	4 110	3 843
Matimba[2,4]	Lephalale	Dec 1987 to Oct 1991	6x665	3 990	3 690
Matla	Bethal	Sep 1979 to Jul 1983	6x600	3 600	3 450
Medupi[2]	Lephalale	Aug 2015 to Nov 2017	3x794	2 382	2 157
		Under construction	3x794		
Tutuka	Standerton	Jun 1985 to Jun 1990	6x609	3 654	3 510
Nuclear (1)					
Koeberg	Cape Town	Jul 1984 to Nov 1985	2x970	**1 940**	**1 860**
Peaking stations					
Gas/liquid fuel turbine stations (4)				**2 426**	**2 409**
Acacia	Cape Town	May 1976 to Jul 1976	3x57	171	171
Ankerlig	Atlantis	Mar 2007 to Mar 2009	4x149.2; 5x148.3	1 338	1 327
Gourikwa	Mossel Bay	Jul 2007 to Nov 2008	5x149.2	746	740
Port Rex	East London	Sep 1976 to Oct 1976	3x57	171	171
Pumped storage schemes (3)[5]				**2 732**	**2 724**
Drakensberg	Bergville	Jun 1981 to Apr 1982	4x250	1 000	1 000
Ingula	Ladysmith	June 2016 to Feb 2017	4x333	1 332	1 324
Palmiet	Grabouw	Apr 1988 to May 1988	2x200	400	400
Hydroelectric stations (2)[6]				**600**	**600**
Gariep	Norvalspont	Sep 1971 to Mar 1976	4x90	360	360
Vanderkloof	Petrusville	Jan 1977 to Feb 1977	2x120	240	240
Total used for capacity management purposes				**47 878**	**45 461**
Renewable energy					
Wind energy (1)[7]					
Sere	Vredendal	Mar 2015	46x2.2	**100**	**100**
Total capacity including renewable energy				**47 978**	**45 561**
Other hydroelectric stations (4)[8]				**61**	**–**
Colley Wobbles	Mbashe River		3x14	42	–
First Falls	Umtata River		2x3	6	–
Ncora	Ncora River		2x0.4; 1x1.3	2	–
Second Falls	Umtata River		2x5.5	11	–
Total Eskom power station capacities (30)				**48 039**	**45 561**
Available nominal capacity – Eskom-owned					**94.84%**

Source: Eskom Integrated Report 2017

Figure 3.1-8 Summary of Eskom Power Stations

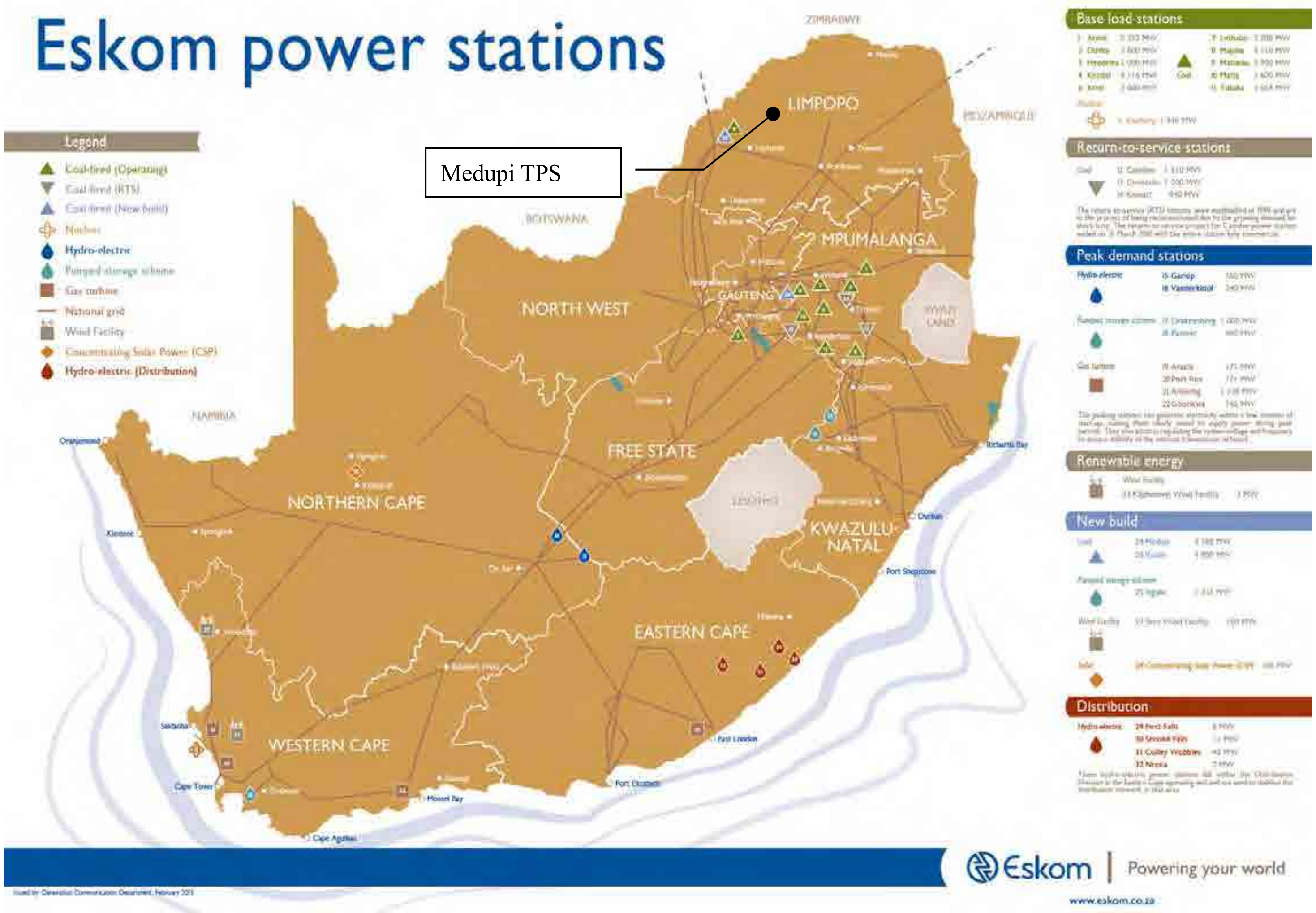


Figure 3.1-9 Location of Eskom Power Stations

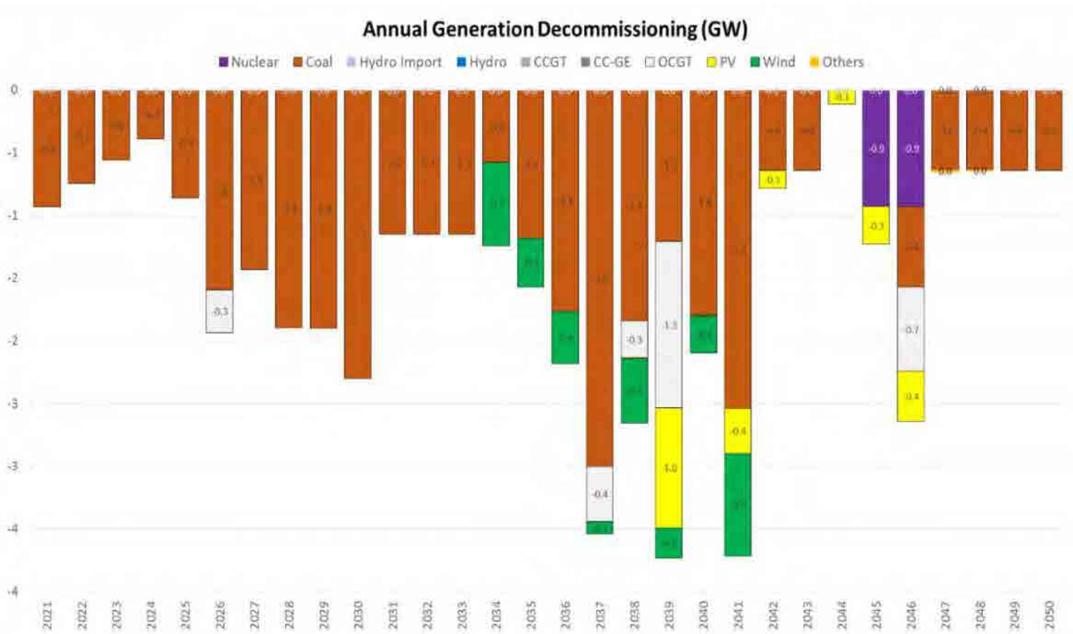
3.1.3. Master Plan and Strategy of Power Sector

(1) Integrated Resource Plan (IRP)

The National Development Plan 2030 (NDP 2030) identifies the need for South Africa to invest in a strong network of economic infrastructure designed to support the country's medium- and long-term economic and social objectives. NDP 2030 envisages that, by 2030, South Africa will have an energy sector that provides reliable and efficient energy service at competitive rates, is socially equitable through expanded access to energy at affordable tariffs, and is environmentally sustainable through reduced pollution.

Originally, the Integrated Resource Plan (IRP) 2010-2030 prepared by DoE was promulgated in March 2011. It led to the Revised Balanced Scenario (RBS) that was published in October 2010. MoE should review the IRP regularly in order to keep it a "living plan". That is why the IRP will be revised with changes to the socio-economic situation because this describes the future image under precondition at that time. The Draft IRP 2016 Updated and the Draft IRP 2018 Updated were publicized in November 2016 and August 2018, respectively. The Draft IRP 2018 Updated added the prediction from 2030 up to 2050 in addition to the prediction up to 2030.

The schedule of generation decommissioning up to 2050 is shown in Figure 3.1-10. It shows that a total of 12.93 GW and 33.40 GW of generation will be withdrawn from the power grid up to 2030 and 2050, respectively.



Source: Draft Integrated Resource Plan 2018 Updated

Figure 3.1-10 Schedule of Generation Decommissioning up to 2050

(2) South African Grid Code

The South African Grid Code (SAGC) is issued by the RSA grid code secretariat and is approved in NERSA. The latest SAGC version 9.0 was publicized in July 2014, and it consists of seven sub codes, i.e., governance code, metering code, network code, system operation code, information exchange code, transmission tariff code, and preamble.

The governance code describes the provisions necessary for the overall administration and review of various aspects of the grid code. The metering code specifies the transmission tariff and energy trading metering requirements and clarifies the responsibilities in terms of metering installations. The network code contains connection conditions for generators, distributors, and end-use customers, as well as the standards used to plan and develop the Transmission System. The system operation code sets out the responsibilities and roles of the participants as far as the operation of the interconnected power system (IPS) is concerned, and more specifically the issues related to reliability, security, and safety. The information exchange code defines the reciprocal obligations of parties with regard to the provision of information for the implementation of the grid code. The transmission tariff code sets out the objectives of transmission service pricing and the procedure to be followed in applications to change the revenue requirements or the tariff structure. The preamble sets the context for the sections of the grid code and an explanation of the terms used in it.

(3) Medium-Term System Adequacy Outlook

According to SAGC, Eskom shall annually publish a Medium Term System Adequacy Outlook (MTSAO) as a review for the adequacy of the Interconnected Power System (IPS) that should meet the long term (five-year plan) requirements of the electricity based SAGC.

As per request of NERSA, Eskom prepared MTSAO 2016 to 2021, 2017 to 2022, and 2018 to 2023 in July 2017, October 2017, and October 2018, respectively.

The scope of MTSAO specializes in the generation field, and they do not include the statement of transmission and distribution field.

The South African Interconnected Power System (IPS) is assessed based on the system adequacy metrics, as shown in Table 3.1-3. The adequacy metrics are set based on experience of load shedding on 2018 in order to prevent purchasing high-cost power due to unexpected power supply shortage. If all adequacy metrics meet requirements, the grid seems to be adequate from the view point of generation.

MTSAO states that the shutdown of some PSs should be done apart from the decommissioning of some PSs due to the 50 years superannuation specified in the Draft IRP 2018 Updated. The capacity from Duvha Unit No. 3 is assumed to be unavailable for the purposes of the study of the latest MTSAO. In addition, the latest MTSAO further assumed that the units at Grootvlei, Hendrina, and Komati would be shut down when it was no longer economical to carry out the maintenance required in terms of the Occupational Health and Safety Act (OHS Act) or turbine running hours. As of September 2018, 10 units had already been shut down at these stations, removing 389 MW from the Eskom generation installed base. It was assumed that the remaining units at these stations would be shut down when they are no longer economical to carry out maintenance works.

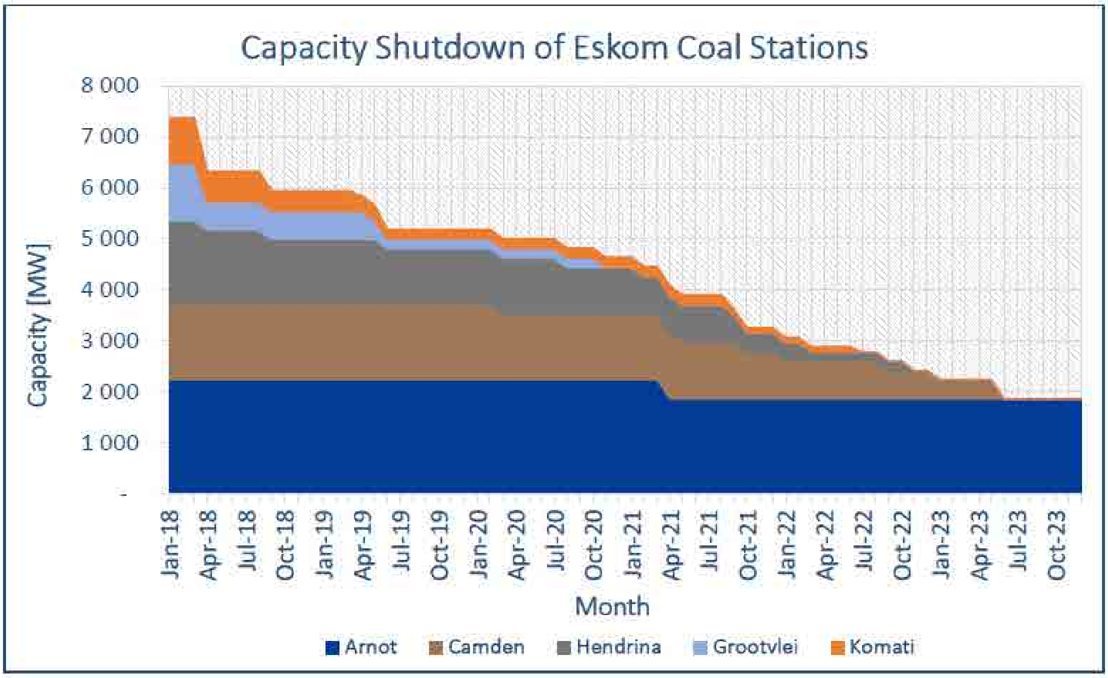
This resulted in the shutdown of a single unit at Arnot in 2021 and all the units of Camden between 2021 and 2023.

The prediction of shutdown of PSs up to 2023 is shown in Figure 3.1-11. A total of 5,731 MW of PSs is predicted to shut down up to 2023.

Table 3.1-3 Adequacy Metrics for Energy Adequacy of Generation

Adequacy Metric	Threshold	Details
Unserved Energy	Not less than 20 GWh per annum	Energy not supplied
OCCGT Load Factor	Not less than 6% per annum	Gross load factor of all OCGT plant
Emergency Level 1	Not less than 133 GWh per annum	Energy supplied by generators operating above their continuous rating
Expensive Base Load Stations	<50% per annum	Gross load factor of the expensive coal-fired base-load stations

Source: Medium-Term System Adequacy Outlook 2018 to 2023, publicized October 2018



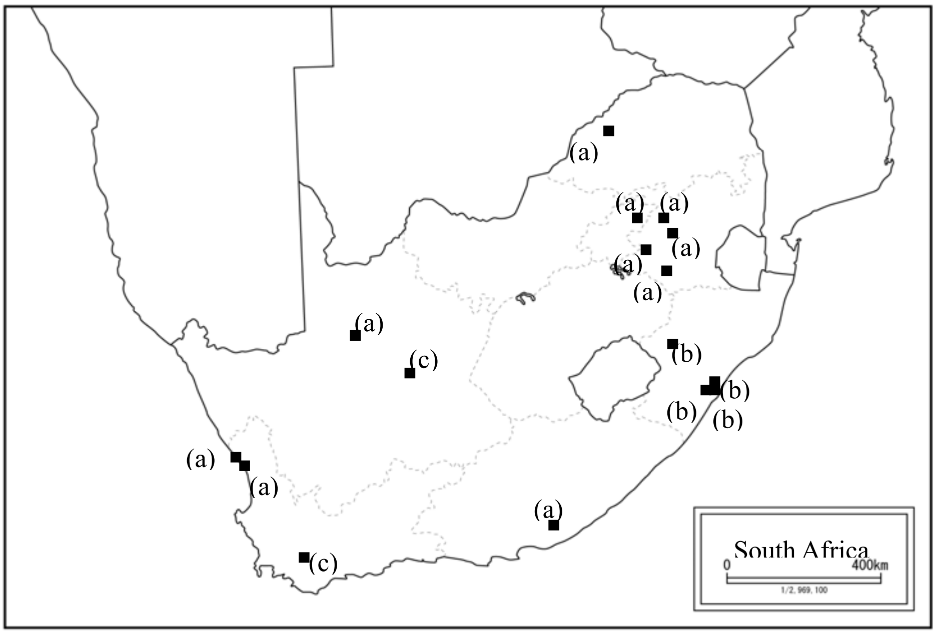
Source: Medium Term System Adequacy Outlook 2018 to 2023

Figure 3.1-11 Prediction of the Shutdown of Power Station up to 2023

3.1.4. Support from the International Donor to Power Sector

(1) World Bank

The support from WB to the power sector is shown in Figure 3.1-12 and Table 3.1-4. Three projects were implemented using funds from the WB from 2007 in the power sector in South Africa.



Source: Prepared by JICA Study Team based on the information from the website of the World Bank as of 5 October 2017

Figure 3.1-12 Support from World Bank to Power Sector

Table 3.1-4 Support from World Bank to Power Sector

No.	Project Name	Borrower	Approval Date	Closing Date	Total Project Cost	Commitment Amount
(a)	Eskom Investment Support Project	Eskom	8 Apr. 2010	31 Dec. 2019	USD 10,750.00 M mil	USD 3,750.00 Mil
(b)	Durban Landfill Gas-to-Electricity Project	Carbon finance to developer of project	11 Jun. 2004	30 Sep. 2018	USD 15.00 Mil	USD 0.00 Mil
(c)	Eskom Renewables Support Project	Eskom Holdings Ltd.	27 Oct. 2011	31 Dec. 2021	USD 1,288.00 Mil	USD 195.00 Mil

Source: Prepared by the JICA Study Team based on the information from the website of WB as of 5 October 2017

(2) African Development Bank

Support from the AfDB to the power sector is shown in Table 3.1-5. Six projects were implemented using funds from the AfDB from 2007 in the power sector in South Africa. Five projects are in the appraisal phase.

Table 3.1-5 Support from African Development Bank to Power Sector

No.	Project Name	Borrower	Approval Date	Closing Date	Total Project Cost	Commitment Amount
(a)	Eskom II - A Loan	-	15 Dec. 2015	-	USD 7.17 mil	USD 7.17 mil
(b)	Eskom II Power Project	-	15 Dec. 2015	-	ZAR 2,147.48 mil	ZAR 299.84 mil
(c)	Medupi Power Project Supplementary Loan	Eskom	31 Jul. 2015 (Appraisal)	-	USD 950.00 mil	-
(d)	Eskom Transmission Improvement Project	Eskom	30 Aug. 2016 (Appraisal)	-	USD 284.00 mil	-
(e)	Thabametsi Coal Power Plant	-	25 Sept. 2017 (Appraisal)	N/A (Pipeline)	USD 2,147.48 mil	-
(f)	Black Lite Solar Project	-	4 May 2016 (Appraisal)	N/A (Pipeline)	USD 2,147.48 mil	-
(g)	Xina Solar One Project	-	23 Jun. 2014 (Appraisal)	-	USD 91.71 mil	USD 64.82 mil
(h)	Eskom Renewable Energy - Upington CSP	Eskom	30 May 2011 (Appraisal)	-	USD 628.70 mil	USD 140.85 mil
(i)	Medupi Power Project (Loan in Euro)	Eskom	25 Nov. 2010	-	USD 2,147.48 mil	USD ,689.98 mil
(j)	Eskom Holdings Limited	Eskom	28 Jun. 2007	-	USD 331,08 mil	USD 331,08 mil

Source: Prepared by JICA Study Team based on the information from the website of AfDB as of 5 October 2017

3.2. Necessity of FGD installation

3.2.1. National Environmental Management Air Quality Act

(1) National Ambient Air Quality Standards

In terms of Section 9 (1) of the NEMAQA (Act 39 of 2004), the national ambient air quality standards are set out in the schedule given in Government Notice No. 1210 issued in December 2009, as shown in Table 3.2-1.

Table 3.2-1 National Ambient Air Quality Standards

Parameter	Averaging Period	Concentration	Frequency of Exceedance	Compliance Date
Sulphur Dioxide (SO_2)	10 minutes	500 μg/m^3(191 ppb)	526	Immediate
	1 hour	350 μg/m^3 (134 ppb)	88	Immediate
	24 hours	125 μg/m^3 (48 ppb)	4	Immediate
	1 year	50 μg/m^3 (19 ppb)	0	Immediate
Nitrogen Dioxide (NO_2)	1 hour	200 μg/m^3 (106 ppb)	88	Immediate
	1 year	40 μg/m^3 (21 ppb)	0	Immediate
Particular Matter (PM_{10})	24 hours	120 μg/m^3	4	Immediate-31 December 2014
	24 hours	70 μg/m^3	4	1 January 2015
	1 year	50 μg/m^3	0	Immediate-31 December 2014
	1 year	40 μg/m^3	0	1 January 2015
Particular Matter ($PM_{2.5}$)	24 hours	65 μg/m^3	4	Immediate-31 December 2015
	24 hours	40 μg/m^3	4	1 January 2016-31 December 2029
	24 hours	25 μg/m^3	4	1 January 2030
	1 year	25 μg/m^3	0	Immediate-31 December 2015
	1 year	20 μg/m^3	0	1 January 2016-31 December 2029
	1 year	15 μg/m^3	0	1 January 2030
Ozone (O_3)	8 hours (running)	120 μg/m^3 (61 ppb)	11	Immediate
Benzene (C_6H_6)	1 year	10 μg/m^3 (3.2 ppb)	0	Immediate-31 December 2014
	1 year	5 μg/m^3 (1.6 ppb)	0	1 January 2015
Lead (Pb)	1 year	0.5 μg/m^3	0	Immediate
Carbon Monoxide (CO)	1 hour	30 mg/m^3 (26 ppb)	88	Immediate
	8 hours (calculated on 1 hourly averages)	10 g/m^3 (1.6 ppb)	11	Immediate

Source: Government Notice No.1210 (2009) of National Environmental Management: Air Quality Act (NEMAQA) (Act 39 of 2004)

(2) Minimum Emission Standards

In April 2010, the list of activities and associated minimum emission standards (daily average) in terms of Section 21 of the NEMAQA (Act 39 of 2004) came into effect. These listed activities amended the requirements in terms of emission standards that needed to be adhered to by industries, including coal and liquid fuel-fired power stations.

Table 3.2-2 provides a summary of the minimum emission standards prescribed for solid fuel combustion installations. Medupi TPS will comply with the NEMAQA air emissions standards for "new" plants by 2020. In the interim, the Medupi TPS will adopt to the minimum emission standards for "existing" plants. The SO_2 emission requirements for Medupi TPS in terms of the minimum emissions standards are as follows:

- 3500 mg/Nm^3, to be achieved from 01 April 2015 (at 273K, 101.3 kPa and 10% O_2)
  : Minimum emissions standards for the Existing Plant
- 500 mg/Nm^3, to be achieved from 01 April 2020 (at 273K, 101.3 kPa and 10% O_2)
  : Minimum emissions standards for the New Plant

However, the compliance timeline with minimum emission standards (500 mg/Nm3) for new plant for the Medupi TPS was examined and revised in the process of issuing Atmospheric Emissions License (AEL) from the Limpopo provincial government, as mentioned in Section 3.2.4 of this report.

Table 3.2-2 Minimum Emission Standards Prescribed for Solid Fuel Combustion Installations (Daily Average)

Application	All installations with design capacity equal to or greater than 50 MW heat input per unit, based on the lower calorific value of the fuel used.		
Substance or mixture of substances		Plant status	mg/Nm^3 under normal conditions of 10% 0_2, 273 Kelvin and 101.3 kPa.
Common name	Chemical symbol		
Particulate matter	N/A	New	50
		Existing	100
Sulphur dioxide	SO2	New	500
		Existing	3500
Oxides of nitrogen	NOx expressed as NO2	New	750
		Existing	1100

Note: Compliance Time Frames
New plants must comply with the new plant minimum emission standards from 01 April 2010
Existing plants must comply with minimum emission standards for existing plant by 01 April 2015
Existing plants must comply with minimum emission standards for new plant by 01 April 2020

Source: Government Notice No.248 (2010) of National Environmental Management: Air Quality Act (Act 39 of 2004)

3.2.2. National Environmental Management Act 1998

The framework act in South Africa for environmental management, including environmental permitting, is the National Environmental Management Act (NEMA) (Act No. 107 of 1998). This enacts the Bill of Rights, Section 24 (Environment) of the Constitution of the Republic of South Africa (1996). This section of the bill sets out the right of all to have an environment that is not harmful to their health or well-being and to have the environment protected for the benefit of present and future generations.

Chapter 5, Sections 23 and 24 of NEMA promotes the application of appropriate environmental management tools in order to ensure the integrated environmental management of activities. The objective of the integrated environmental management approach is to identify, predict, and evaluate the actual and potential impact on the environment, socio-economic conditions, and cultural heritage.

Section 28 of NEMA establishes a duty of care and remediation of environmental damage on every person who causes, has caused, or may cause significant pollution or degradation of the environment. Reasonable measures must be taken to prevent such pollution or degradation from occurring, continuing, or recurring, or, in so far as such harm to the environment is authorized by law or cannot reasonably be avoided or stopped, to minimize and rectify such pollution or degradation of the environment.

3.2.3. Agreement with World Bank

The funding for Medupi TPS construction came in part from a WB loan, for which the loan agreement is dated 16 April 2010. The agreement sets out the terms of the loan and includes a section on environmental and social safeguards. This section requires the installation of FGD at Medupi TPS as follows:

> "2. The Borrower shall:
>
> (a) not later than June 30, 2013, develop, adopt and thereafter implement a program, satisfactory to the Bank, to install FGD equipment in each of the six power generation units of the Medupi Power Plant, taking into account technical, environmental and financial criteria in accordance with terms of reference to be discussed with the Bank, such program to be designed such that the installation of the FGD equipment for the first power generation unit shall commence in the later of (i) the sixth anniversary of the Commissioning Date or (ii) March 31, 2018 or such later date as the Bank may establish following consultations with the Borrower), and, thereafter, continue the installation of the FGD equipment sequentially, in each case thereafter at the time each of the remaining five power generation units is taken out of service for the first major planned outage, it being understood and agreed that all the FGD equipment for the six power generation units shall be installed and fully operational not later than December 31, 2021, or such later date as the Bank may establish following the said consultations with the Borrower; and
>
> (b) afford the Bank a reasonable opportunity to exchange views with the Borrower on such FGD installation program at each of its preparation and implementation phases."

Source: "Comments and Responses Report Version 1: Draft Scoping Report for the Proposed Retrofitting Flue Gas Desulphurisation (FGD) at Medupi Power Station in Lephalale, Limpopo Province" (p.12, No.9.2.1) http://www.zitholele.co.za/projects/12949%20-%20EIA%20for%20Medupi%20FGD/2.%20Scoping%20Phase/Draft%20Scoping%20Report/App-D8-CRR.pdf (Accessed on November 2018)

3.2.4. Atmospheric Emissions License by Limpopo Provincial Government

Atmospheric Emissions License (AEL) provides categories of emissions standards with timelines for compliance. The TPS must currently comply with Category 1 of Government Notice No. 248 (Table 3.2-2): Combustion installations for existing plant status. Therefore, based on the compliance timeframe defined by Government Notice No. 248, the plant must reduce SO_2 emissions to less than 500 mg/Nm^3.

As mentioned in 3.2.1 (2) of this report, Eskom realized that while Medupi would be able to meet the "existing" plant standards from April 2015, it would not be able to fully comply to the SO_2 requirements of the "new" plant minimum emission standard from 2020 until such time that the FGD system is installed and operated. Eskom has submitted its application to DEA at the end of February 2014 seeking postponement from compliance with the new emission standards. A response was received from the DEA, dated 13 February 2015, in which the application for the postponement of compliance for the Medupi TPS was granted. The DEA had granted postponement for compliance with the minimum emission standards of a "new" plant from 1 April 2020 to 31 March 2025 with a limit of 3500 mg/Nm^3 during that period. A compliance of 500 mg/Nm^3 is applicable from 1 April 2025.

Through the process above, the Medupi TPS received the AEL for the Medupi TPS, which was issued by the Limpopo provincial government, as contemplated in Chapter 5 of the NEMAQA (Act No 39 of 2004) on 01 April 2015.

<u>Section 7.1.4 of the revised AEL states:</u>

"The License Holder shall, continuously operate, and maintain a flue gas desulphurization (FGD) plant for control of SO_2 on all six units. The Flue Gas Desulphurization plant shall be retrofitted in each unit within six years after the first commissioning of each unit and during the General Overhaul outages."

<u>Section 7.2 tables the SO_2 limits for Stack 1 and Stack 2 as:</u>

3500 mg/Nm^3, to be achieved from 01 Aril 2015 (continuous daily average)

500 mg/Nm^3, to be achieved from 01 April 2025 (continuous daily average)

<u>Section 7.2.1 of the PM10 and NOx limitation state</u>:

PM10 emissions shall not exceed 50 mg/Nm^3

NOx emissions shall not exceed 750 mg/Nm^3

Source: Atmospheric Emissions License by Limpopo Province Government, March 2015

Section 47 of NEMAQA defines the renewal of atmospheric emission licenses and atmospheric emission licenses. When the situation is changed, Eskom can negotiate with Limpopo provincial government and DEA about the conditions of AEL before the compliance time in order to revise the AEL in line with Section 47 of NEMAQA.

Section 3 of Governmental Notice No. 1207 dated 31 October 2018 is about the amendment to the limited activities and associated minimum emission standards identified in terms of section 21 of NEMAQA and defines that the one-time postponement with the compliance timeframe for minimum emission standards for new plants may not exceed a period of five years from the date of issue. Also, no one-time postponement with the compliance timeframes with minimum emission standards for new plant will be valid beyond 31 March 2025. Medupi TPS is categorized as the Existing Plant. The Governmental Notice No.1207 defined that the existing plant to be decommissioned by 31 March 2030 may apply to the National Air Quality Officer for a once-off suspension of compliance timeframes for minimum emission standards for new plant.

3.2.5. Waterberg-Bojanala Priority Area (WBPA) Air Quality Management Plan (AQMP)

The Medupi TPS falls within the Waterberg-Bojanala Priority Area (WBPA), crossing the North West and Limpopo provincial borders. Under the NEMAQA, airshed priority areas can be declared where there is concern of elevated atmospheric pollutant concentrations within the area, and was officially declared on 15 June 2012 (Government Gazette, No. 35435). The Air Quality Management Plan (AQMP) for the WBPA, therefore, needs to consider the current and future threats to air quality. The AQMP development process included three main components: i) the characterization of the baseline air quality in the WBPA; ii) the quantification of potential threats posed to ambient air quality by emissions from future energy-based projects in the WDM and in Botswana up to 2030; and, iii) the development of the WBPA AQMP and its supporting Implementation Plan. The baseline characterization of the WBPA reported on 7 August 2014 that power generation activities contribute 95% of SO_2, 93% of NO_2, and 68% of particulate emissions across the Waterberg District Municipality.

3.3. FGD Installation Planning in the Entire South Africa

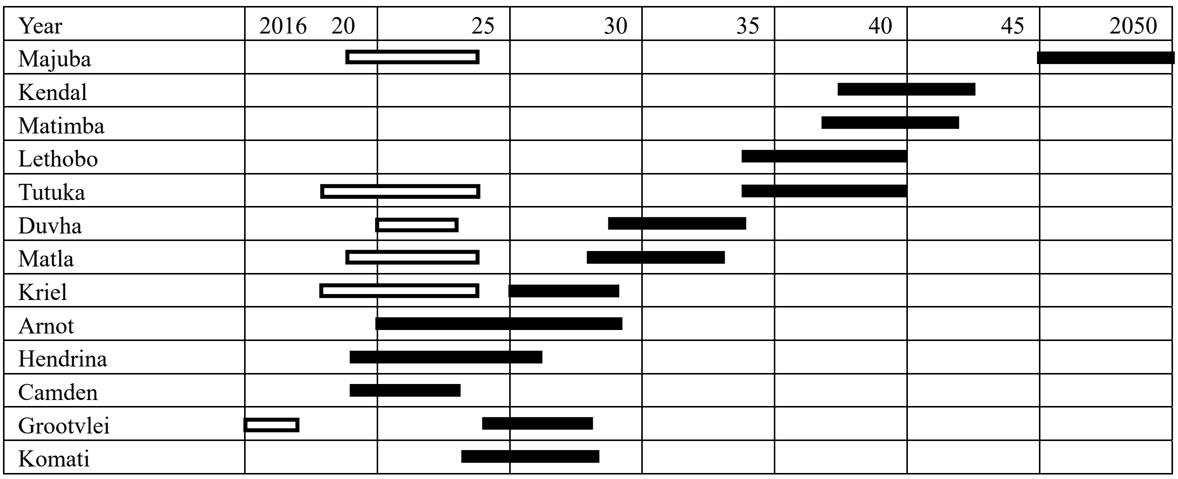
3.3.1. FGD Installation Planning in the Entire South Africa

(1) Air Quality Retrofit

The Draft IRP 2018 Updated showed the Eskom PSs life and air quality retrofit as an authorized plan by the government. It is shown in Table 3.3-1.

Six TPSs, i.e., Majuba, Tutuka, Duvba, Matla, Kriel, and Groovlei, plan to take pollution abatement countermeasures by 2025. However, Groovlei TPS is reported as "already shutdown TPS" last September 2018 as mentioned in MTSAO, so its operation by 2030 is unpredictable through taking pollution abatement countermeasures. It seems that the other seven TPSs will not take pollution abatement countermeasures; however, four of those, i.e., Arnot, Hendrina, Camden, and Komathi, are to be shutdown up to 2023 without a recovery plan thereafter.

Table 3.3-1 Eskom PSs Life and Air Quality Retrofit



: 50year life decommissioning : Emission abatement retrofit (FFP and/or LNB)

FFP: Fabric Filter Precipitator LNB: Low NOx Burner

Source: Integrated Resource Plan 2010 - 2030 Updated, November 2016, Department of Energy

(2) FGD Installation Plan Eskom Wide

The Eskom-wide FGD installation plan is shown in Figure 3.3-1. The Kusile TPS and the Medupi TPS will comply with the domestic regulations, but the other seven plants, namely the Majuba, Kendal, Matimba, Lethabo, Tutuka, Duvha, and Matla PSs, will operate without an FGD in the next ten years due to some reasons. Apart from the mentioned plants, six plants will be decommissioned due to the superannuation of those who will pass the 50-year timeframe from the commencement of operation.

	PM	NOx	SO_2
Kusile	On commissioning		
Medupi	On commissioning		After 6 yrs
Majuba	Compliant	2025	No retrofit plans
Kendal	2025	Already	Not funded
Matimba	Compliant	Already	Not funded
Lethabo	2025	No retrofit plans	No retrofit plans
Tutuka	2025	2025	No retrofit plans
Duvha	2025	No retrofit plans	No retrofit plans
Matla	2025	2025	No retrofit plans
Kriel	2025	Decommissioning	Decommissioning
Arnot	Compliant	Decommissioning	Decommissioning
Hendrina	Compliant	Decommissioning	Decommissioning
Camden	Compliant	Decommissioning	Decommissioning
Grootvlei	2017	Decommissioning	Decommissioning
Komati	Decommissioning	Decommissioning	Decommissioning

Most power stations currently comply with the 2015 Minimum Emission Standards

- Currently comply
- Comply after postponement
- No retrofit plans for 10 years
- Decommissioning within 10 years
- Need to comply, funding limited

No retrofit plans for SO2 and NOx at some stations because their ambient NOx levels are low, impact on tariff, no water available for FGD

Source: Power Point document "Japanese International Cooperation Agency (JICA) and Nippon Koei Medupi FGD Orientation" prepared by Eskom, 4 September 2017

Figure 3.3-1 FGD Installation Plan Eskom Wide

3.3.2. FGD Installation Project On-going/In the Future

(1) Kusile TPS

An FGD will be installed in parallel with the new boiler construction. The schedule of commercial operation of Kusile TPS is shown in Table 3.3-2. As of May 2019, one unit is in commercial operation, and all of the construction work will be completed in June 2022.

Table 3.3-2 Schedule of Commercial Operation of Kusile TPS

Unit	Period
No. 1	Under Commercial Operation (August 2017)
No. 2	31 March 2019
No. 3	31 December 2019
No. 4	31 December 2020
No. 5	31 August 2021
No. 6	30 June 2022

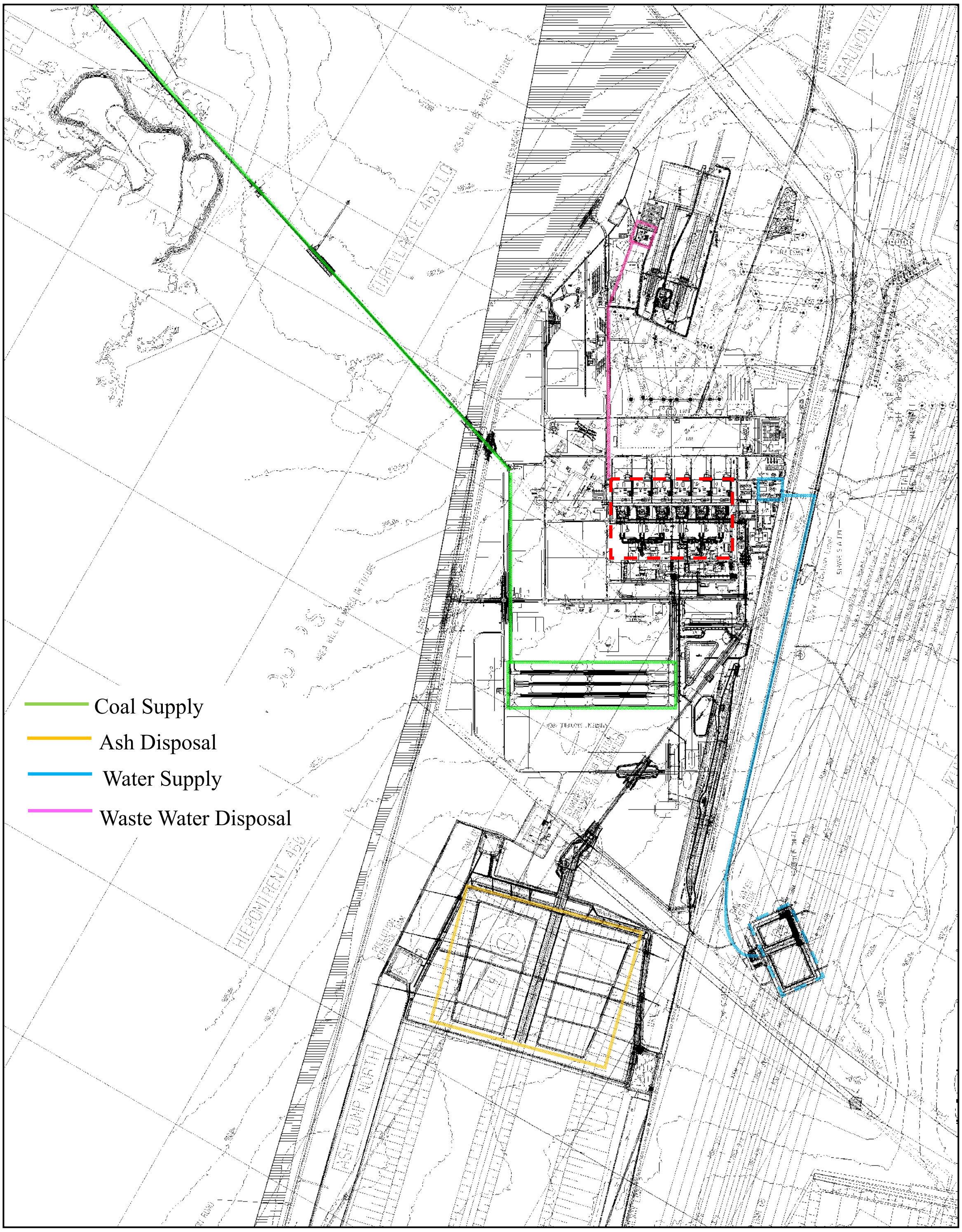
Source: Medium-Term System Adequacy Outlook 2018 to 2023, publicized October 2018

Chapter 4 Outline of Medupi Power Station

4.1. Outline of Medupi Power Station

4.1.1. Layout

The plant layout of the Medupi TPS is shown in Figure 4.1-1. The dimensions of Medupi TPS are approximately 1,800 m in the vertical and approximately 2,700 m in the horizontal. The main plant facilities, e.g., boiler, turbine building, and ACC, are located in the center of the Medupi TPS area. The water supply facility is located near the main plant facility in the south side. Wastewater treatment is located in the east end of Medupi TPS. The Grootegeluk coal mine exists at the north side of the Medupi TPS and is supplied with coal by a belt conveyer. The Grootegeluk coal mine supplies its coal to other consumers too. The existing railway runs on the east and south sides of Medupi TPS to transport coal from the coal mine toward Thabazinbi.



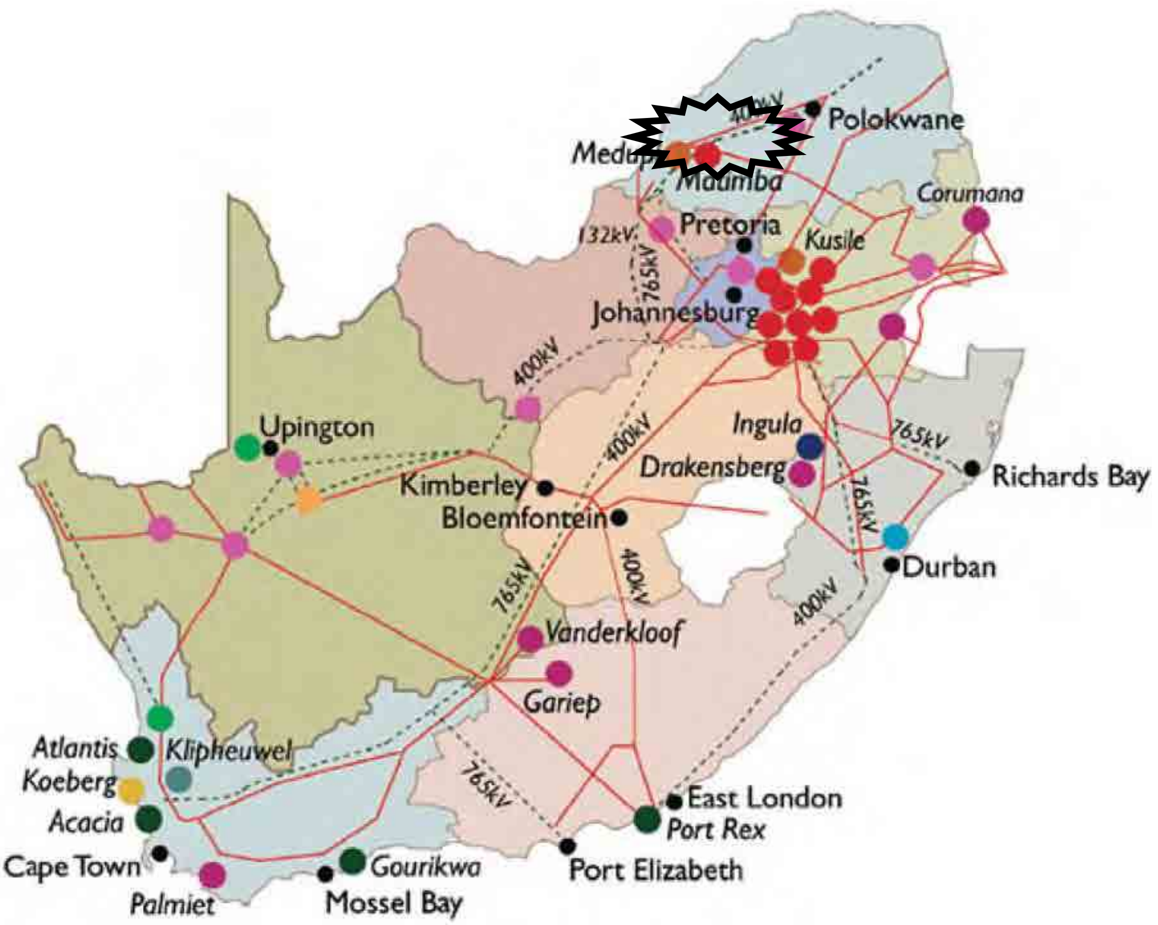
Source: Received from Eskom at the end of September 2017

Figure 4.1-1 Plant Layout of Medupi TPS

4.2. Power Evacuation

The generated power of Medupi TPS, about 4,764 MW (794 MW x 6 units), is transferred to the power consumption areas (Johannesburg, Polokwane, and the east direction) by three 400 kV transmission lines.

The power system diagram in South Africa (more than 400 kV) is shown in Figure 4.2-1.



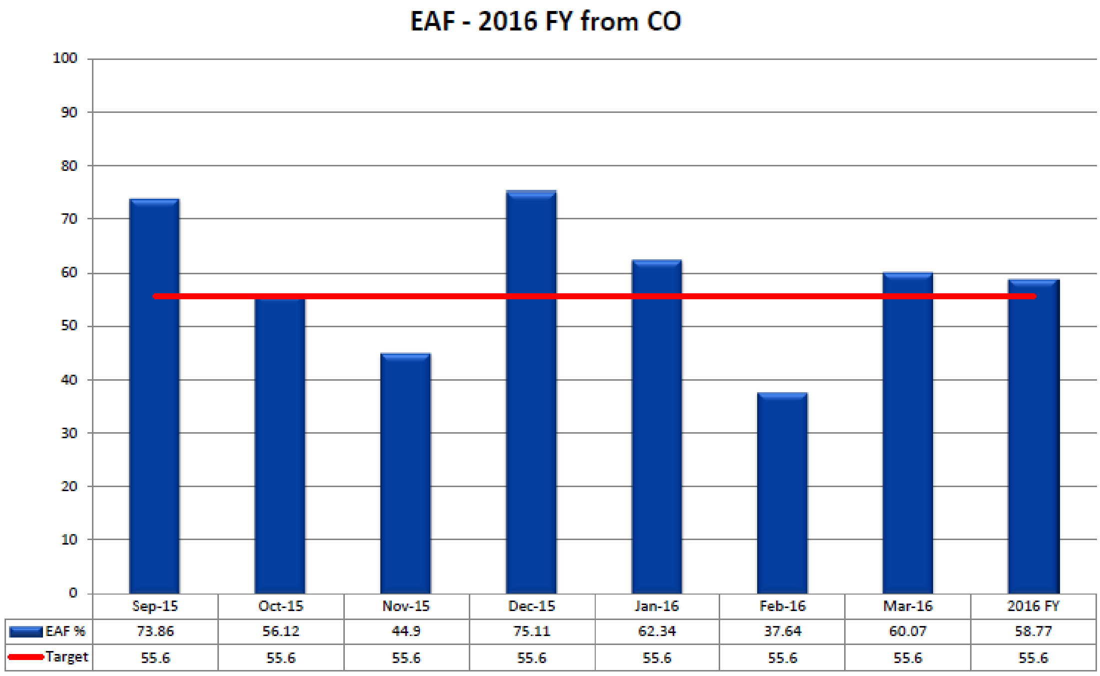
Source: Eskom Website

Figure 4.2-1 Power System Diagram in South Africa (more than 400 kV)

4.3. Operational Record of Medupi Power Station Unit 6

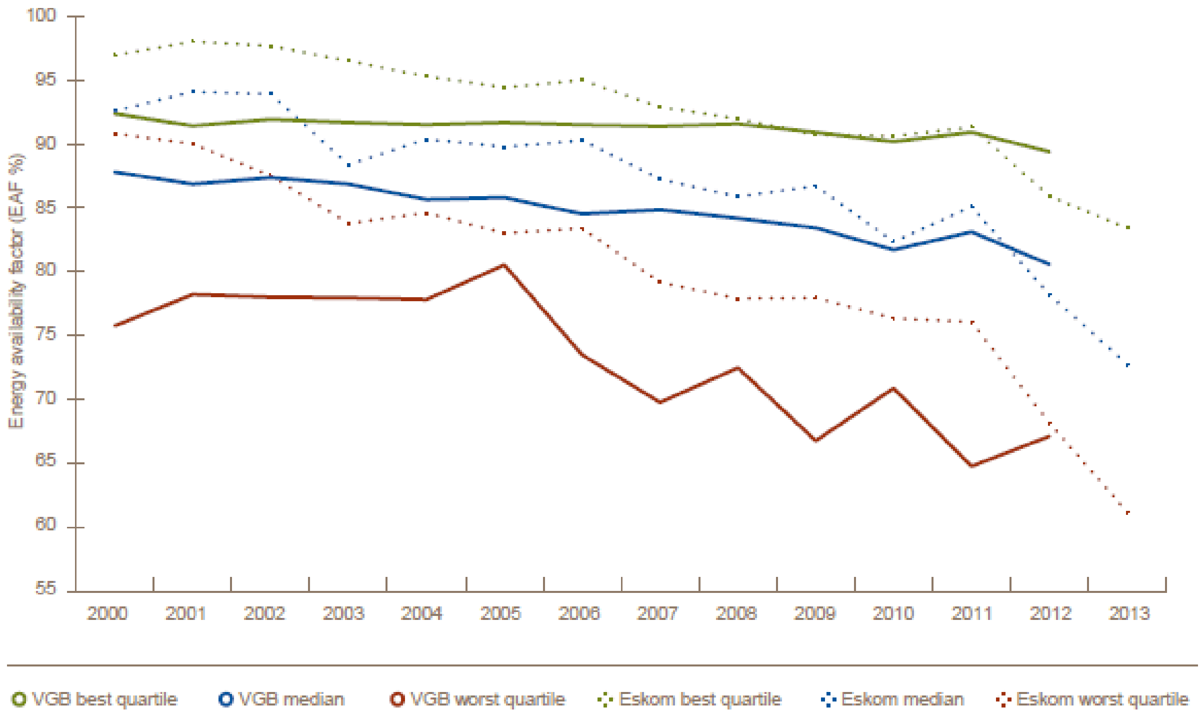
4.3.1. Energy Availability Factor (EAF)

The Energy Availability Factor (EAF) of Unit 6 from commissioning is shown in Figure 4.3-1. The EAF is an indicator that shows the percentage of energy that it is available for the grid. In other words, it indicates the actual annual electric power generation percentage after subtracting the lack of generation due to shutdown and/or load decrease, regardless if it is planned or unplanned, so the ideal annual electric power generation with its full power without shutdown the whole year is regarded 100%. The target value of EAF of Unit 6 is set at 55.6% and has generally been kept for commercial operations up to FY 2016. For reference, the EAF on Eskom's existing coal TPS (2000-2013) is shown in Figure 4.3-2.



Source: Power Point document "Medupi Unit 6 Performance FY2016/17" prepared by Eskom, 3 October 2017

Figure 4.3-1 Energy Availability Factor of Unit 6 from Commissioning



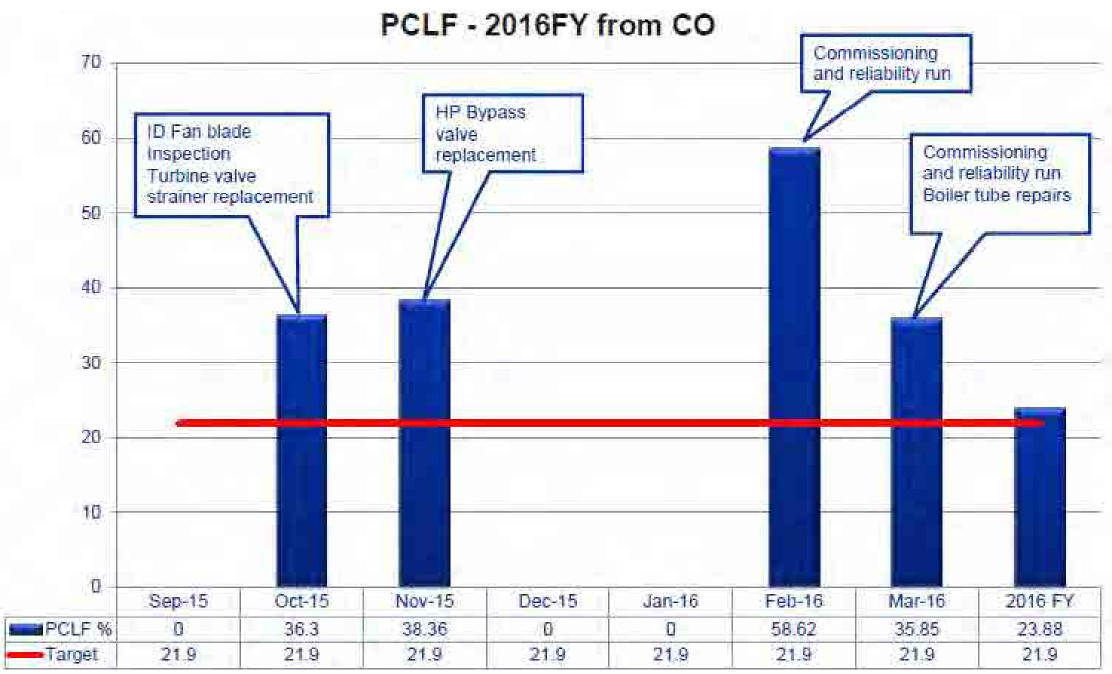
Source: Website of Eskom

Figure 4.3-2 EAF on Eskom's Existing Coal Thermal Power Station (2000 - 2013)

4.3.2. Planned Capability Loss Factor (PCLF)

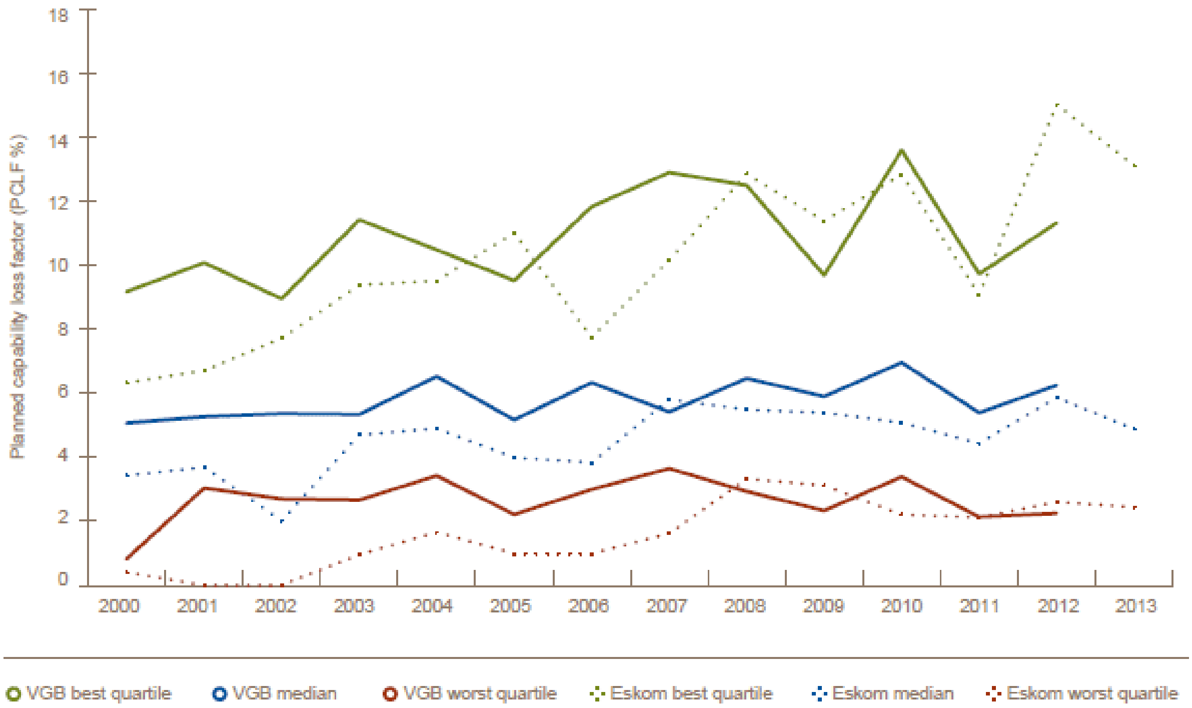
The Planned Capability Loss Factor (PCLF) is an indicator that shows the energy that was not produced during a certain period because of planned shutdowns or load reductions due to plant management control. The PCLF of Unit 6 from commissioning is shown in Figure 4.3-3.

The PCLF also indicates the annual electric power generation loss in percentage due to shutdown and/or load decreasing in case it is planned, so the ideal annual electric power generation with its full power without shutdown the whole year is regarded 100%. The target value of PCLF of Unit 6 is set at 21.9%. It could not be maintained in some months during FY 2015 due to Initial problems. However, it improved in FY 2016. For reference, the PCLF on Eskom's existing coal TPS (2000-2013) is shown in Figure 4.3-4.



Source: Powerpoint Document "Medupi Unit 6 Performance FY2016/17" prepared by Eskom, 3 October 2017

Figure 4.3-3 Planned Capability Loss Factor of Unit 6 from Commissioning

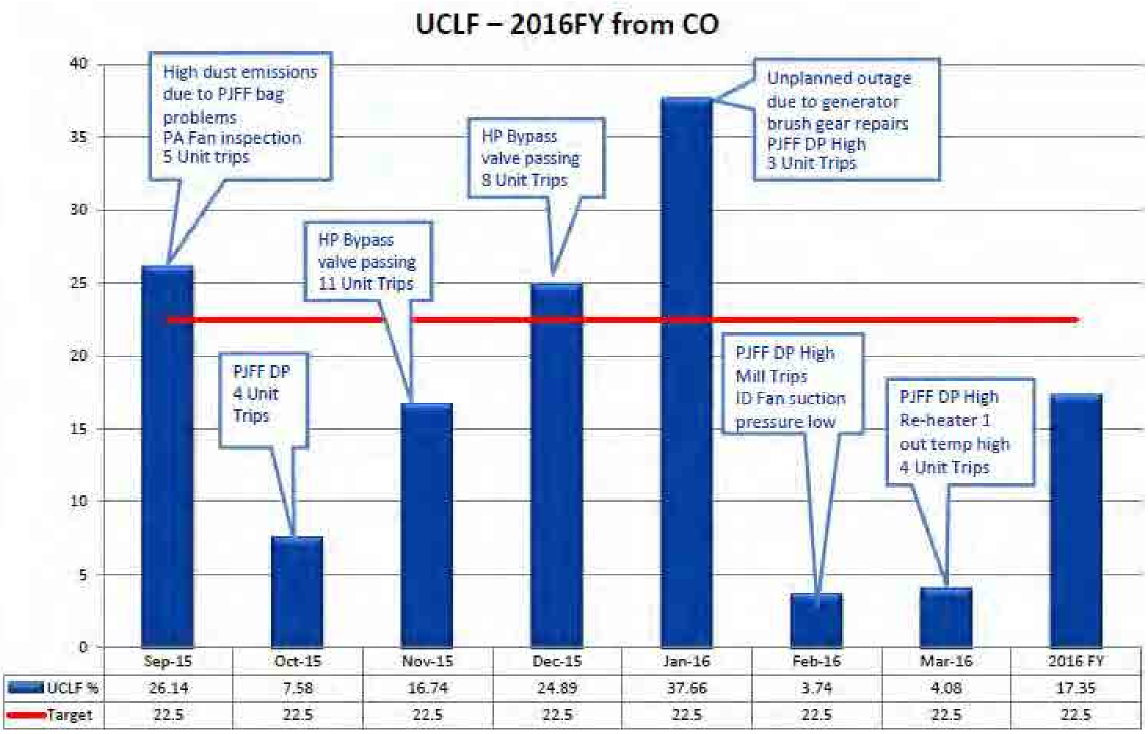


Source: Website of Eskom

Figure 4.3-4 PCLF on Eskom's Existing Coal Thermal Power Station (2000 - 2013)

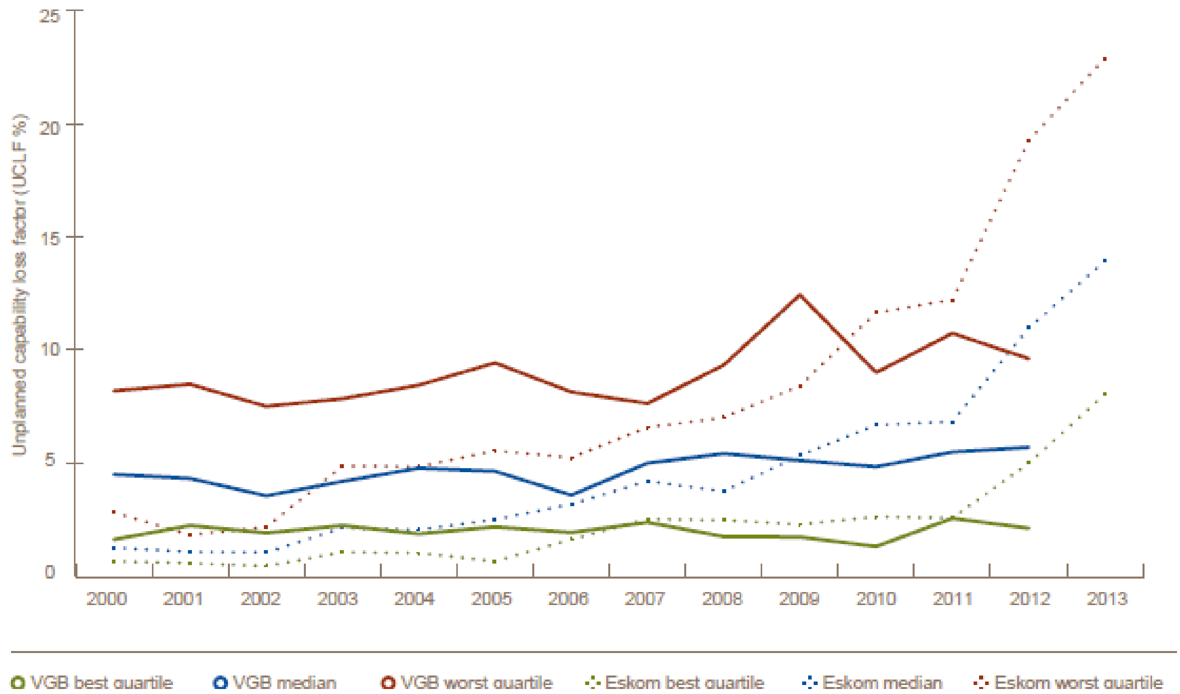
4.3.3. Unplanned Capability Loss Factor (UCLF)

The Unplanned Capability Loss Factor (UCLF) is an indicator that shows the lost energy due to unplanned production interruptions resulting from equipment failures and other plant conditions. The UCLF of Unit 6 from commissioning is shown in Figure 4.3-5. The UCLF indicates the annual electric power generation loss in percentage due to shutdown and/or load decrease in case it is unplanned, so the ideal annual electric power generation with its full power without stop the whole year is regarded 100%. The target value of UCLF of Unit 6 is set at 22.5%. It could not be kept in some months during FY 2015 due to teething problems; however, it improved in FY 2016. For reference, the UCLF on Eskom's existing coal TPS (2000-2013) is shown in Figure 3.1-6.



Source: Powerpoint Document "Medupi Unit 6 Performance FY2016/17" prepared by Eskom, 3 October 2017

Figure 4.3-5 Unplanned Capability Loss Factor of Unit 6 from Commissioning

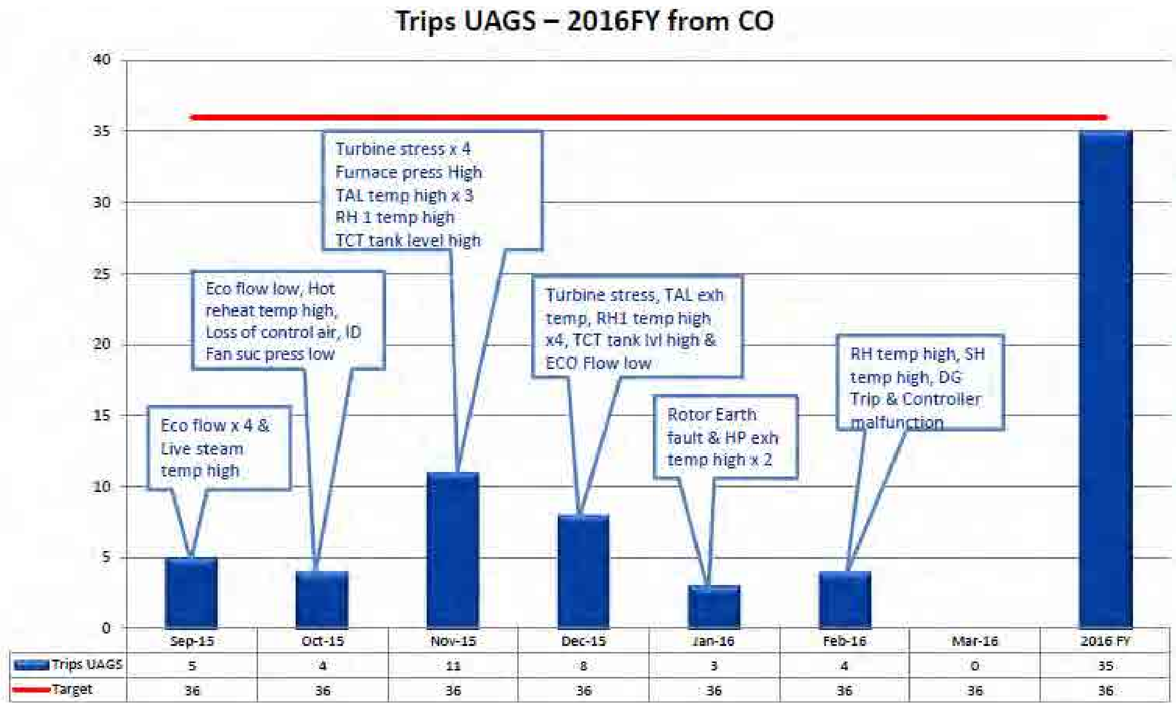


Source: Website of Eskom

Figure 4.3-6 UCLF on Eskom's Existing Coal Thermal Power Station (2000 - 2013)

4.3.4. Unplanned Automatic Grid Separation (UAGS)

The UAGS is an indicator that shows the reliability of service provided to the electrical grid and the number of supply interruptions per operating period. The UAGS of Unit 6 from commissioning is shown in Figure 4.3-7. The target value of the UAGS of Unit 6 is set at eight and has generally been kept for commercial operation in FY 2016.



Source: Powerpoint Document "Medupi Unit 6 Performance FY2016/17" prepared by Eskom, 3 October 2017

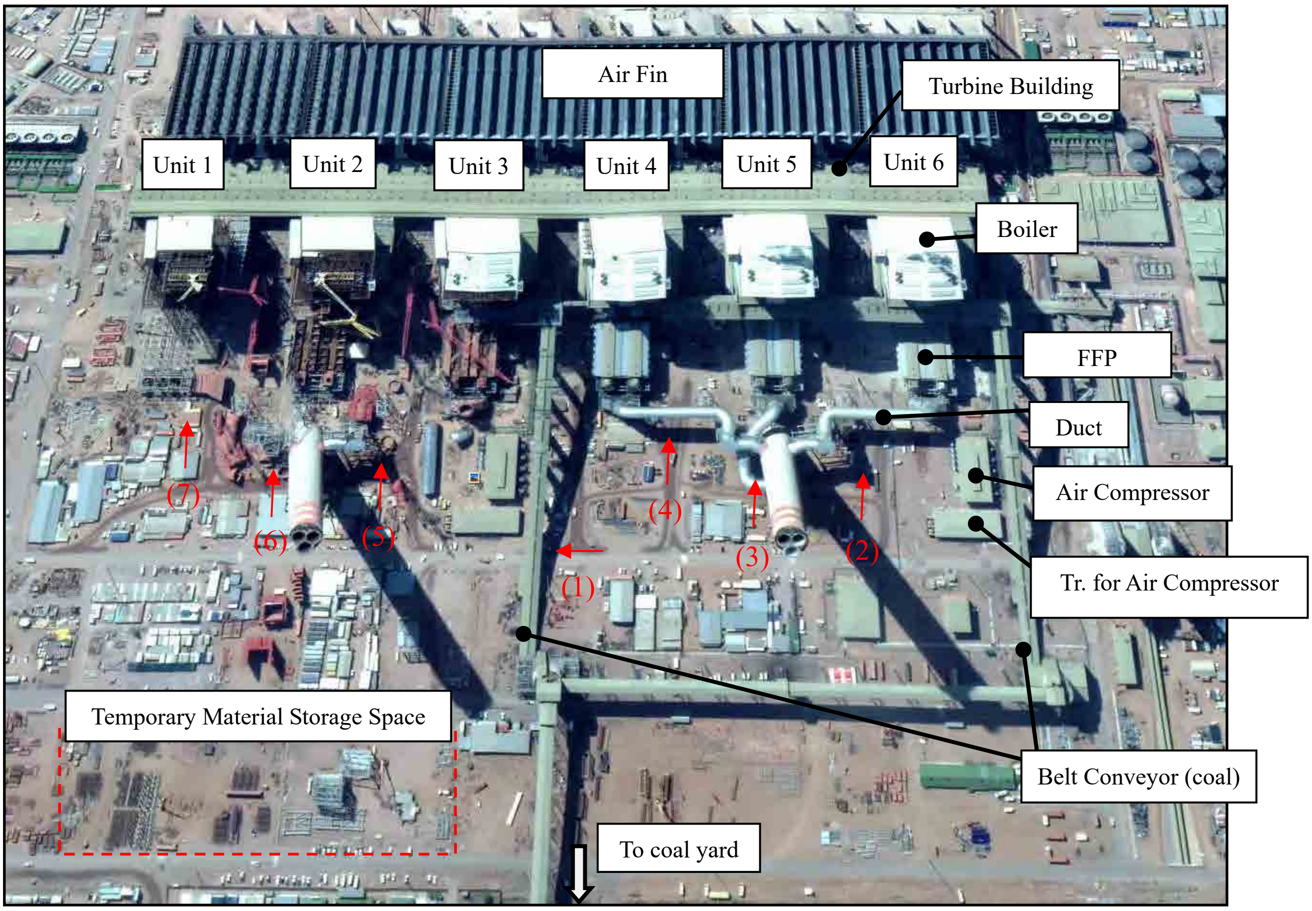
Figure 4.3-7 Unplanned Automatic Grid Separation of Unit 6 from Commissioning

Chapter 5 Location and Site Features

5.1. Site Details

5.1.1. Overall View

An overview of the planned area for FGD installation is shown in Figure 5.1-1. The FGD will be installed between the FFP and the stack with a by-pass duct. Units 4 to 6 will have the enclosed belt conveyer, but it will not cause any problem to the transportation of construction material and moving of heavy machinery which will be mentioned later. There are spaces where temporary materials can be stored.



FFP: Fablic Filter Precipitator

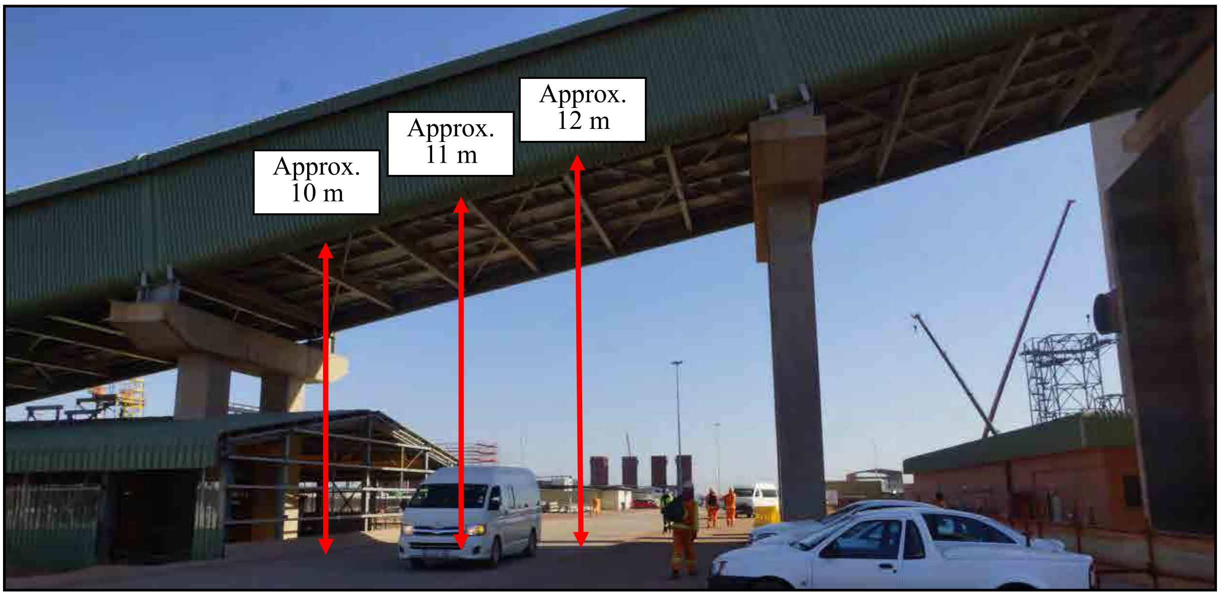
Source: Taken by JICA Study Team using Google Earth (taken in May 2017)

Figure 5.1-1 Overview Around Planned Area of FGD Installation

5.2. Location and Accessibility

5.2.1. Clearance between Belt Conveyor and Road Surface

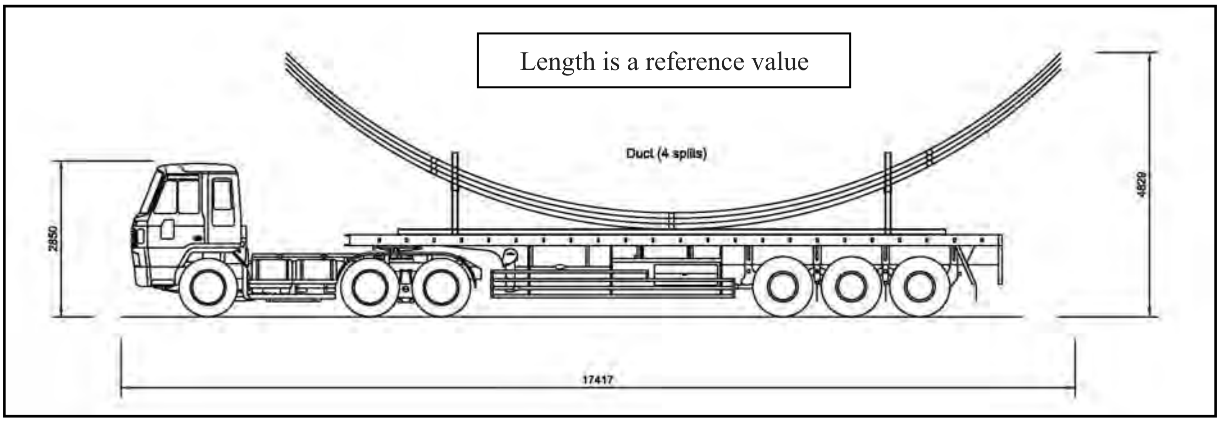
The clearance between the belt conveyor and the road surface is shown in Figure 5.2-1. The JICA Study Team measured the distance using a laser rangefinder at the site. The narrowest clearance is 10 m. It means that the height of the trailer cargo should be less than 10 m in order to pass under the belt conveyor.



Source: Taken by JICA Study Team

Figure 5.2-1 Clearance between the Belt Conveyor and Road Surface

The image of the transportation of absorber is shown in Figure 5.2-2. The largest structure is the absorber; however, in case the absorber is separated into four splits, the height of the packing, including the trailer, should be kept to less than 5 m. It is an acceptable height to pass under the coal conveyor of the TPS.



Source: Prepared by the JICA Study Team

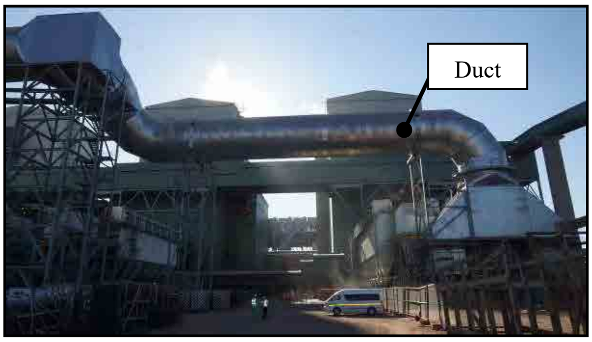
Figure 5.2-2 Image of Transportation of Absorber

5.2.2. Duct for Unit 6 to Unit 1 (as of the end of June 2017)

The views around the duct of each unit are shown in Figure 5.2-3.

The existing duct is aerially installed and is supported by a steel structure. The absorber and bypass duct must be installed while utilizing limited spare space.

View No. (2) Duct for Unit 6



View No. (3) Duct for Unit 5

View No. (4) Duct for Unit 4

View No. (5) Duct for Unit 3

View No. (6) Duct for Unit 2

View No. (7) Duct for Unit 1

Source: Taken by the JICA Study Team

Figure 5.2-3 Views Around the Duct of Each Unit

5.2.3. Description for Equipment

The current situation of the candidate area of FGD is shown in Figure 5.2-4.

Source: Taken by the JICA Study Team

(a)	Chimney	(b)	Duct
(c)	Boiler House	(d)	Fabric Filter Precipitator
(e)	ID Fan	(f)	Belt Conveyor (coal)

Source: Prepared by the JICA Study Team

Figure 5.2-4 Current Situation of Candidate Area of FGD

5.2.4. Temporary Material Storage Space and Equipment Assembly

The candidate area for temporary material storage space is shown in Figure 5.2-5. The area is currently utilized as a storage area.

Source: Taken by the JICA Study Team

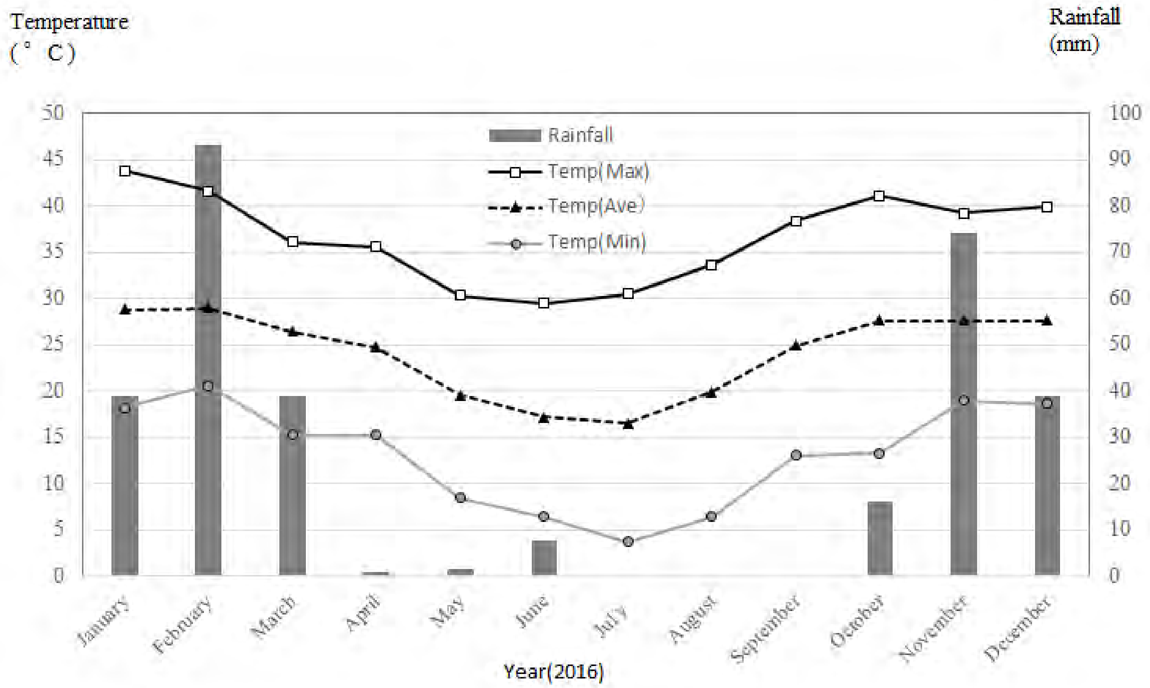
Figure 5.2-5 Candidate Area for Temporary Material Storage Space

5.3. Climate and Metrological Data

The Medupi Monitoring Station located about 4.5 km southwest of the Medupi TPS is equipped for continuous monitoring of meteorological parameters of wind velocity (WVL) and wind direction (WDR) in line with the provisional Atmospheric Emission License (AEL).

The monitoring data shows dominant wind directions during daytime that are from north-east, east-north-east, and east. At night, the most frequent directions were from east-north-east, east, and west-south-west. The dominant wind directions are felt during the winter season (June to August). During daytime, the most frequent directions were from east-north-east. Only at night were the wind directions in west and west-south-west dominant. Winds from all other directions were infrequent during day and night, and wind speeds remained low. The highest 10-minute period wind velocity for July 2016 to June 2017 is 8.6 m/s (See Appendix 5.1)

Lephalale area is influenced by the local steppe climate. There is not much rainfall in the Lephalale area all year long. The average temperature in the Lephalale area is 24.1°C. In 2016, the total annual rainfall was 310 mm. The driest months are July, August, and September with 0 mm of rainfall. In February, precipitation reaches its peak, with an average of 93 mm rainfall.



Source: http://rp5.co.za/Weather_archive_in_Ellisras

Figure 5.3-1 Temperature and Rainfall in Lephalale (2016)

5.4. Geological Data

5.4.1. General Information

The site is underlain by sedimentary rocks of the Waterberg Group. These rocks terminate along the Eenzaamheid Fault near the northern boundary of Naauw Ontkomen. Rocks of the Karoo Supergroup are found to the north of this fault. The Waterberg rocks, which are of Mokolian age (1,600 to 1,700 million years) have been intruded by a number of diabase dykes. The Karoo rocks in the area are of Permian age (250 to 300 million years). Outcrops are rare in the area, although the surface of the Waterberg rocks has been exposed over considerable areas on the Naauw Ontkomen by shallow excavations for road building material. A major part of the site is covered by soils of varying thickness.

The Eenzaamheid Fault, which strikes east-west near the northern boundary of the site, forms the northern limit of Waterberg rocks in the area. It is a normal fault along which a downthrow to the north of about 250 meters has occurred. The age of movement along this feature is unknown, but it probably predates the deposition of the Karoo rocks in the area. There is no evidence of recent reactivation.

5.4.2. Geological Features

The ground of this site is structured by conglomeratic quartzite. The condition of the rock is fresh as a whole, and the weathering of the rock is limited. In the rock mass survey of the site that is planned for construction of FGD (2011-2013), the foundation rock strength was valuated as “H (“hard” (25-70MPa)) to VH (“very hard” (75-200MPa)). The borehole logs on the site are attached at the end of the book as Appendix 5.2.

Table 5.4-1 Existing Survey Report (Excerpt)

Title	Outline	Date
Medupi Power Station: Shallow Groundwater Study	Survey of shallow groundwater and consider dewatering system.	2009-06
Medupi Power Station Foundation Mapping: Chimney South	Geotechnical mapping of the chimney south foundation	2009-11-04
Rock Logging Data of each FGD -Inspection Certificate	Geotechnical mapping of each FGD foundation	2011-2013
Geotechnical Investigation – Excess Coal Stockyard Final Report	Geotechnical investigation required for detailed design of excess coal stock yard and others	2013-02-06

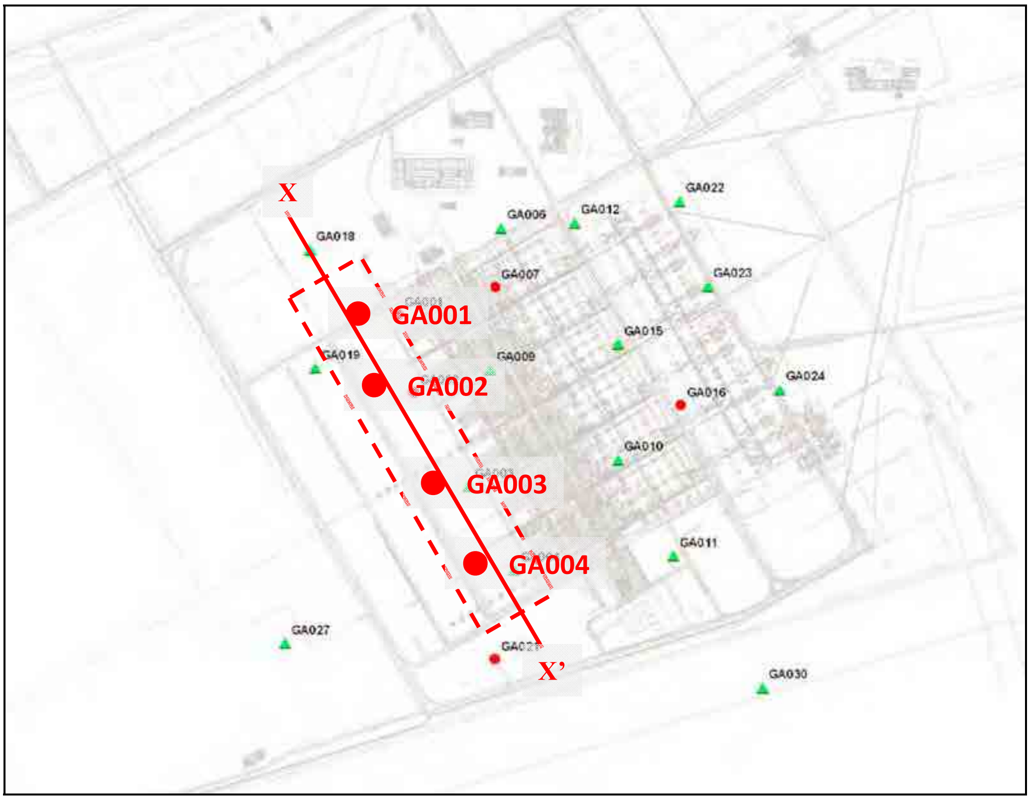
Source: Sorted by the JICA Study Team

Source: Unit 2 Rock Logging Data Flue Gas Duct Base D - Inspection Certificate (18 July 2013)

Figure 5.4-1 FGD Foundation Rock (Unit 2)

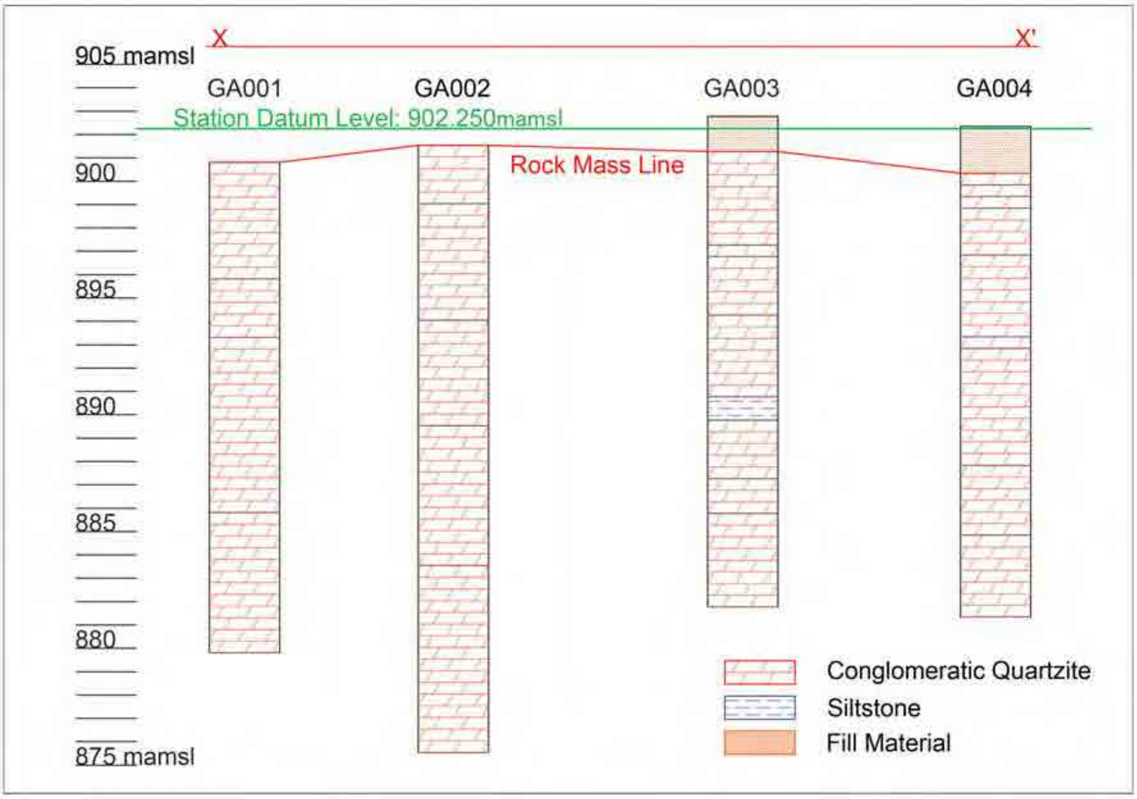
In the previous soil investigation by Eskom for the survey of the shallow groundwater and for consideration of the dewatering system, some borings were dug. The borehole log locations near the planned area of FGD are shown in Figure 5.4-2.

The long profile of rock mass line (close to the planned area of FGD) are shown in Figure 5.4-3. The soil condition at the location of FGD installation has no problems. There is a bedrock of approximately 1-m depth from the station datum level.



Source: Medupi Power Station Shallow Groundwater Study/June 2009

Figure 5.4-2 Borehole Logs Locations near the Planned Area of the FGD Installation



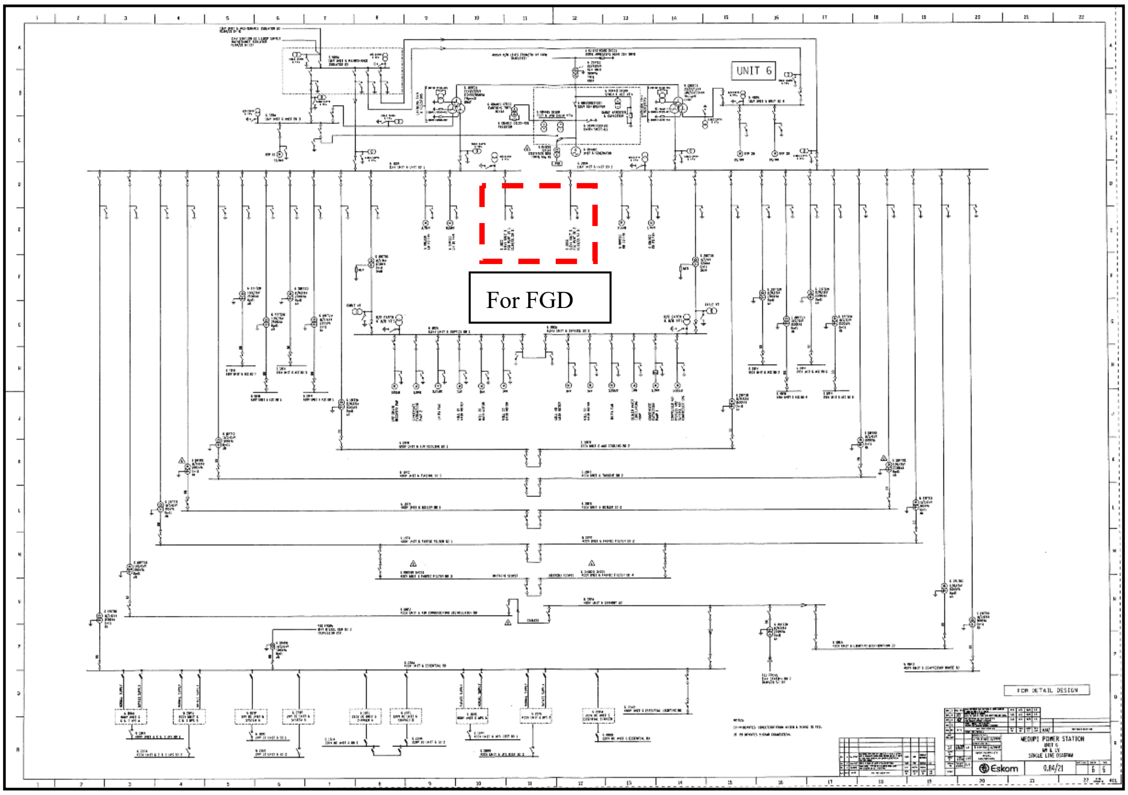
Source: Prepared by the JICA Study Team

Figure 5.4-3 Long Profile of Rock Mass Line

5.5. Fuel Sources and Transportation

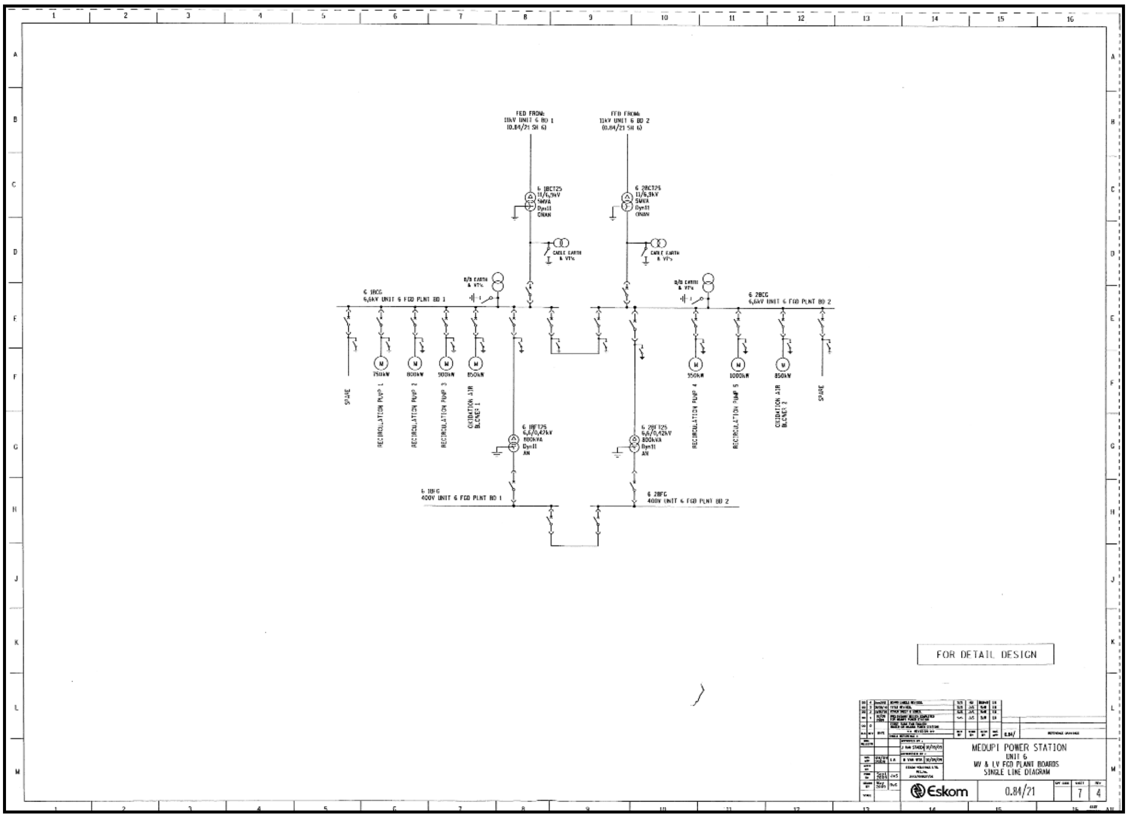
5.6. Single Line Diagram

The single line diagram (bus side) is shown in Figure 5.6-1. Eskom has already factored in the FGD installation and the planned branch point. The single line diagram (feeder side) is shown in Figure 5.6-2. Eskom has already calculated the necessary capacity for FGD installation and planned the component of electrical circuit. There are two sets of five MVA transformers that are needed as the main components of the power supply to FGD per six sets.



Source: Received from Eskom at the end of June 2017

Figure 5.6-1 Single Line Diagram (Bus Side)



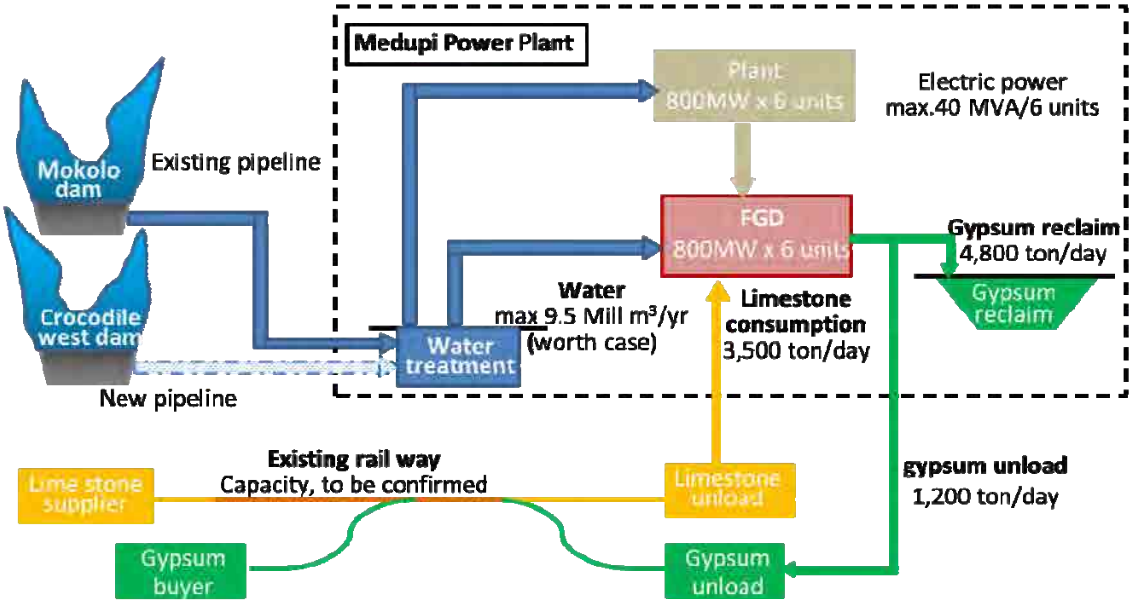
Source: Received from Eskom at the end of June 2017

Figure 5.6-2 Single Line Diagram (Load Side)

Chapter 6 Review of the Basic Design Report

6.1. Scope of the Project

The project scope is shown in Figure 6.1-1. Eskom is planning to adopt the Wet Flue Gas Desulfurization (FGD). Wet FGD requires water and limestone for the chemical reaction process, which produces gypsum as a by-product. The amount of water consumption, limestone consumption, and gypsum production are 9.5 million m^3/year, 3,500 ton/day, and 6,000 ton/day, respectively.



Source: Prepared by the JICA Study Team

Figure 6.1-1 Image of the Project Scope

6.2. Review of the Basic Design Report

6.2.1. Performance Guarantee

Eskom had once intended to design the system and to conduct a detailed design, with a guarantee of their performance by obtaining an FGD system design license from Steinmuller Engineering GmbH in Germany. It is in fact known that some power generation companies based in the United States of America (USA) try to take this guarantee in order to improve capacity and decrease project cost. However, they have stored adequate knowledge prior to such challenge. Even though Kusile FGD has already operated, installation of FGD in addition to the existing flue gas system requires higher technical capacity. The JICA Study Team recommends for Eskom to avoid taking the risk of performance guarantee, including keeping top performance of the existing flue gas system, and also to achieve performance of the FGD.

The JICA Study Team was informed that a similar contract configuration sample was available in an FGD plant of an electric power utility company in the USA licensed by a Japanese FGD engineering company. Such contract configuration may give Eskom an advantage to obtain high technical potentials. However, Eskom shall take full responsibility on technical performance and on the completion period of the Project.

6.2.2. System Configuration

(1) Current System Configuration

Boiler flue gas is exhausted from a gas air heater (GAH), flows through a fabric filter (FF), is induced by an induced draft fan (IDF), is introduced into an absorber, and is connected to a stack flue tube through a flue duct.

In Japan, it is quite common to install a gas cooler (GC) before an absorber in order to reduce water evaporation in the absorber. It is also recommended to install a GC in the Medupi TPS to save on water consumption so that the saved water can be utilized for other purposes in the area.

The JICA Study Team was informed that Eskom had studied a GC system in 2014; however, they refrained from adopting it due to some reasons mentioned below.

- The layout space will be tight for installing a GC onto the existing duct, especially for Units -5 and -2, but Units -6, -4, -3, and -1 will have enough space.
- The countermeasures against corrosion and/or erosion of a GC seem to be studied in Eskom. The operation data and maintenance record collected in 2014 by Eskom in Europe and/or other areas could not give enough reliable data and reasonable economical aspect to convince Eskom.
- A GC frequently requires rehabilitation expenditure due to erosion or corrosion.

(2) Necessity of Water Saving Consideration

As mentioned in Chapter 8, Medupi PS has only one water resource from Mokolo River which provides 10.9 million m^3/year, called MCWAP1, as of January 2018. However, 13.4 million m^3/year water is required after completion of six FGD installations, so a new water resource is essential.

Eskom will apply for a water use license in July 2018 for Crocodile River which is 140 km away, called MCWAP2, and will obtain approval by January 2019.

Current water rights cover the water use for only three units of FGD; however, if a water saving equipment is introduced, current water rights can cover water use for five units of FGD.

(3) Benefit of FGD with Gas Cooler

The FGD system design is improved to save water evaporation by introducing GC after 1990.

The flue gas which from the boiler through the ESP or FF to the absorber is cooled down by 30°C to 40°C by the GC. It can reduce water evaporation in the absorber by 30% to 35% in general. The gas temperature design can be selected on a case-to-case basis.

In the past, the GC type was either regenerative, rotary, or ljungstrom. However, those types are complicated and needed longer duct work. Further, a small amount (5% or so) of untreated dirty gas would escape and be entrained into clean treated gas.

Then new non-leak GC type had been developed and introduced. Specifically, the GC heat exchanger and gas reheater heat exchanger are connected by piping, and heating media of water is circulated by a pump. This system had greatly solved space and layout difficulty and had become a major conducted type.

As the white steam smoke from stack is not welcomed in Japan, it is also controlled by regulations. A gas reheater after the absorber is also required to reduce white steam smoke. Thus, all the PSs in Japan have been designed and constructed with both GC and gas re-heater (GRH) systems.

The actual operation records in Hitachi-naka (Unit-2) in Japan showed that the renewal period is more than 10 to 15 years. It shows that an experienced manufacturer can design a GC to withstand long-term use, i.e., more than 10 years, without replacement of bundle.

(4) Recommendation

The JICA Study Team recommends the adopting introduction of GC in order to reduce water evaporation in the absorber. This is very important to water economy in the region both in economic and ecological points of view.

Comparison of wet FGD with/without GC is shown in Table 6.2-1. Originally, Eskom selected the FGD without GC as option C; however, the JICA Study Team preferred the FGD with a GC but without a GRH.

Water resources should be carefully utilized especially in this dry country and possibly in neighboring countries as the Limpopo River is flowing down the border of some countries.

Also, the increased draft loss due to the addition of an FGD system (absorber, GC, and possibly gas re-heater) may require reinforcement of the existing draft force, such as modifying the existing IDF to increase fan head or installing another boost up fan (BUF) in the series.

The additional draft loss will be 250 mm to 350 mm Aq in total. The IDF head margin should be surveyed obtaining detailed information from the boiler and fan manufacturers. There might be a possibility of modifying the existing IDF (axial type fan), especially onto the last stage of the impeller, and getting some more pressure head.

Installing a gas reheater after the absorber is the most common style in Japan since the white steam smoke should not be observed from outside and should be reheated before feeding it to the stack flue tube. This should assist better propagation in the air to reduce the ground level concentration.

In Japan, 85°C to 90 °C is commonly selected by the local government.

The alternative plan of Eskom is to install a GC only so that the recovered heat would be supplied to the boiler feedwater at low pressure heater No.1 as it is also one of the excellent ideas to raise plant efficiency.

Table 6.2-1 Comparison of Wet FGD With/Without Gas Cooler (ZAR 1 = JPY 8.7)

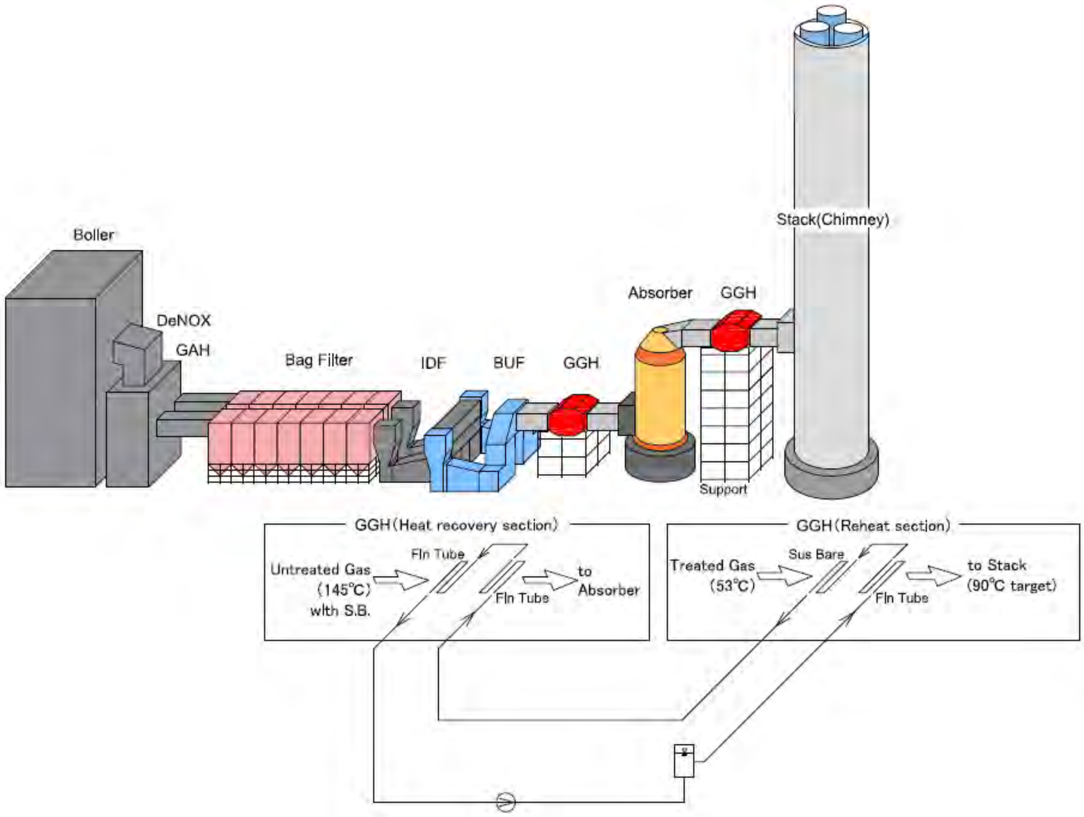
	Option A	**Option B**	**Option C**
	With both GC and GRH (New proposal from Japanese side)	With GC without GRH (Alternative of Medupi FGD BD)	Neither GC nor GRH (Original plan of Medupi FGD BD)
Layout	Kindly refer to Figure 6.2-1	Kindly refer to Figure 6.2-2	Kindly refer to Medupi FGD BD
Water saving (Positive impact for environmental and social aspects)	Water consumption per unit will be reduced from 182 t/h to 121 t/h. It means 33.5% reduction of water evaporation in the absorber.	Same as left	Original case No water saving.
Necessity of additional improvement of flue gas system	No issues regarding stack corrosion, but modification of ID or installation of BUF is needed. (modification of IDF or additional BUF); It is necessary to modify or replace IDF or add, in series, BUF to compensate the increased draft loss of set of installation of FDG.	Additional improvement of flue gas system is not needed. (Induced Draft Fan) It should be confirmed whether the head margin of existing IDF would cover the increased draft loss of absorber and GC. (Stack) It should be confirmed by Eskom whether the existing stack refractory can permit such flue gas with temperature as low as 53°C to 60°C, although the SO_2 contents are controlled at 500 mg/m^{3}N or less due to regulation. (In Medupi FGD BD, 400 mg/m^{3}N is targeted) If the refractory of flue tube inside is not designed against acid corrosion, another Wet Stack with acid resistant lining material (such as FRP) should be additionally installed. (However, the plant layout may not allow space for another wet stack construction.)	Additional improvement of flue gas system is not needed. (Induced Draft Fan) In case the margin of IDF delivery pressure, such as 2.5 kPa, could accommodate total FGD draft loss, the existing IDF could be used as they are, depending on total draft loss of FGD system.
Environmental impact	No negative impact	(Acid droplet) If low temperature wet gas such as 53°C to 60 °C is emitted from	(More water usage) More amount of water, 2.4 million ton per six units annual,

	Option A With both GC and GRH (New proposal from Japanese side)	**Option B** With GC without GRH (Alternative of Medupi FGD BD)	**Option C** Neither GC nor GRH (Original plan of Medupi FGD BD)
		stack top, acidic droplet, sometimes called acid rain, may fall on the TPS and surrounding area. Reheating and evaporation of acidic water droplet to vapor before discharging from stack is highly recommended.	will be consumed by FGD. If water saving countermeasures, such as introduction of GC, are adopted, environmental impact by FGD will be mitigated.
Social impact	No negative impact White steam will not be observed even in winter. Maximum ground level concentration will be reduced if the stack outlet gas is reheated and its temperature is raised.	(White steam/vapor) White steam smoke can be observed especially in winter. It will give a negative impression to the neighborhood. In Japan, some neighbors may call the TPS to claim reduction of air "pollution" frequently . (SOx ground level concentration) Lower temperature will reduce blow-off velocity and gas spreading. Small acidic droplet may fall on nearby area. The malfunction of low temperature flue gas will remain at ground level concentration although the local regulation only requires discharge concentration at the stack tube outlet.	(More water usage) More water, about 2.4 million ton per six units, will be consumed annually by FGD. If water saving countermeasures, such as introduction of GC, are adopted, environmental impact by FGD will be mitigated. For example, the margin water will be utilized for drinking water and/or irrigation water.
Structure and elements of GC and GRH	The history of introducing water saving type FGD From the ecological point of view, a water saving type FGD is greatly required and major FGD engineering companies developed several types and applied in various TPSs. Various technical operation records had been fed and improved. GC and GRH materials against corrosion or erosion Basically, some kinds of carbon steel tubes are keys for GC and GRH heat exchangers, which are physically tough and economically recommendable. Such technical outcome and fruits backed up with long and sound operation records can be applied to this project, which will assure less maintenance.		**(Base); no GGH**
Operational impact	No negative impact The water saving type FGD with GC is an already established technology in Japan, and Japan manufacturers have many track records. Such FGD plant has already been proven more than 10 years with general normal maintenance under stable operation. (One sample case) In the Hitachi-naka case, a tube bundle of GC had been operated 13 years without heavy trouble and after GRH tube bundle have been	No negative impact	No negative impact

		Option A	**Option B**	**Option C**
		With both GC and GRH (New proposal from Japanese side)	With GC without GRH (Alternative of Medupi FGD BD)	Neither GC nor GRH (Original plan of Medupi FGD BD)
		replaced and renewed, which remained as they are.		
Outgo	Additional cost for GC system per six units (A)	ZAR 1,121 million (JPY 9,750 million) Additional cost is incurred as additional BUF is required to compensate pressure loss by a set of GCs and GRH. Breakdown Set of GC and GRH, ZAR 776 million BUF, ZAR 345 million.	ZAR 465 million (JPY 4,050 million)	No additional cost
Outgo	Replace cost per six units (B)	ZAR 276 million per 10 years (bundle replace) (JPY 2,400 million)	ZAR 166 million per 10 years (bundle replace) (JPY 1,440 million)	No additional cost
Outgo	Additional operation power cost per six units (C)	*If capacity of BUF is 4 MW per unit,* *6 x 4 x 24 x 365 x 80% x ZAR 236/MWh* *=ZAR 40 million per year* (JPY 348 million/year)	No additional cost	No additional cost
Outgo	Outgo per 30 years (D=A + 3xB + 30 x C)	ZAR 3,149 million/30 years (JPY 27,396 million/30 years)	ZAR 963 million (JPY 8,370 million)	Original case
Income	Reduction of water consumption fee per six units (E)	ZAR 32 million/year Suppose that the water reduction merit could be converted to water costs; --- Water consumption 121 t/h. Water reduction 61 t/h 6 x 61 x 24x 365 x 80% x 90% x 14 ZAR/t = ZAR 32 million/year (JPY 281 million/yea)	Same as left	Water consumption 182 t/h This is an ecological issue to be solved.
Income	Reduction of coal by efficiency improvement per six units (F)	NA	*If plant efficiency is higher at 0.3% (tentative) than the original case,* *4,764 MW /20.5 (MJ/kg) x 3,600* x *0.3%* x *24* x *365 x 80%* x *90% x 870 ZAR/t* *=ZAR 15 million/year* (JPY 134 million/year)	NA
Income	Reduction of operation cost per 30 years (F=30xE + 30xF)	ZAR 969 million (JPY 8,430 million)	ZAR 1,896 million (JPY 16,260 million/year)	Original case
Recommendation			Recommended	

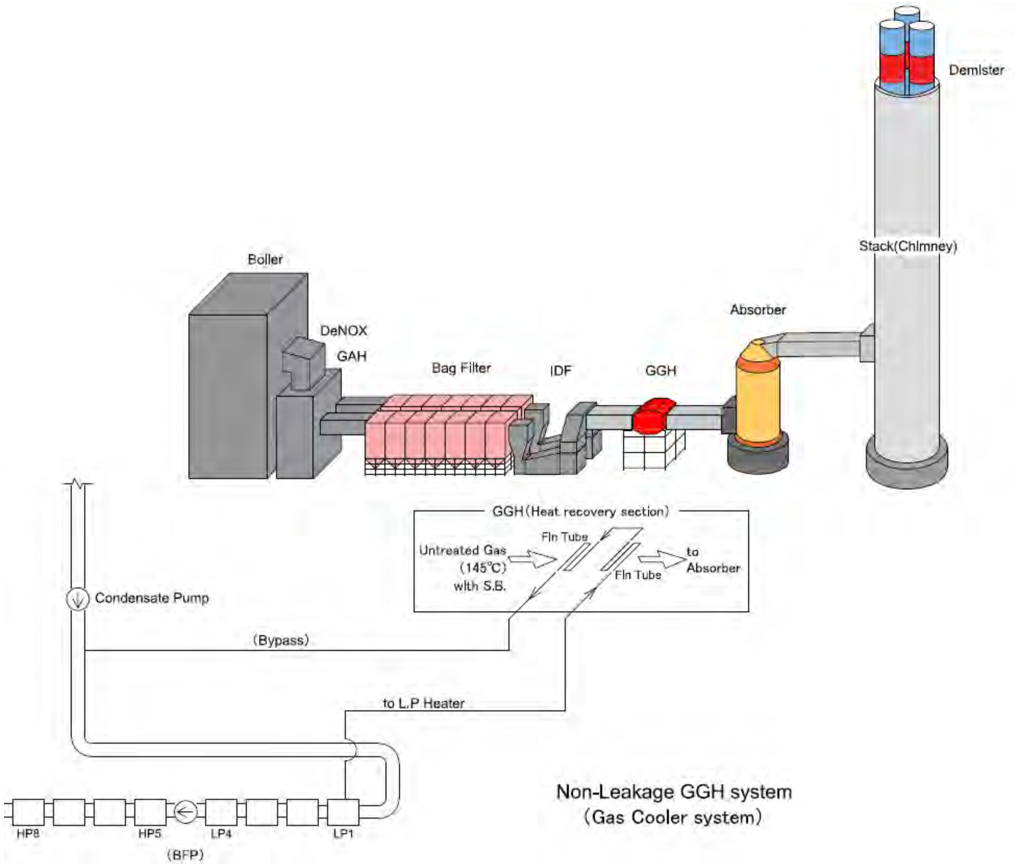
GC: Gas Cooler, GRH: Gas Re-Heater, IDF: Induced Draft Fan, BUF: Boost Up Fan

Source: Prepared by JICA Study Team



Source: JICA Study Team

Figure 6.2-1 With Gas Cooler and Gas Re-Heater System



Source: JICA Study Team

Figure 6.2-2 With Gas Cooler System

6.2.3. Other Technical Issues

(1) Issues and Countermeasures on Gas Cooler

1) Droplet of Acid Mist (Vortex Demister)

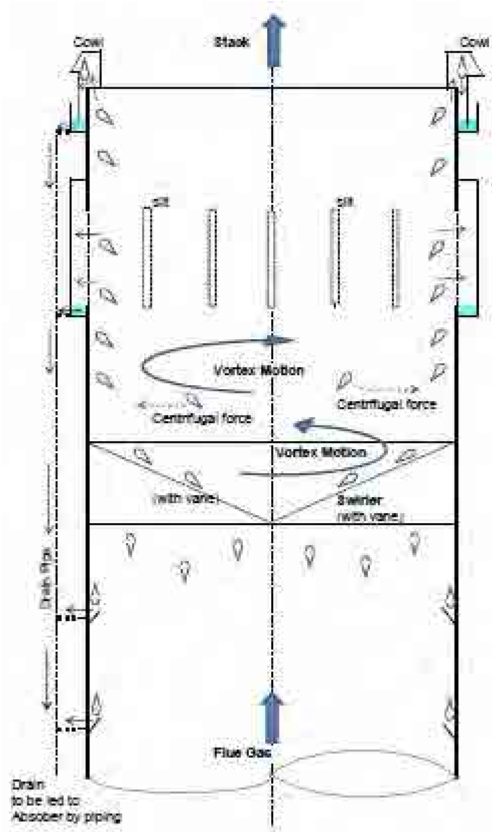
According to the technical specification Option-2 of Eskom Medupi FGD BD, Eskom does not intend to install a GRH after the absorber. Without a reheater, cold saturated wet gas will be introduced to the stack flue tube. The temperature of gas will decrease by a few degrees while going up the stack top, producing a small amount of acidic mist, and liquid droplet will be exhausted from the stack nozzle.

To eliminate the acidic mist, it is recommended to install a mist demister, such as the Vortex Demister, inside the flue tube top in addition to the mist eliminator installed at the top of the absorber.

An image of the Vortex Demister is shown in Figure 6.2-3.

Without the demister, diluted acidic mist droplets or so called stack rain, will fall adjacent to the stack area in the TPS. Although steam white smoke from the stack outlet nozzle is not significant in pollution control, acidic mist droplets from the stack nozzle may cause minor damage in the structures, roofs, and roads inside the TPS.

The demister creates draft loss, which should be considered in planning of total draft loss and IDF.



Source: Prepared by JICA Study Team

Figure 6.2-3 Image of Vortex Demister

2) Corrosion of Stack by Acid Mist (stack flue tube lining temperature)
It was reported by Eskom that the existing lining inside the stack flue tube is tolerant to the gas temperature from 48°C to 145°C in wide range.

However, the temperature of flue gas going through stack is prospected to be 50°C or more. Therefore, corrosion of stack by acid mist is not an issue.

3) Ash Erosion Characteristics
Eskom is paying attention to the ash characteristics, especially for erosion caused by the ash burned coal produced from coal mine in South Africa. An ash sample of the Japanese TPS utilizing imported coal, had been taken to SA for comparison of affection of the FGD system. Eskom had analyzed and found that the SA ash had contained less erosive ingredients. Actual erosion, corrosion wear and sound operation hours can be evaluated as a reliable index. Further study may be expected in this regard.

4) Consideration of Location of Gas Cooler
Nowadays, Low-low Temperature Electric Precipitator (EP) is the most prevailing.

Low-low temperature EP has been developed, and it is most prevalent due to its less troublesome performance. This is because of better dust collection efficiency of the EP at lower temperatures.

A comparison of location of GC is shown in Table 6.2-2.

In addition, space issue for Unit No. 5 and No. 2 shall also be carefully studied, including crane access space for the retrofit construction work.

Table 6.2-2 Comparison of Location of Gas Cooler

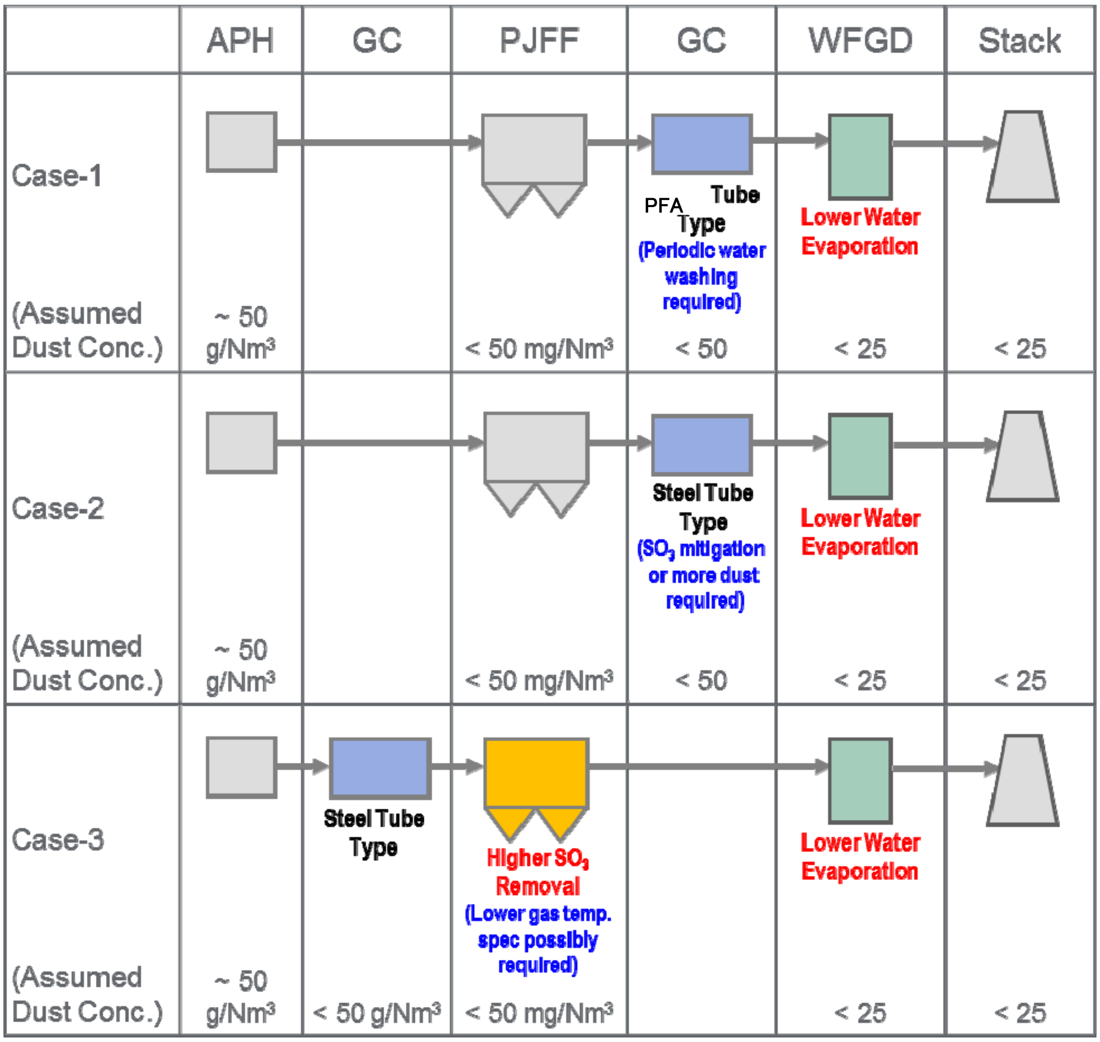
<table>
<tr><th colspan="2"></th><th>PFA material GC located downstream of PJFF (Low Temp. FF)</th><th>Steel material GC located downstream of PJFF (Low Temp. FF)</th><th>GC located upstream of PJFF (Low-Low Temp. FF)</th></tr>
<tr><td colspan="2">Image</td><td>Case-1; Refer to Figure 6.2-4</td><td>Case-2; Refer to Figure 6.2-4</td><td>Case-3; Refer to Figure 6.2-4</td></tr>
<tr><td></td><td></td><td colspan="2">Flue gas is cooled by GC to around 90°C downstream of FF (at inlet of FGD).</td><td>Flue gas is cooled by GC to around 90°C upstream (inlet) of FF.</td></tr>
<tr><td rowspan="2">Lifetime</td><td>Erosion (Wear);</td><td colspan="2">No issue (few negative impacts regarding erosion)
Erosion of GC tubes will seldom be seen because the dust (fly ash) concentration in flue gas is very low. (deducted at upstream of GC)</td><td>No issue (few negative impacts regarding erosion)
Flue gas velocity is one of the major factors to consider erosion in a dusty (fly ash) environment.
Ash erosion in GC can be avoided by sizing GC to be appropriate flue gas velocity and shaping to prevent drift.
$\because$ Erosion $\propto$ (Flue Gas Velocity)^4</td></tr>
<tr><td>Corrosion & Clogging and/or Plugging;</td><td>It causes pressure-loss increase in GC rapidly.
Careful water washing is required.</td><td>It causes pressure-loss increase in GC rapidly.
Injection of limestone powder at upstream of GC can be considered as a measure to prevent corrosion and plugging of GC.</td><td>No issue (few negative impacts regarding corrosion and clogging and/or plugging)</td></tr>
<tr><td>Maintenance</td><td>Pressure loss</td><td>Periodic water washing is required.
In the case of Europe PS, water washing is necessary 4 to 6 times/day.
If pressure loss increase, even washings carried out, GC shall be necessarily shut down for full washing.</td><td>Periodical soot-blower or steel ball cleaning is necessary frequently.
If pressure loss increase, even washings carried out, GC shall be necessarily shut down for full washing.</td><td>No issue (few negative impacts regarding maintenance)
Pressure loss might rise gradually during operation; however, periodical soot blowing can regain almost original pressure loss.
The accumulated dust on GC tubes/fins is easily blow down out by soot blowers without GC shutdown.</td></tr>
<tr><td>Modification of Equipment</td><td>Measures against pressure loss increase</td><td colspan="2">No issue (few negative impacts regarding maintenance)
Pressure loss increases by installing a GC will be lower than 0.9 kPa. The expected pressure losses at original flue gas system, FGD, and spray nozzles are 5.0, 1.53, and 0.50 kPa, respectively.
It means that total pressure loss is 7.93 kPa (= 5.0+1.53+0.5+0.9), plus some draft loss margin by fouling factor.
Since the capacity of IDF is 10.18 kPa, existing IDF may be able to accommodate the pressure loss due to introduction of FGD, spray nozzles and GC without modification of impeller/blade.</td><td>No issue (few negative impacts regarding maintenance)
Pressure loss increases by installing GC will be lower than 0.9 kPa. However, existing IDF can accommodate pressure loss due to introduction of FGD, spray nozzles, and GC without modification of impeller/blade.
At the same time, flue gas temperature downstream of GC is lowered to 90°C from 145°C; thus, actual gas volume is decreased, which will reduce flue gas velocity and draft loss between GC and FGD only in 13% (= 1- (273 + 90)/ (273 + 145)) and will help IDF's capacity.
It means power consumption of IDF will be reduced compared to the low temperature FF system.</td></tr>
</table>

	Replacement	According to the report, replacement of bundles is necessary every 6 years.	In the Soma-Kyodo PS case, replacement of bundles is necessary with interval of 10 or more years.	In Hitachi-Naka PS case, replacement of bundles is necessary with interval of 10 or more years.
	Other measures against corrosion, etc.	A wastewater treatment system to treat washing water shall be considered, which should accommodate wastewater with low pH, high temperature, and some fly ash.	To prevent corrosion and plugging of GC, measures to inject, such as limestone powder upstream of GC, can be considered, if necessary.	Reinforcement of heating system of FF may be required The lowered inlet gas temperature might require reinforcement of the heating system (such as by low pressure steam heating) of FF ash hopper zone to maintain FF ash fluidity.
Additional cost	Introduction of limestone power injection system	No need	Needed, if necessary USD 2.0 million x 6 = USD 12.0 million	No need
	Water treatment system	Needed USD 0.3 million x 6 = USD 1.8 million	No need	No need
	Reinforcement (by steam) of heating system of FF	No need	No need	Needed USD 0.1 million x 6 = USD 0.6 million
Recommendation				Recommended. This system is expected to have less additional costs and few negative impacts from both erosion and corrosion, as well as stable operation and less maintenance costs.

APH: Air Preheater, PJFF: Pulse Jet Fabric Filter, GC: Gas Cooler, IDF: Induced Draft Fan

* D/S = Dust / Sulfur Ratio, showing operating condition of Gas-Gas Heater as indicated in Figure 6.2-8.

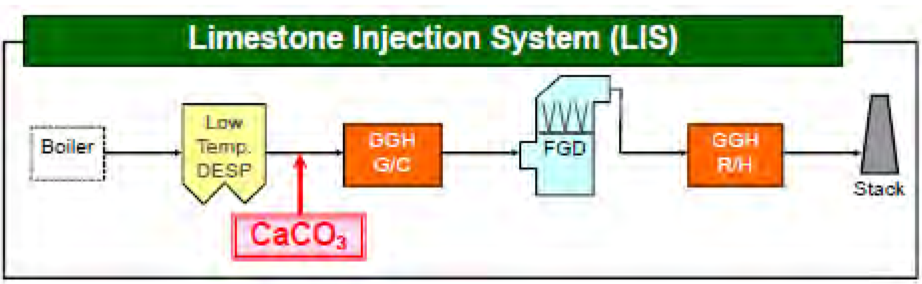
Source: Prepared by JICA Study Team



APH: Air Pre-Heater, GC: Gas Cooler, PJFF: Pulse Jet Fabric Filter, WFGD: Wet Flue Gas Desulphurization (System)

Source: Prepared by JICA Study Team

Figure 6.2-4 System Configuration according to Gas Cooler Location/Type



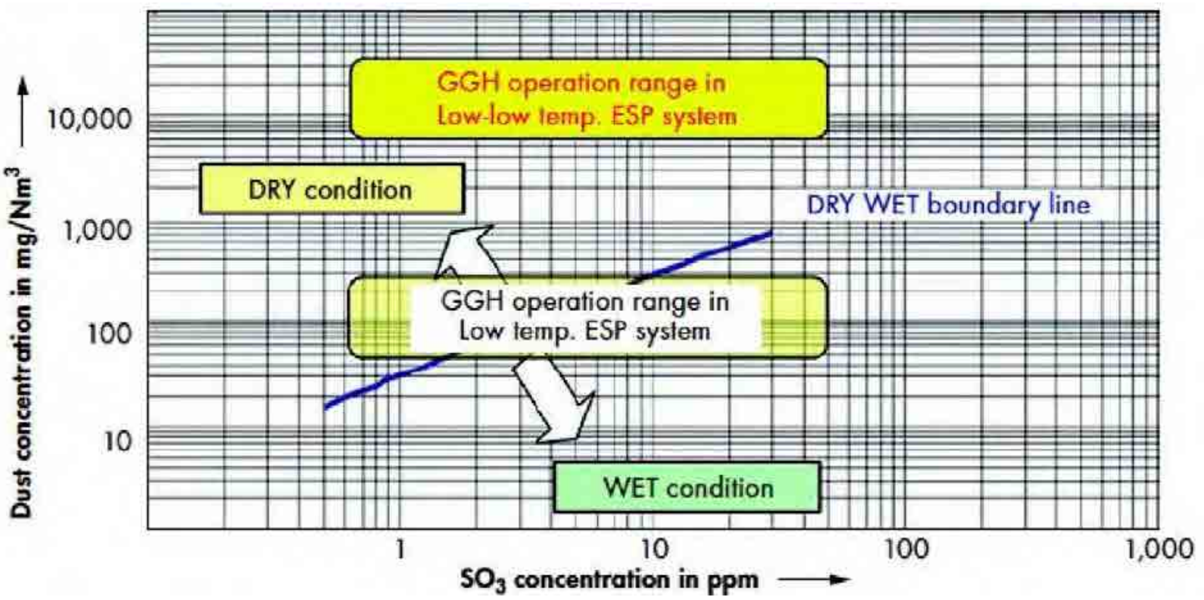
Source: MHPS

Figure 6.2-5 Image of Limestone Powder Spraying System

5) Mechanism of Corrosion

Eskom is concerned with corrosion because they know some Europe PS face corrosion issues with the adoption of GC through an FGD survey. Actually, TPS in Japan faced the same issue and had already overcome it. The JICA Study Team explained the mechanism of corrosion to Eskom technical colleagues and showed no issue in the case of a GC located upstream of the Pulse Jet Fabric Filter (PJFF) through a series of discussions.

In Japan, it is known that NO corrosion by SO_3 occurs in a powdery atmosphere of flue gas. Corrosion can be avoided if the SO_3 mist is coated by dust in powdery atmosphere. It is a physical neutralization effect (not chemical neutralization effect). It similar to a surface of a croquette which can be kept dry in much bread crumbs. A key factor is the dust and SO_3 ratio (D/S ratio). The correlation diagram between D/S ratio and wet/dry condition is shown in Figure 6.2-6. If D/S ratio plot is in the domain of the upper left side from dry wet boundary line, i.e., D/S ratio is high, the flue gas is in dry condition, and SO_3 can be coated by dust.



Source: VGB Powertech 11, 2014

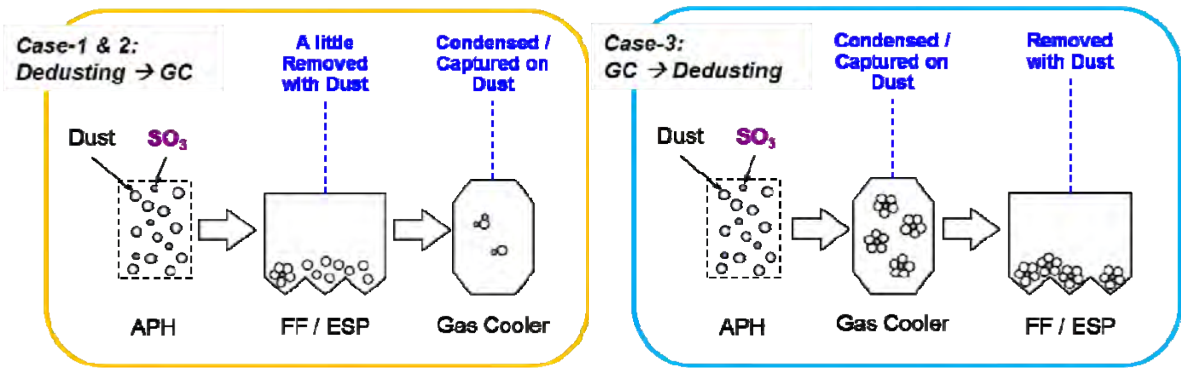
Figure 6.2-6 Correlation Diagram between D/S Ratio and Wet/Dry Condition

The mechanism of corrosion is shown in Table 6.2-3. In case of a GC located upstream of the PJFF, SO_3 mist is coated by dust because D/S ratio stays high. (No issue)

Table 6.2-3 Mechanism of Corrosion

	PFA material GC located at downstream of PJFF (Low Temp. FF)	Steel material GC located at downstream of PJFF (Low Temp. FF)	GC located at upstream of PJFF (Low-Low Temp. FF)
At APH zone;	No issue (dry) Gas temperature is higher than dew point.		
At FF/ESP zone;	No issue (dry) Gas temperature is higher than dew point. Although a part of SO_3 is condensed at the cold end of APH element, the rest of SO_3 is still in the vapor phase at the FF zone. Therefore, the dust (fly ash) is completely "dry" there at 130-140°C and corrosion at the FF and/or clogging of a filter mesh can be prevented by maintaining temperature in the FF more than the acid dew point.		No issue (dry) SO_3 mist coated by dust comes and is caught as dry dust. As described below, the dust is completely "dry" at the FF zone although the operating temperature is around 90°C (lower than acid dew point, but higher than water dew point). In a semi-dry FGD system, the operating temperature of the FF is around 80°C or sometimes lower (even after considering some margin to the water dew point), but this process is practically and commercially used and clogging issues have seldom been reported. Thus, corrosion and/or acid smut will not occur in or after Low-Low Temperature FF when the design concept of FF is similar to that of Low-Low Temperature ESP and/or FF for semi-dry FGD.
At GC	Issue of plugging of GC surface (wet) If lower than dew point, SO_3 mist is condensed. Because they are in less dust concentration, SO_3 mist is not coated by dust. Wet SO_3 mist adheres to the GC surface. At downstream of the FF, the dust content in flue gas is generally 10 mg/Nm^3 or lower. In case some SO_3 is contained and the flue gas is cooled down to 90°C simultaneously, SO_3 is condensed to be SO_3 mist without dust at GC zone. The dust with SO_3 mist will be in "wet" condition, and SO_3 mist may be stuck onto GC tubes/fins.		No issue (dry) If lower than dew point, SO_3 mist is condensed. Because they are in higher dust concentration, SO_3 mist is coated by dust. Those adhere to the GC surface but not to a high extent. There is a large amount of dust in the flue gas at the GC zone in comparison with the SO_3 content. When the flue gas is cooled down to around 90°C at the GC, SO_3 is condensed at acid dew point and is captured by dust and then removed at the FF with dust as shown in Figure 6.2-7 (Case-3). Rich dust particles will adhere to the surface of SO_3 mist particles, and SO_3 particles temporarily become no more adhesive nor sticky. The SO_3 with dust is still in "dry" condition due to high D/S*. In "dry" condition, the accumulated dust on GC tubes/fins is easily blown out by soot blowers without GC shutdown.

Source: Prepared by JICA Study Team

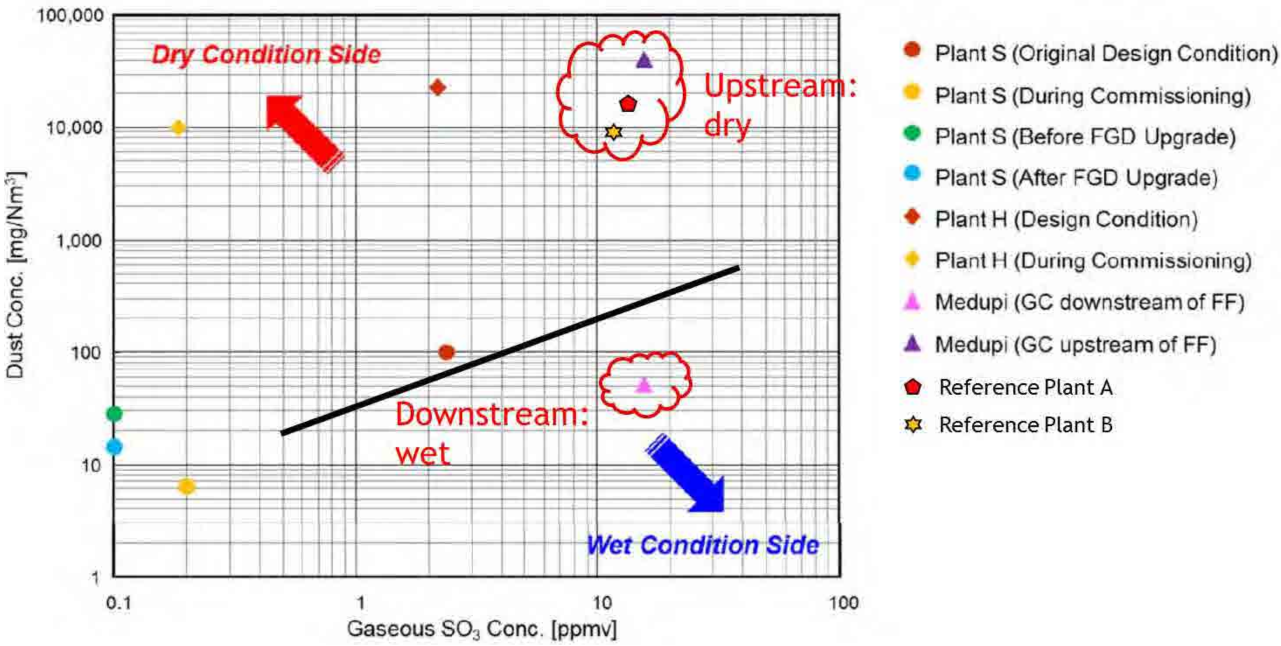


Source: Prepared by the JICA Study Team

Figure 6.2-7 Model of SO_3 Behavior with Gas Cooler

An example of D/S in reference plants and Medupi PS is shown in Figure 6.2-8. Corrosion does not occur in Medupi if the cooler is located upstream of the FFP. Reference plants A and B in Japan have proven that erosion has not been a critical issue over 10 years and several years, respectively, and operation condition of Medupi is safer than the reference plants in terms of corrosion.

SO_3 is wet and cooler if located downstream of FFP.



Source: Prepared by JICA Study Team

Figure 6.2-8 Example of D/S in Reference Plants and Medupi PS

Table 6.2-4 Coal specification on reference plant

	Reference Plant A	Reference Plant B
Producing area	South Africa	N/A
Commercial operation	2000	2013
Capacity (MW)	1,050	1,000
Gas cooler inlet flue gas condition (actual measurement/design condition)		
Flow rate (Nm^3/h-wet)	2,844,000 / 2,939,000	2,900,000 / 2,721,700
Temperature (°C)	146 / 140	125 / 132
H_2O (vol. %)	7.9 / 8.7	8.1 / 7.9
SOx (ppmv-dry)	384 / 875	390 / 406
Dust content (g/Nm^3-dry)	15.05 / 18.7	8.6 / 14.8
Ash properties (actual measurement/design condition)		
SiO_2	46.6 / 39.5	69.2 / 76
Al_2O_3	31.4 / 32.7	15.3 /17.5
Fe_2O_3	2.33 / 4.3	2.2 / 4.5
CaO	8.52 / 11.5	1.5 / 0.4
MgO	1.67 / 2.1	0.69 / 0.35
Coal properties (design condition)		
Moisture (%)	10.3	9
Total sulfur (%)	0.7	0.5
Ash (%)	15.9	15.9
Cl (mg/kg)	300	N/A

Source: Prepared by JICA Study Team

6.2.4. Packaging

(1) Current Packaging Philosophy

The Engineering, Procurement, and Construction (EPC) is commonly applied for large construction projects as major responsibility can be taken to the EPC contractor.

On the other hand, Eskom had once intended to conduct the FGD project, dividing 35 packages when Eskom had completed Medupi FGD BD in 2014. Then, Eskom had reshuffled those 35 packages and combined them into eight packages in June 2017. Please refer to the Eskom revised Package Plan shown in Table 6.2-5.

(2) Recommendation

Since such packaging plan has been developed by Eskom resulting to several studies, including domestic procurement circumstances, it should basically be maintained, except P-1 “Absorber” and P-2 “Limestone slurry preparation and Gypsum dewatering”.

The JICA Study Team recommendation policies are a combination of both of P-1 and P-2, separating “Engineering and Procurement” and “Construction (including Erection)”. Regarding the combination of P-1 and P-2, since Absorber, Limestone Preparation, and Gypsum Dewatering are the elements to secure a performance guarantee of FGD system, the three equipment should be unified into the same package. Therefore, P-1 and P-2 are recommended to be engineered by one Contractor. Regarding the separation of both “Engineering and Procurement” and “Construction (including Erection)”, where “Construction” is excluded from the scope of contract, international bidders having many experiences can participate in the bid as they can be free from construction risk. Where “Engineering” and “Procurement” are separated, the Employer may have the responsibility of performance guarantee. JICA recommends that the contractor have responsibility to secure the performance guarantee, optimizing their design based on their know-how.

In conclusion, as P-1 and P-2 are key processes of the FGD, it is recommended to repackage it into Engineering, Procurement, and Supply (EPS) and Construction (including Erection), say CP-1 and CP-2 as shown in Figure 6.2-9.

Table 6.2-5 Packaging Strategy by Eskom

Item	Scheme
P-1 Absorber	Eskom Engineering, Eskom Procurement, Eskom Construct
P-2 Limestone Slurry Preparation and Gypsum Dewatering	EPC (International)
P-3 DCS	EPC (International)
P-4 Electrical	EPC (International)
P-5 Water Treatment Plant	EPC (International or domestic)
P-6 Rail, Limestone Supply and Gypsum Disposal	EPC (Domestic)
P-7 Civil Work for Rail, Limestone Supply and Gypsum Disposal (Liners, PCD’s, Storm Water Management)	EPC (Domestic)
P-8 Site Service	Service
P-9 MCWAP connection	EPC (Domestic)

Source: Sorted by the JICA Study Team based on information from Eskom

Eskom Plan	
P-1 Absorber	Eskom Engineering Eskom Procurement Eskom Construct
P-2 Limestone Slurry Preparation and Gypsum Dewatering	EPC

JST Proposal	
CP-1 Absorber, Limestone Preparation and Gypsum Dewatering	EPS +TA
CP-2 Absorber, Limestone Preparation and Gypsum Dewatering	Eskom Construction

EPS: Engineering, Procurement and Supply, TA: Technical Adviser

Source: Prepared by JICA Study Team

Figure 6.2-9 Recommendation for Packaging

6.2.5. Project Schedule

Originally, Eskom prepared the project schedule from approval to commissioning, including detailed engineering, procurement, and construction, as a combination of the 35 packages. However, as mentioned before, Eskom tried rescheduling in parallel with the repackaging.

The schedule prepared by Eskom as of March 2017 is shown in Table 6.2-6. Construction contracting will be completed in November 2019 while construction will begin in January 2020. Commercial operation of U6 FGD will start in August 2021, which means that construction duration for U6 FGD takes 1.5 years. The JICA Study Team determined that the schedule is challenging. In a project case in the country where procurement system is established, erection work at almost the same scale of FGD construction takes 15 to 18 months. After erection work, commissioning takes seven months. It means that at least 22 months is required from commencement of construction to commercial operations.

Table 6.2-6 Schedule Prepared by Eskom, as of March 2017

Item	Period
Overall project execution packaging strategy developed	February 2017
Environment impact - specialist reports review complete	March 2017
Environment Impact Report - Draft Report (DEIR)	July 2017
Construction contract works (document finalization and signing)	September 2020
Construction commencement	October 2022
Commercial Operation U6 FGD	February 2025
Commercial Operation U5 FGD	February 2025
Commercial Operation U4 FGD	September 2026
Commercial Operation U3 FGD	September 2026
Commercial Operation U2 FGD	March 2028
Commercial Operation U1 FGD	March 2028

Source: Sorted by the JICA Study Team based on information from Eskom

6.2.6. Applicable Standard

Medupi FGD BD described that “the design and specification of work shall be basically carried out under Eskom specific codes and South African codes. However, where no Eskom specific codes and South African codes are applicable, British standards and codes will be used. If British standards and codes are not available, American standards or international standards and codes will be used.”

The BD indicates a series of available standards and codes; however, the standard for performance test procedure of FGD has not been specified. In case the Eskom will be responsible in taking performance guarantee for FGD, it would be no problem if the bidding document does not include any standard regarding performance guarantee for FGD. On the other hand, in case of making a contractor take such responsibility, it is necessary to specify the standard of performance test procedure for FGD, e.g., ASME. The JICA Study Team recommends that the ASME PTC40-2017 as standard of performance test procedure be added in the tender documents.

Chapter 7 Procurement and Construction Philosophy

7.1. Construction Market in South Africa

7.1.1. Main Player of Construction Field of South Africa

The JICA Study Team refers to "SA Construction 4th Edition" issued by Price Waterhouse Coopers (PwC) in South Africa and Kusile TPS in Engineering News "Key Contracts and Suppliers" published by Creamer Media to select companies specializing in construction of PSs in South Africa.

Based on the above data, the JICA Study Team had interviews with local companies to study the actual market of South Africa regarding the FGD project.

The interviewed companies are listed below.

Table 7.1-1 Interviewees

No.	Company Name	Main Agenda
1	AVENG	Construction for TPS
2	GROUP FIVE	Construction for TPS
3	Stefanutti Stocks Civils	Construction for TPS
4	WBHO	Construction for TPS
5	ACTOM	Steel Production for TPS
6	A. Leita Steel	Steel Production for TPS
7	Murray & Roberts	Steel Production for TPS
8	Tubular	Steel Production for TPS
9	IDWALA	Limestone and Gypsum
10	PCC	Limestone and Gypsum
11	Afri-Roads	Gypsum
12	Marley	Gypsum

Source: Sorted by the JICA Study Team based on information from Eskom

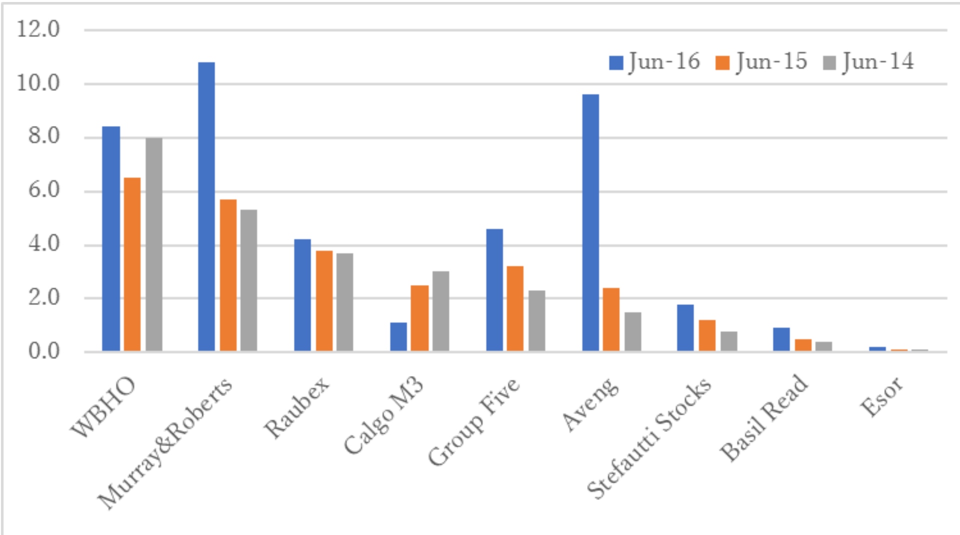
7.1.2. Construction Market in South Africa

(1) General Information

The construction industry in South Africa contributes to employment and growth; however, it has been in a slump since 2009. Nine companies from the industry, i.e., WBHO, Murray & Roberts, Raubex, Calgro M3, Group Five, Aveng, Stefautti Stocks, Basil Road, and Esor, are main players in South Africa. The market capitalization of the top nine construction companies is shown in Figure 7.1-1.

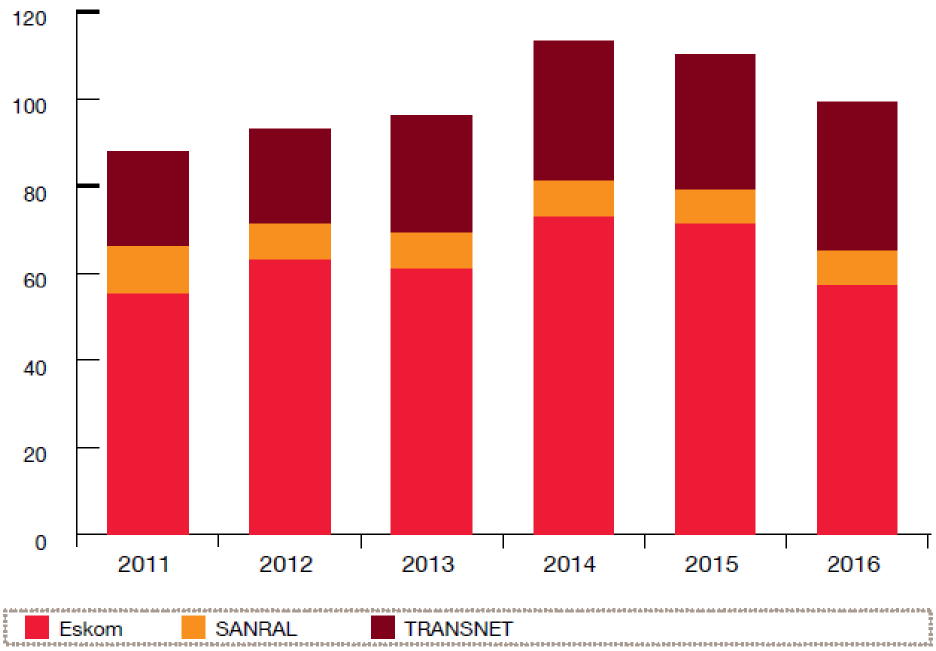
Capital expenditures of Eskom, Transnet, and Sanral are shown in Figure 7.1-2. The scale of public companies, including Eskom, is approximately ZAR 100 billion in total in the last three years. The majority of the public sector capital expenditure is undertaken by Eskom, Transnet, and South African National Roads Agency (Sanral). Eskom expenditure amounted to ZAR 57 billion in 2016. For reference, the total expenditure in the scope of all public sector construction in the same duration is ZAR 258 billion. For reference, total expenditure in the scope of all public sector construction in the same duration is ZAR 258 billion.

Capital expenditure for energy is shown in Figure 7.1-3. Currently, capital expenditure for energy is at an increasing trend, where the scale as of 2016 has grown twice over compared to 2010.



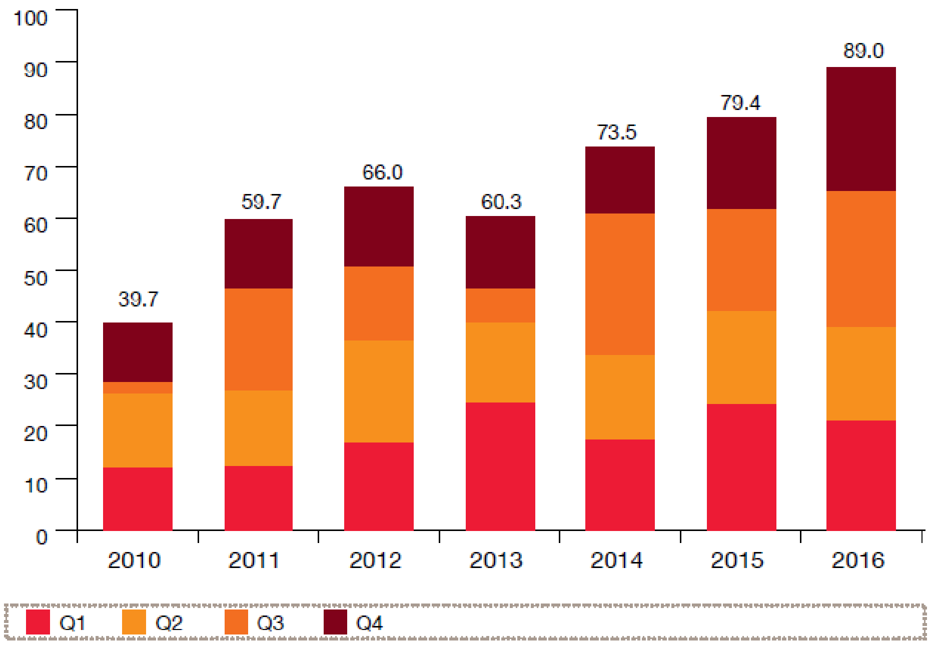
Source: SA Construction 4th Edition, PwC

Figure 7.1-1 Market Capitalization of the Top Nine Construction Companies (Unit ZAR in Billion)



Source: SA Construction 4th Edition, PwC

Figure 7.1-2 Capital Expenditure by Eskom, Transnet, and Sanral (Unit ZAR in Billion)



Source: SA Construction 4th Edition, PwC

Figure 7.1-3 Capital Expenditure for Energy Sector Construction (Unit ZAR in Billion)

Table 7.1-2 Common Risks Recognized by Major Construction Companies in South African Construction Market

Challenges	Actions Required by Industry
B-BBEE and Transformation	
Transformation is a key challenge in South Africa. Despite significant progress since the establishment of a democratic government in 1994, South African society is characterized by income and social service inequalities.	Proactive monitoring of compliance with B-BBEE codes and employment equity targets as well as changes to legislation are imperative in the South African construction industry. Timely transformation strategies (or compliance planes) should follow in order to remain competitive and achieve transformation goals. The transformation commitment in the October 2016 settlement agreement clearly indicate the high importance attributed to transformation of both the government and the industry.
In 2007, the Department of Trade and Industry released original B-BBEE codes, nine sectors, including construction, have their own codes and the Construction Sector Charter on Black Economic Empowerment was issued in June 2009. Compliance with the Charter by the industry is seen as not only society but also economically imperative.	Construction companies increased their participation in discussions about the new B-BBEE codes while adjusting business practices to be compliant with new codes.
In May 2015, the new B-BBEE condes were gazetted. The amendments to the codes significantly changed the manner in which companies' B-BBEE status is calculated, increasing the number of points required to achieve a particular level. On 4 March 2016, the Minister of Public Works, Thulas Nxesi, convened a high level meeting of construction industry captains and principals with the vies to mapping out an urgent way forward in the finalization of the gazette of the	Other strategic responses included various empowerment programs, a focus on management control and skills development, other internal initiatives, and headhunting.

Construction Sector Code.	
Non-compliance with employment equity could negatively impact companies in the following manner: Reduce their ability to win tenders; Increase the likelihood of client sanctions and sanctions from the Department of Labor; and Increase the possibilities of penalties being imposed on South African projects.	
Health, Safety, and Environmental Sustainability	
Construction is inherently a high-impact and dangerous industry. Any major incident, while a tragedy in its own right, also has implications for the reputation and ability of the entity involved to procure work in certain sectors. The construction industry has less than 50% rate of compliance with health and safety standards.	Health, safety, and environmental statistics have improved in recent years. However, this needs to be monitored, and reporting of statistics is required across the industry.
Industrial Action	
Ongoing industrial unrest in South Africa continues to cause project delays and disruptions, affecting safety, productivity and profitability. It also adds a further hurdle to the decision-making process for investment in new capital projects.	In order to mitigate the risk of labor unrest and prevent significant project disruptions and delays, open communication between unions and construction companies to monitor and resolve potential labor issues is essential.
Strikes have reached a new level in terms of number, duration, and violence, and they have inflicted significant damage to the economy in both the short and medium terms.	Strike mitigation plans must be put into place, proactive labor relations strategy with allowances in tenders for labor unrest.
This has had an impact on both project and business performance. The recent wide-scale and prolonged industrial action has placed pressure on the underlying contractual relationships.	Proactive engagement with communities prior to project commencement assists to manage expectations.
Liquidity Risk	
A lack of sufficient working capital increases exposure to liquidity risk. This may negatively impact credit, acquisitions, and growth opportunities.	It is essential that cash-flow requirements over the life of a contract be considered at the tendering stage, together with robust working capital cash-flow management.
The negative conditions experienced in the economy has contributed to liquidity problems experienced by construction companies as well as significant cash outlays required for new projects.	Close monitoring and management of outstanding claims and project overheads and tougher debt collection measures are also essential to mitigate liquidity risk.
Talent Management and Staff Retention	
People are an entity's most important asset, and various specialist skills are requires to deliver projects successfully. South Africa's construction industry has grown significantly in size over the last decade, resulting in a skills shortage in the industry at all grades. Loss of skills and expertise affects the ability of companies to successfully complete contracts and undermines expansion. Growth strategies place high demands on companies to maintain appropriate leadership capacity, and this has been a continued focus of 2016.	A remuneration policy focusing on performance and the retention of key talent is essential for the sustainability of a business. Regular succession reviews to identify potential talent retention risks and career planning strategies should be undertaken, as should in-house training, promotion from within and development initiatives.
Growth, Expansion, and Operational Performance	
Growth in the South African construction industry has declined in recent years due to: ・ Decline in business confidence and volatile labor market; ・ Government's reduced spending on infrastructure projects; ・ Competition in the industry, which has continued to drive down margins; ・ Limited expansion into new markets, which has been	In order to address the risks posed to growth and expansion, companies need to: ・ Focus on effective contract negotiation on equitable terms and efficient contract management; ・ Align capacity with planned SA Government spending;

hampered by volatile commodity prices and exchange rates	· Focus on gaining a competitive edge in the market; and · Explore growth options in new and emerging markets
Poor performance has also been a concern. Due to the competitive nature of the market, combined with skills shortages, there is pressure on companies to deliver on projects.	The implementation and monitoring of project management procedures and policies over the life cycle of a project and the assignment of accountability are imperative in mitigating the risks posed to project execution.
Poor execution of contracts results in margin erosion and losses. This includes the risk of poor quality control on site, which results in rework, increased costs, and delayed delivery of contracts.	Increased focus on closing out loss-making projects, improving efficiencies and productivity.
Macro-Economic Environment	
Continued poor economic performance by the South African economy has had a negative financial impact on business and their operations. This affects business and investor confidence and limits for capital projects and infrastructure.	Maintaining key stakeholder relationships in order to assist in winning new work in this depressed cycle.
Tender Risk	
There is inherent risk in the tendering process as it requires educated and highly judgmental views to be taken on pricing, mark-up, geological conditions, and the quality and availability of materials.	To mitigate tender risk, extensive tender risk assessment procedures need to be undertaken at the tendering stage of each project.
There is a risk of bidding for and winning contracts on onerous terms or under unacceptable commercial conditions.	Experienced estimators should be involved in contract pricing, which is to be subject to review by senior management.
Legislation and Regulatory Compliance	
Non-compliance with applicable legal and regulatory requirements may lead to reputational damage, penalties and fines and may impact the entities operations. The increasingly complex regulatory landscape requires entities to meet new regulatory requirements and stakeholder expectations while supporting performance objectives, sustaining value, and protecting the brand.	Compliance with regulatory and legislative requirements is imperative in preventing loss to a business and maintaining a company's reputation in the industry.

Source: SA construction 4th Edition, pwc

(2) CIDB of Company

South Africa has the Construction Industry Development Board (CIDB). The role of CIDB is facilitating and promoting the improved contribution of the construction industry to SA's economy and society. CIDB must promote uniformity of construction procurement, efficient and effective infrastructure delivery, construction industry performance improvement, development of the emerging sector, industry transformation, and skills development.

Home building is not included into the activity of CIDB because this is regulated by the National Home Builders Regulatory Council (NHBRC). Accordingly, contractors undertaking housing projects for the public sector do not need to be registered on the CIDB Register of Contractors. However, the client is required to register construction projects on the CIDB Register of Projects. Projects that are above ZAR 200,000 in value, in the public sector and above ZAR 10 million for the private sector and state-owned entities are registered. The CIDB Register of Contractors was established by Section 5 (1) (d) of the Construction Industry Development Board Act (Act 38 of 2000). It requires CIDB to establish a register system that categorizes contractors in a manner that facilitates public sector procurement and promotes construction companies' development. It is the sole registration and grading system for construction companies in South Africa, and all construction companies seeking to participate in the public sector's work must be registered on the CIDB Register with the exception of home builders and subcontractors only with labor. The CIDB Register classifies construction companies in nine grades, 1st to 9th, based on their capability to undertake projects as shown in Table 7.1-3.

The register systems are essential risk management tools for the client of work in the public sector. They may award construction contracts only to the registered contractors that are capable of undertaking the works based on the registration. The registered companies indicate to potential clients their capability based on relevant criteria such as financial capacity, track record, and technical capabilities.

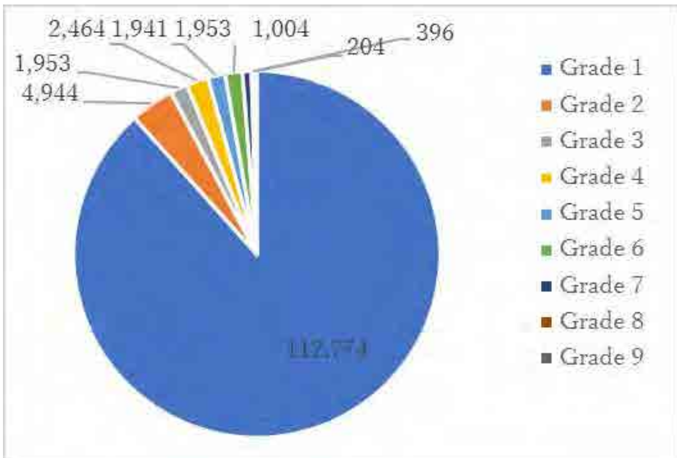
In contrast, the contractors in the 3rd to 9th grades are required to provide financial statements to prove financial capability and proof of track record to determine its capability to carry out the works, e.g., certificates of completion or final payment certificates.

First grade contractors comprised 80% of the total registered CIDB contractors, and by July 2015, this percentage had risen to 88% of the active registered contractors.

Table 7.1-3 Contractor Classification Criteria (Unit: ZAR)

Grade	Maximum value of a contract	Largest contract completed in the past 5 years
1	200,000	No requirement
2	650,000	130,000
3	2,000,000	450,000
4	4,000,000	900,000
5	6,500,000	1,500,000
6	13,000,000	3,000,000
7	40,000,000	9,000,000
8	130,000,000	30,000,000
9	No limit	90,000,000

Source: Study of Grade 1 Contractors, CIDB



Source: Study of Grade 1 Contractors, CIDB

Figure 7.1-4 Number of Companies for Each Grade (as of July 2015)

1) AVENG

AVENG is a multidisciplinary company focusing predominantly on the construction and civil engineering business.

AVENG has various divisions, i.e., buildings, manufacturing, rail, steel, and piping. The Steel Division makes for its rebar and steel reinforcement. The Piping Division carries out the piping works on the Medupi and Kusile TPS Projects.

AVENG prefers FIDIC Red Book and has experiences with FIDIC Yellow Book.

2) GROUP FIVE

GROUP FIVE is a diversified construction, infrastructure concessions, and services group with an established and growing international client-base engaged in resources, energy, and infrastructure delivery. GROUP FIVE has the following divisions: building construction, civil engineering, energy engineering (power and oil and gas), roads and earthworks, and steel manufacturing.

GROUP FIVE worked on the Kusile FGD in a form of joint venture (JV) with Stefanutti Stocks, WBHO, and Basil Read. This JV also worked on the civil works for the turbine houses and the boiler houses.

GROUP FIVE is familiar with FIDIC Red Book. It also has experiences with the Construction Industry Development Board (CIDB).

3) Stefanutti Stocks Civils

Stefanutti Stocks is one of the biggest civil construction companies in South Africa. They are listed on South African stock exchange.

Stefanutti Stocks has the following divisions: structural, roads and earthworks, geotechnical, building construction, and pipeline.

4) WBHO

WBHO is one of the biggest civil construction companies in South Africa. WBHO has the following divisions: building construction, civil engineering, and roads and earthworks.

WBHO worked on the Kusile FGD in a form of JV with Stefanutti Stocks, GROUP FIVE, and Basil Read. WBHO built the concrete works for Kusile FGD. At that time, the engineering was done by Andile Sangweni who has enough experience on FGD works. There are two FGD plants in Kusile, one for the three units (1 to 3) and the other one for the other three units (4 to 6). WBHO built the lift shafts for the boiler house using the slide (slip forming) method. The boiler house structural steel was done by Hitachi with Murray and Roberts as their subcontractor. WBHO prefers the FIDIC Red Book if it is the only contractor. It also has experience with the New Engineering Contract (NEC); however, this contract type has a high administrative workload.

(3) Additional Information

1) AVENG

- AVENG also has a piling division, and its annual turnover is around ZAR 200 million.
- AVENG is currently doing work for Eskom in Majuba (rail offloading project) TPS.
- The AVENG manufacturing division provides steel reinforcement, paving, and sleepers.
- AVENG has capacity for the civil works of the FGD. In Kusile, the main activities have been on balance of plant (BOP) and auxiliary cooling tower system.
- The standard working hours is 07:00 to 17:00.
- Safety measures at the site regarding AVENG has good practical accomplishments with Sasol/Eskom/Mines, etc.

2) GROUP FIVE

- GROUP FIVE is capable of executing projects in excess of ZAR 1 billion.
- The GROUP FIVE steel manufacturing division works on the large bore steel pipes, fabricated steel structures, scaffolding, formwork, and steel reinforcing for use in concrete structures.
- GROUP FIVE does most of the activities with in-house engineering as per above and has adequate capability for the FGD. In Kusile, some of the main activities have been on the air-cooled condenser (ACC), with slip forming of the 120 ACC columns.
- The standard working hours is 07:00 – 16:00 for five days a week.
- There is no work on holidays and Sunday, but they can work on two Saturdays per month at the maximum. However, it should be noted that the South African Labor Act governs the number of work hours of the site staff, and it also prohibits too much overtime.
- GROUP FIVE safety is the top priority in accordance to the Occupational Health and Safety Act (OHS Act). It is a standard requirement that legislative safety requirements are upheld; therefore, it is built into the company policies and procedures.

3) Stefanutti Stocks Civils

- Stefanutti Stocks is a civil construction company with experience in construction of PSs. They worked on bulk earth works and piling at the Kusile TPS.
- They are the lead partners of the JV for the Kusile TPS and the main members of the JV with WBHO, Basil Read, and GROUP FIVE.
- Stefanutti Stocks is a self-sufficient civil construction company. They own tower cranes, concrete pumps, and trucks. Their biggest crane has a capacity to lift 150,000 tons.
- Stefanutti Stocks buys steel, PVC, and HDPE from local companies.
- Capacity of sub-contractor. Stefanutti Stocks is the lead partner at Kusile TPS, and the JV partners are WBHO, Basil Read, and GROUP FIVE
- Workers only report three Saturdays every month, and they are not allowed to work on Sundays. Holidays are exceptional and are paid as overtime. The program should be based on five working days a week. However, it should be noted that the South African Labor Act governs the number of hours that can be worked by site staff, and it also prohibits excessive overtime.
- Zero harm is their philosophy when it comes to safety. In Kusile, they recorded 9,000 hours without injuries.

4) WBHO

- WBHO has building construction, civil engineering, and roads and earthworks.
- Civil division for all concrete works, roads and earthworks, including ground works (do rail track work, asphalt, etc.), and building construction with turnover of ZAR 5.5 billion.
- The WBHO group RMS (owned by WBHO) does the rebar work, formwork, and reinforcement for concrete except rebar fixing. WBHO sets up a batch plant at the site and buys aggregates from local suppliers.
- WBHO does most activities in-house as per above and has adequate capacity for the FGD. The main activities in Kusile were on the absorber concrete works and ACC concrete works.
- The standard working hours is 07:00 to 17:00, with 45 minutes allotted for lunch and tea-time.
- No work on holidays is based on five days a week. Saturdays are only meant for catch up and a maximum of three Saturdays per month can be used for work. However, it should be noted that the South African Labor Act governs the number of hours that can be worked by site staff, and it also prohibits too much overtime.
- At WBHO, safety is a top priority in accordance with the Occupational Health and Safety Act (OHS Act). It is a standard requirement to have the following in place: method statement, standard operating procedure (SOP), risk assessment, all personal protective equipment (PPE) and access requirements in place, and legal appointment of competent people familiar with the OHS Act and in line with Eskom procedures and who understand the site procedures.

(4) Standard Forms (Conditions) for Contract

According to “Construction Health & Safety in South Africa” prepared by CIDB, the CIDB Standard for Uniformity in Construction Procurement recommends the usage of the following standard forms of contract for engineering and construction works' contracts:

- General Conditions of Contract (GCC) for Construction Works as published by the South African Institution of Civil Engineering;
- Conditions of Contract for Construction for Building and Engineering Works designed by the Employer ("Red Book") (1999), Conditions of Contract for Plant and Design-Build for Electrical and Mechanical Plant and for Building and Engineering Works, designed by the Contractor ("Yellow Book") (1999), Conditions of Contract for EPC/Turnkey Projects ("Silver Book") (1999) or Short Form of Contract ("Green Book") (1999) published by the International Federation of Consulting Engineers (FIDIC);
- JBCC series 2000 Principal Building Agreement or Minor Works Agreement published by the Joint Building Contracts Committee; or

- NEC3 Engineering and Construction Short Contract, NEC3 Engineering Construction Contract, NEC3 Professional Services Contract or NEC3 Term Services Contract published by the Institution of Civil Engineers.

Based on the interviews, Aveng prefers FIDIC red book and has experiences with FIDIC yellow book. GROUP FIVE is familiar with FIDIC red book. It also has experiences with the CIDB. WBHO prefers FIDIC red book if the contract contains only construction works without designing. WBHO also has experience with the NEC, that is a family of contract format; however, this contract type has a high administrative workload.

(5) Broad-Based Black Economic Empowerment (B-BBEE) of Company

B-BBEE grade of interviewees in construction industry is shown in Table 7.1-4. AVENG is pushing to improve its accreditation to Level 3. GROUP FIVE is a Level 3. Stefanutti Stocks Civils is B-BBEE Level 4 accreditation. WBHO is a Level 4 and is pushing to improve its accreditation to Level 3.

All companies of interviewees, i.e., AVENG, GROUP FIVE, Stefanutti Stocks Civils, and WBHO, pointed out that B-BBEE bidding has no possibility of exemption when working in South Africa.

At least 30% of the original contract amount should be subcontracted in order to achieve B-BBEE requirements. It should be noted that the bidder should be required to clarify the full list of local companies that will work as sub-contractor. In case a company tries to obtain B-BBEE grade, the company must submit compliance report to B-BBEE Commissioning. Then, the examination of a compliance report takes approximately three months. It means that a new comer who has interest in bidding should start dealing regarding B-BBEE at least three months before the bidding date.

Table 7.1-4 B-BBEE Score of Interviewees in the Construction Industry (as of July 2017)

No.	Company Name	B-BBEE Score
1	AVENG	Level 3
2	GROUP FIVE	Level 3
3	Stefanutti Stocks Civils	Level 4
4	WBHO	Level 4

Source: Sorted by JICA Study Team based on information by interview from each company

(6) Civil Work Cost Information in South Africa (for reference)

Civil work cost information in South Africa is shown in Table 7.1-5. The JICA Study Team asked a cost information from four companies, namely AVENG, GROUP FIVE, Stefanutti Stocks Civils, and WBHO.

According to GROUP FIVE, Stefanutti Stocks Civils, and WBHO, the wages of civil workers and electric workers are specified in Task Grade Wage Rates Table. The Bargaining Council for the Civil Engineering Industry (BCCEI) releases such table. According to the website of BCCEI, BCCEI is a statutory body created under the Labor Relations Act (LRA) 66 of 1995 to provide for the co-regulation of stable and productive employment relations in the civil engineering industry. The council is an industry-based forum of organized business and labor that regulates employment conditions and labor relations in the civil engineering industry. It provides the necessary administrative infrastructure and technical expertise to ensure effective collective bargaining, industry compliance, dispute resolution, and social protection services.

Table 7.1-5 Civil Work Cost Information in South Africa (Unit: ZAR per m^3)

Item	AVENG	GROUP FIVE	Stefanutti Stocks Civils	WBHO
Concrete Work				
1) Concrete	3,500	12,000 to 16,000 (including Concrete, Excavation, Form and Re-bar)	1,500	1,100 to 1,300
2) Excavation	N/A		N/A	90
3) Form Work	N/A		N/A	150 to 400
4) Re-bar	N/A		N/A	11,000 ZAR/ton

N/A: Not Available

Source: Prepared by the JICA Study Team based on interview with local construction companies

(7) Wage Structure of Civil Worker

Wages of civil worker and electric worker are specified in Task Grade Wage Rates Table (TGWRT).

TGWRT is specified as part of a collective agreement that is negotiated among four organizations, i.e., South African Forum of Civil Engineering Contractors (SAFCEC), Consolidated Employers Organization (CEO), National Union of Mine Workers (NUM), and Building Construction and Allied Worker Union (BCAWU), then is issued by the Ministry of Labour through gazetting. Companies and unions not allied in these four organizations are restricted in the mentioned collective agreement.

The negotiation for revision of collective agreement is held at a three-year mandate basis and may be held in case the Bargaining Council for the Civil Engineering Industry (BCCEI) recommends for its revision. The latest revision was negotiated in June 2018 and was issued in September 2018. The latest TGWRT is shown in Table 7.1-6.

The task grade has nine categories following civil work difficulty. Grade one is the category for a worker who engages in the easiest work domain and grade nine is the category for a worker who engages in the hardest work domain. The wage of all categories annually increases following TGWRT. In the latest revision, September 2019, the wage increasing ratio was set as 7.5% every year in compound basis against the unit wage final year of previous revision.

Table 7.1-6 Latest Task Grade Wage Rates Table (September 2018 to August 2021)

<table>
<tr><th rowspan="2">Grade</th><th rowspan="2">Occupational Group</th><th rowspan="2">Job Title</th><th colspan="3">Hourly Rate (ZAR/hr)</th></tr>
<tr><th>Up to 31 Aug. 2019</th><th>From 1 Sep. 2019 to 31 Aug. 2020</th><th>From 1 Sep. 2020 to 31 Aug. 2021</th></tr>
<tr><td>1</td><td>General Worker</td><td>General Worker</td><td>34.45</td><td>37.04</td><td>39.82</td></tr>
<tr><td rowspan="5">2</td><td>Site Support</td><td>Artisan Aid</td><td rowspan="5">35.26</td><td rowspan="5">37.90</td><td rowspan="5">40.75</td></tr>
<tr><td>Construction Hand Grade IV</td><td>Structure Construction Hand
Premix Paving Checker
Steel Bending Machine Operator
Civil Construction Bricklayer Gr II
Crusher Assailant</td></tr>
<tr><td>Operator Grade V</td><td>Boom Scraper Operator
Pedestrian Roller Operator</td></tr>
<tr><td>Checker</td><td>Checker</td></tr>
<tr><td>Chainman</td><td>Chainman</td></tr>
<tr><td rowspan="4">3</td><td>Construction Hand Grade III</td><td>Shutterhand Gr III
Concrete Hand Gr II</td><td rowspan="4">36.24</td><td rowspan="4">38.96</td><td rowspan="4">41.88</td></tr>
<tr><td>Operator Grade IV</td><td>Track Rig Operator (General)
Bore Pile Operator
Drilling Operator</td></tr>
<tr><td>Site Support</td><td>Junior Clerk</td></tr>
<tr><td>Welder</td><td>Welder Semi Skilled</td></tr>
<tr><td rowspan="3">4</td><td>Construction Hand Grade II</td><td>Shutterhand Gr II
Reinforcing hand Gr II
Concrete Hand Gr I
Fence Erector
Guard Rail Erector</td><td rowspan="3">37.59</td><td rowspan="3">40.41</td><td rowspan="3">43.44</td></tr>
<tr><td>Operator Grade III</td><td>Concrete Mixer Operator
Continuous Flight Auger Operator
Batch Plant Operator
Concrete Dumper Operator
Concrete Pump Operator
Tower Crane Operator
General Premix Roller Operator
Milling Machine Operator
Paver Operator
Excavator Operator
Front End Loader Operator
TLB Operator
Dozer Operator
Grader Operator (General)
Gunite Nozzleman</td></tr>
<tr><td>Driver Grade II</td><td>Motorcycle Driver</td></tr>
</table>

		Tractor Driver Light Motor Vehicle Driver Driver Operator Heavy Duty Driver (Rigid) Extra Heavy Duty Driver (Rigid)			
	Site Support	Material Tester			
5	Construction Hand Grade I	Shutterhand Gr I Piling Auger Machine Operator Reinforcing hand Gr I Pipelayer Gr 1 Curblayer Gr I Civil Construction Brick layer Gr I	42.54	45.73	49.16
	Operator Grade II	Mobile Crane Operator Screed Operator Scraper Operator			
	Driver Grade I	Heavy Duty Driver (Articulated) Extra Heavy Duty Driver (Articulated)			
	Site Support	Assistant Surveyor			
6	Operator Grade I	Grader Operator (final level)	48.29	51.91	55.80
7	Supervisor Gr II Plan Serviceman	Supervisor Gr II Plan Serviceman	55.31	59.46	63.92
8	Supervisor Gr I	Supervisor Gr I	62.01	66.66	71.66
9	Artisan	Diesel Mechanic, Fitter, and Tuner	70.09	75.35	81.00

(8) Construction Availability of Local Construction Company for FGD Project

The construction availability of the local construction company FGD project is shown in Table 7.1-7. Based on own experiences, the JICA Study Team can say that construction works regarding FGD are divided into twelve categories, i.e., construction IT and communication, permanent plant IT and communication, FGD absorber construction, duct construction, piping construction, structure construction, electrical construction, superstructure construction, mechanical construction, C and I installation based on own experience, rail road construction, and substation construction. All of the local construction companies do not have capability for construction IT and communication and permanent plant IT and communication. AVENGE, GROUP FIVE, and Stefanutti Stocks Civils can cover most of the other construction works.

Table 7.1-7 Construction Availability of Local Construction Company FGD Project

Item	AVENG	GROUP FIVE	Stefanutti Stocks Civils	WBHO
Construction IT and Communication	N/A	N/A	N/A	N/A
Permanent Plant IT and Communication	N/A	N/A	N/A	N/A
FGD Absorber Construction	N/A	Capable	Capable	Capable
Duct Construction	Capable	Capable	Capable	Capable
Piping Construction	Capable	Capable	Capable	Capable
Structure Construction	Capable	Capable	Capable	Capable
Electrical Construction	Capable	Capable	Capable	N/A
Superstructure Construction	Capable	Capable	Capable	Capable
Mechanical Construction	Capable	Capable	Capable	N/A
C and I Installation	Capable	Capable	Capable	N/A
Rail Road Construction	Capable	Capable	Capable	Capable

Substation Construction	Capable	Capable	Capable	N/A

N/A: Not Available

Source: Prepared by the JICA Study Team based on interview with local construction companies

7.1.3. Material Market of South Africa

(1) Company Profile

1) ACTOM

ACTOM has adequate capacity with their facility in Bellville, Cape Town. Currently, ACTOM is a service provider to Eskom for operation of PSs under their boiler-serve contract. ACTOM capability includes boiler internals, high pressure piping, milling plant, precipitators, FFs, and scraper conveyors.

ACTOM has experience with the NEC contract type as used by Eskom on the boiler-serve contract, and the bidding process is well documented. ACTOM is also familiar with FIDIC.

2) A. Leita Steel

A. Leita Steel has adequate capacity with their facility in Waltloo, Pretoria. A. Leita Steel capability includes structural steel fabrication and plate work.

A. Leita Steel provided the steel for the air-cooled condenser of Medupi PS under a subcontract with Kentz. Production at the facility is 150 tons per week of structural steel, excluding plate work. For Medupi PS, 26,000 tons of structural steel were supplied in three years and four months. A. Leita Steel Proposal Team puts the bids together but generally subcontracts from the construction companies.

3) Murray & Roberts

Murray & Roberts has Genrec, a subsidiary company in Wadeville. Genrec has adequate capacity for FGD. The facility can produce 2,500 to 5,000 tons per month with an average of 4,500 tons per month. Murray & Roberts is selling this company (Genrec), although they still continue to focus on the erection of the steelwork.

Murray & Roberts has experience in NEC contract type as well as with FIDIC and whatever bespoke contract type that clients would like to explore.

4) Tubular

Tubular is one of the biggest steel constructors in South Africa. Tubular has the following divisions: structural, mechanical, electrical, instrumentation, piping, plate work, and detailing. Tubular has the capacity to process iron plates (rollers), and the maximum thickness that they process is 65 mm.

Tubular has done work on Kusile FGD in a form of JV with Stefanutti Stocks and WBHO. Tubular has no handling and no processing equipment for finned tubes, and they sub-contract if processing is to be carried out. Around a 150-ton trailer was used to transport a duct of 45 m in length and 6.5 m in diameter. Further, permits are needed when they transport such loads.

(2) General Information

1) ACTOM

- ACTOM is in the electro-mechanical sector and a wholly South African owned firm with 8,000 employees. ACTOM has 43 operating divisions.
- Currently, ACTOM has no difficulty to procure and fabricate (S235 thickness for 20 mm) in South Africa.
- ACTOM has no difficulty to weld steel plate as ACTOM has in-house capability to qualify and develop weld procedures.
- ACTOM has sufficient capacity to fabricate FGD absorber as ACTOM has an in-house capacity of adequately qualified and experienced resources that can fabricate and erect the plant.
- ACTOM has sufficient capacity to do ducts and dampers as ACTOM has in-house capacity of adequately qualified and experienced resources that can fabricate and erect the plant.
- ACTOM has in-house capacity to procure the specification of valve as and when required.
- ACTOM has sufficient capacity to manufacture support structure steel as ACTOM has in-house capacity of adequately qualified and experienced resources.
- ACTOM is mindful that the fabrication duration depends on information provided, i.e., scope of work, specifications, drawings, etc. However, ACTOM would anticipate that it could be between nine and 11 months for fabrication of an absorber unit.
- ACTOM cannot fabricate by double line. For ACTOM, the rate of fabrication depends on a well-defined scope of work, specifications, drawings, welding procedures, and a well-defined and agreed schedule.
- ACTOM is happy to provide transportation by road.

2) A. Leita Steel

- A. Leita Steel fabricates structural steel and is wholly owned by a South African firm.
- A. Leita Steel currently has no difficulty in procuring and fabricating S235 with thickness of 20 mm in South Africa.
- A. Leita Steel has no difficulty in welding steel plate as A. Leita Steel has in-house capability to qualify and develop weld procedures.
- A. Leita Steel is mindful that fabrication duration is dependent on information provided, i.e., scope of work, specifications, drawings, etc.
- A. Leita Steel cannot fabricate by double line.
- A. Leita Steel is happy to provide transportation by road.

3) Murray & Roberts (M&R)

- M&R is in the power/water/petrochemical and mining sectors.
- Referring to Genrec, the facility would have no difficulty in welding steel plate (S235

thickness for 20 mm) as Genrec has in-house capability to qualify and develop weld procedures.

- M&R has sufficient capacity to fabricate FGD absorber as M&R has in-house capacity of adequately qualified and experienced resources that can fabricate and erect the plant. M&R replaced Cosira from Unit 3 in Kusile.
- M&R has sufficient capacity to work on ducts and dumpers.
- M&R has in-house capacity to procure the specification of valve as and when required.
- M&R has sufficient capacity to work on support structure.
- M&R is happy to provide transportation by road.

4) Tubular

- Tubular is a steel construction company and market leaders offering a complete construction solution encompassing structural steelwork, plate work, piping, electrical, and instrumentation.
- Tubular is self-sufficient company with regard to plant, equipment, transport and tools. It has workshops/fabrication facilities, blasting and painting facilities in Emalahleni, a piping facility in Wadeville and Germiston, and a plant maintenance facility in Sundra, Mpumalanga.
- Tubular holding has its own structural steel workshop. It is capable of producing 1,200 tons/month of steel and has the largest furnace roof in the world weighing in at 90 tons for Kusile were they produced about 24,000 tons of steel. Fiber glass which they used for Kusile TPS was issued for free by GE Power.
- Tubular has no capacity to do civil construction works; therefore, it will need a civil works sub-contractor. Its preferred sub-contractors are WBHO and Stefanutti Stocks.
- The standard working hours is 07:00 to 17:00 with a 30-min lunch break. They have 55 hours average working week. It is computed as follows: Monday to Friday – 07:00 to 17:00 = 9.5 hours, Saturday – 07:00 to 13:00 = 5.5 hours, but because workers only work three Saturdays every month, that gives an average of 55 hours working week including overtime.
- Workers report on three Saturdays every month, and they are not allowed to work on Sundays. Holidays are exceptional, and they are paid as overtime. The program should be based on a five-day working week. However, it should be noted that the South African Labour Act governs the number of hours that can be worked by the site staff and also prohibits too much overtime.
- Tubular safety is a top priority of safety measures on site. All its health standards are as per OHSAS 18001 regulations, and it is an Eskom approved standard.

(3) B-BBEE of Company

B-BBEE grade of interviewees in steel production company is shown in Table 7.1-8. ACTOM is a Level 3 B-BBEE supplier with 32% black ownership. The ACTOM strategic objective is to achieve 51% black ownership by September 2017 (process is underway). A. Leita Steel is aiming to achieve a Level 4 B-BBEE supplier rating by restructuring its trading company in September 2017. M&R is a Level 3 B-BBEE supplier. Tubular is a Level 8 B-BBEE accreditation.

Table 7.1-8 B-BBEE Score of Interviewees in Steel Production Company (as of July 2017)

No.	Company Name	B-BBEE Score
1	ACTOM	Level 3
2	A. Leita Steel	Level 4
3	Stefanutti Stocks Civils	Level 3
4	WBHO	Level 4

Source: Sorted by the JICA Study Team based on information by interview from each company

(4) Material Cost Information in South Africa (for reference)

Material cost information in South Africa is shown in Table 7.1-9. The JICA Study Team asked the cost information from four companies, i.e., ACTOM, A. Leita Steel, Murray & Roberts, and Tubular. Murray & Roberts has both section construction and steel fabrication. Three companies, i.e., ACTOM, A. Leita Steel, and Murray & Roberts, did not share their cost information. Material cost is an excluded wage. According to Tubular, wage of steel fabrication is specified in the Metal and Engineering Industries Bargaining Council (MEIBC) rates. It is publicized in the internet. (reference with http://www.meibc.co.za/)

Table 7.1-9 Material Cost Information in South Africa (Unit: ZAR per ton)

Item	ACTOM	A. Leita Steel	Murray & Roberts	Tubular
Structural Steel				
1) Supply and fabrication	N/A	N/A	N/A	27,000
2) Detailing	N/A	N/A	N/A	1,400
3) Corrosion protection	N/A	N/A	N/A	6,500
4) Erection	N/A	N/A	N/A	8,000
Plate Work				
1) Supply and fabrication	N/A	N/A	N/A	55,000
2) Detailing	N/A	N/A	N/A	1,200
3) Corrosion protection	N/A	N/A	N/A	5,900
4) Erection	N/A	N/A	N/A	14,500
Piping Work				
1) Supply and fabrication	N/A	N/A	N/A	45,000
2) Detailing	N/A	N/A	N/A	2,500
3) Corrosion protection	N/A	N/A	N/A	12,500
4) Erection	N/A	N/A	N/A	85,000

N/A: Not Applicable

Source: Prepared by the JICA Study Team based on interview with local material companies

7.1.4. Limestone Market in South Africa

(1) Outline of Limestone

Limestone is a rock that is mainly made of mineral calcite (calcium carbonate $CaCO_3$).

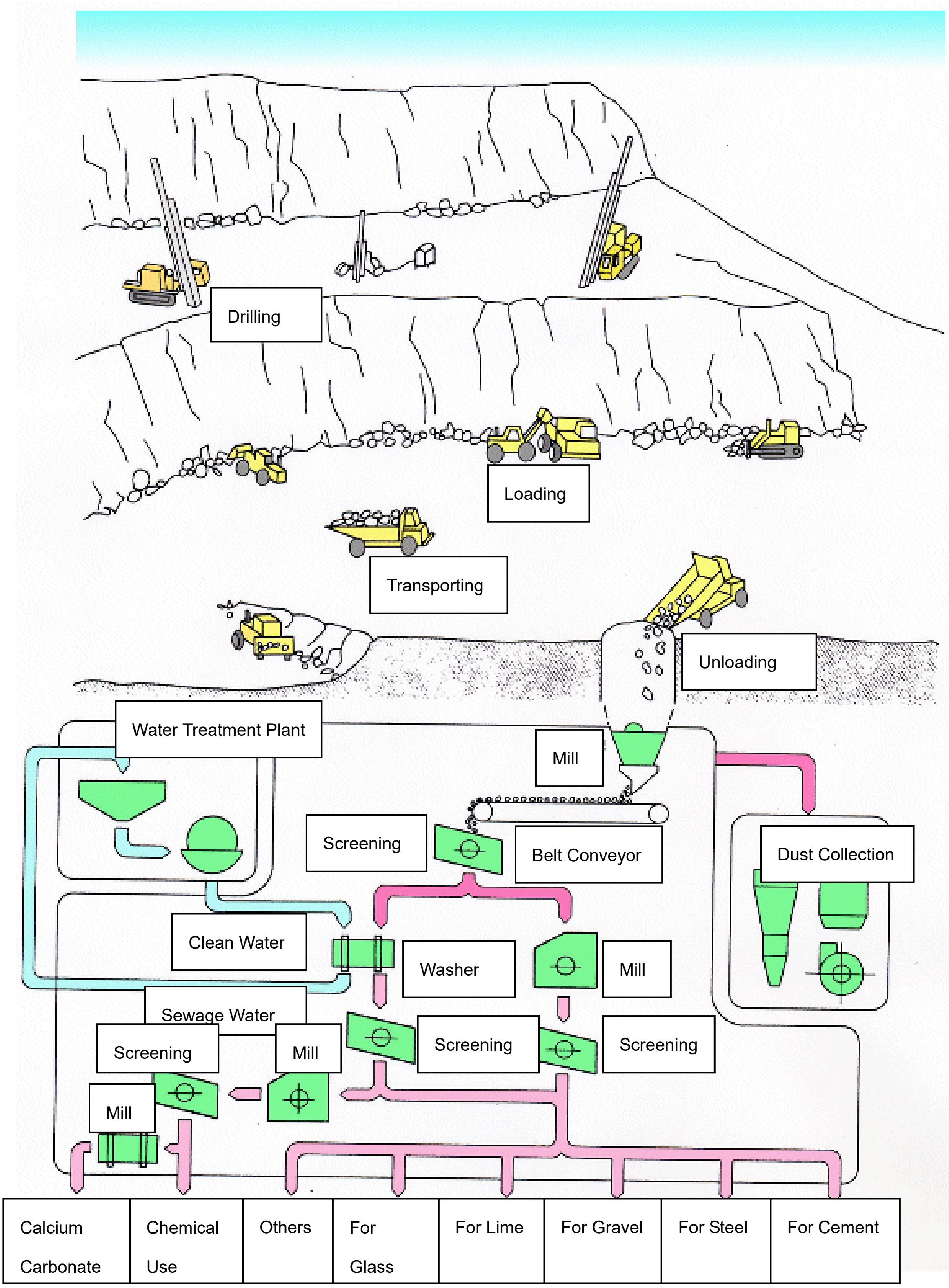
Mining and production of limestone is sold as a limestone product after drilling/blasting, loading/carrying, crushing/shredding, shipping and transportation.

In drilling/blasting, blast holes (about 10 to 20 cm in diameter) are drilled according to the height of the mining bench (5 to 15 m) with a hole machine. After drilling, an explosive is loaded in the hole and blasting is conducted.

In loading and transportation, limestone crushed by blasting is loaded on a dump truck by a wheel loader or a hydraulic excavator and is transported to a vertical shaft. The size of the heavy machinery used for loading and conveying is being increased for the purpose of high-efficiency. As for the wheel loader, machinery with a bucket capacity of 5 to 10 m^3 is common (maximum is 20 m^3), and as for the dump truck, one that is loaded a quantity of 20 - 100 t is often used (maximum is 218 tons).

In crushing/concentrating, the limestone loaded to the vertical shaft is crushed into a size of about 10 to 20 cm by a crusher, conveyed by a belt conveyor, and sifted by sifting equipment (screen). The secondary and tertiary crushing and sieving are repeated, and limestone products of various sizes are produced according to various uses as necessary.

In shipping and transportation, limestone products produced by crushing and concentrating facilities are shipped to each user such as cement factory, ironworks plant, raw concrete factory, lime calcination plant, and so on. Belt conveyors, ships, trucks, and railroads are used as transportation methods according to geographical conditions.



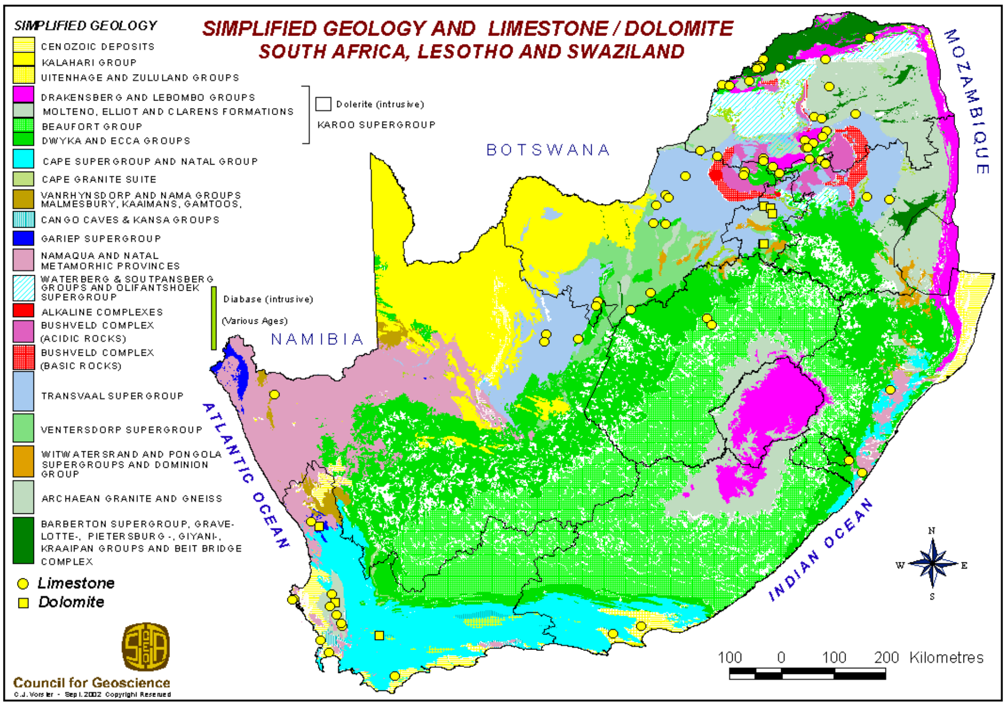
Source: Website of Limestone Association of Japan (http://www.limestone.gr.jp/introduction/)

Figure 7.1-5 Limestone Mine

(2) Limestone Production in South Africa

The locality of limestone and dolomite of South Africa are shown in Figure 7.1-6. Dolomite is a mineral similar to limestone, but it contains magnesium carbonate in addition to calcium carbonate.

There are many limestone mines in South Africa most of which are small mines.



Source: Council for Geoscience

Figure 7.1-6 Locality of Limestone and Dolomite of South Africa

(3) Framework for Mine Development

In South Africa, all mines are owned by the South African government and the Department of Mineral Resource has jurisdiction under the Mines and Petroleum Resources Development Program (Mineral and Petroleum Resources Development Act). In South Africa, the right related to mineral exploitation is classified into the prospecting right, the mining right, the exploration right, and the production right by the Petroleum Resources Development Law. The petroleum exploration right and the oil digging right are about exploration and mining oil and are not related to the mining of limestone and other minerals. Both mine exploration rights and mining rights are permitted by submitting proposals from businesses. If a business operator who satisfies the requirements of the Petroleum Resources Development Law submits a proposal in a form in accordance with the provisions of the Petroleum Resources Development Act, the competent minister must grant the right. Mine exploration rights will not exceed five years, mining rights will be granted not more than 30 years. Both mine exploration rights and mining rights are exclusive rights, and new rights are not granted if mine exploration rights and mining rights are granted to the area already.

(4) Limestone Development Business Operators and Handling Companies in South Africa

There are two limestone development companies in South Africa, one is PPC and the other is IDWALA. The typical constituent chemicals of limestone produced by both companies are shown in the table.

Table 7.1-10 Typical Constituent Chemicals of Limestone

Limestone Supplier & Type	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	MnO_2	Mn_2O_3	SO_3	P_2O_5
PPC									
% Crushed	93.5	2.2	2.5	0.3	0.5	-	0.8	<0.05	<0.005
% Graded	96.0	2.2	0.8	0.2	0.2	-	0.7	<0.05	<0.005
Idwala	96.0	1.5	0.7	-	-	0.8	-	-	-

(5) Limestone Procurement

1) IDWALA

IDWALA is one of the biggest limestone manufacturers in South Africa. IDWALA is currently supplying 10,000 tons/month per unit of diameter 20-8 mm limestone for Kusile TPS. IDWALA has the capacity to supply 1.3 million tons per year.

Currently, IDWALA transports limestone from its mine in Danielskuil by rail and off-load to its Vereeniging Plant. IDWALA transports limestone by road using tipper trucks from Vereeniging to Kusile TPS.

IDWALA specializes in limestone with 95% or higher purity, and there is no mine that produces lower purity limestone.

2) PPC

PPC is one of the biggest limestone manufacturers in South Africa. PPC is not transporting limestone to Medupi TPS and Kusile TPS, currently.

PPC is transporting limestone from its mine in Lime Acres by road to Botswana Power

Corporation (BPC) (for Morupule TPSs) for its FGD plant. PPC provides limestone that is 96% calcium carbonate, and there is no mine that produces lower purity limestone.

3) Afri-Roads

Afri-Roads is a company that deals limestone and gypsum products.

Afri-Roads does not have its own trucks; thus, Afri-Roads hires trucks to deliver limestone. In addition, Afri-Roads has been engaging with Transnet regarding transportation of limestone by rail. Afri-Roads has five limestone suppliers who have distributor licenses.

Afri-Roads also deals with natural and synthetic gypsum. According to Afri-Roads, there is currently a shortage in supply of gypsum in South Africa. As of October 2017, Afri-Roads is importing natural gypsum from Middle East. Afri-Roads thinks the South African market requires around 400,000 tons/month of gypsum at the moment. On the other hand, Afri-Roads is currently supplying gypsum at 22,000 tons/month. Most of its gypsum is in powder and paste state.

(6) Study on the Specification of Limestone for FGD

1) Purity

As of January 2018, the mine that can supply the necessary quantity of the Medupi PS is only PPC or IDWALA that produces limestone with a purity of 95% or more.

In case that 85% limestone is adopted, it is necessary to develop limestone companies' mines in accordance with the Petroleum Resources Development Law. Considering the smooth and reliable progress of the construction of the FDG with the deadline for completion, rather than accepting new risk factors involving consultation with the mining development business, the premise utilizing already developed mines is low risk.

For that reason, it is reasonable to exclude the mines of 85% purity because they are not developed as of January 2018, although FGD basic design mentioned about limestone with purity of 85%.

2) Grain Size

As previously explained, the limestone company will crush and sift the large lime and then deliver it to the Medupi PS. Limestone in fine particle size requires much time and labor for processing on the limestone company side, resulting in high cost. Also, limestone in fine particle size may cause dissipation during transportation.

Limestone (IDWALA) to be delivered to the Kusile PS is 8-20 mm in diameter, thus limestone of the same size is proposed for the Medupi PS by the JICA Study Team.

In FGD, it is grinded into the form of powder by a mill with limestone preparation equipment. Therefore, the FGD mill should meet the specification that can process the limestone in 8-20 mm diameter.

(7) Unit Price for Limestone

According to the interview with the limestone company, as of January 2018, it is 196.43 ZAR/ton (PPC) with the limestone specification described above.

(8) Transportation of Limestone

Mines that produce the limestone specified above are Danielskuil (IDWALA) and Lime Acres (PPC) located in Northern Cape province. The possibility of transportation and its costs are examined in Section 8.2.

7.1.5. Gypsum Disposal

(1) Outline of Gypsum

Gypsum is a generic term for minerals that have the chemical composition of calcium sulfate ($CaSO_4$). There are natural gypsum produced from mine and synthetic gypsum that is a merchandise/by-product produced with chemical process. Chemical gypsum includes phosphate gypsum, FGD gypsum, titanium gypsum, smelting gypsum, and hydrofluoric acid gypsum. For gypsum, there are usages as raw gypsum or calcined plaster. The main application is for cement. Cement mixed with clay and silica formulate clinker after crushing and calcining. After crushing, the clinker is quickly solidified by kneading. However, coagulation can be adjusted/relaxed by adding an appropriate amount of gypsum.

In addition, since the hardened gypsum has water of crystallization, it exerts excellent properties of no-combustion, heat insulation, fire protection, and sound insulation without causing heat to pass through until the water of crystallization becomes released as water vapor in case of fire. This property is utilized for building materials such as boards and plasters. Gypsum plaster is manufactured by mixing slaked lime and dolomite mainly with calcined gypsum. When water is added, it cures in a short time, and it has characteristics not causing shrinkage and cracking, even if it is applied.

Further, gypsum is also used as a fertilizer for alkaline soil improvement and calcium supplementation. About 2 million tons of chemical gypsum are estimated to be produced worldwide (mostly phosphate gypsum). Throughout the world, approximately 51% of gypsum is used in the cement and concrete industries and 39% in the wall board and plaster industries.

(2) Gypsum Generation at Medupi PS

In the basic design for FGD of Medupi PS, the amount of gypsum generated from FGD is estimated as shown in the Figure 7.1-6. In the basic design, two cases of limestone with purity of 85% and 96% were studied. In the largest cases, it is estimated that the amount of gypsum generated is 248,354.42 kg/h (=2.18M ton/year) with 85% purity limestone and 233,768.97 kg/h (=2.05 M ton/year) with 96% purity limestone. However, as discussed in Section 7.1.4 "Limestone Market in South Africa", as of January 2018, there is no limestone mine already developed with 85% purity that is capable of satisfying the required quantity of the Medupi PS. Thus, it is reasonable to study only the case of 96% purity.

Table 7.1-11 Total Amount of Gypsum Generated from FGD

		Crocodile West Water		Mokolo Water	
		Gypsum Production kg/h	Gypsum Purity %	Gypsum Production kg/h	Gypsum Purity %
85% Limestone	Design Coal	145,512.91	88.90	145,697.63	88.85
	Worst Coal	247,536.96	88.48	247,758.45	88.44
	Worst Coal + Attempt	248,111.61	88.48	**248,354.42**	88.43
96% Limestone	Design Coal	139,214.95	96.56	139,281.70	96.54
	Worst Coal	233,249.68	96.49	233,330.49	96.47
	Worst Coal + Attempt	233,680.45	96.49	**233,768.97**	96.47

Source: Basic Design Report/Eskom

(3) Gypsum in South Africa (Department of South Africa)

According to the report "Gypsum in South Africa" (Department of Mineral Resources (DMR), September 2011), gypsum in South Africa is under jurisdiction of DMR. However, DMR gathers information on only natural gypsum; thus, there is no statistical data on synthetic gypsum.

According to the report, gypsum currently distributed in South Africa is mostly low-quality natural gypsum. Major markets for natural gypsum in South Africa are plasterboards and cement manufacture, followed by the agricultural sector where it is used for soil treatment. At the time of the survey, it is stated that synthetic gypsum distributed in South Africa is phosphate gypsum, although FGD gypsum is not distributed.

The price of gypsum in the USA as of January 2018 is USD 7.25/ton.

(4) Gypsum Market Research Study in South Africa (by Over the Moon)

In the report (Gypsum Market Research Study, April 2009) when Eskom ordered Over the Moon (Environmental and Engineering Consulting Company) to investigate the gypsum market in South Africa, the following statement is made.

1) Gypsum Usage

The major usages of gypsum are indicated below:

- Wallboard
- Plaster
- Cement
- Agricultural applications
- Mining/mine rehabilitation applications
    - Encapsulation/neutralization of acid generating material

- Acid-mine drainage formation/transport buffer or barrier (including mine void filling)
- Alkaline amendment to neutralize acid-producing rock
- Control of subsidence in underground mines
- Pit-filling to achieve approximate original contour in surface mines
- Soil amendment
- Synthetic soil component

The per capita usage of plasterboard in South Africa is low compared to current world consumption figures, indicating a high potential for market growth. On the other hand, the growth of market for cement and plaster will have a small increase, and agricultural usage has kept its current market size. Gypsum will replace lime in road building and coal mining, and it should be noted that growth in the mining sector could be more marked if focus was given to marketing gypsum use in the sector.

2) Gypsum Quality

In the plasterboard market, the demand for purity is more than 95%. On the other hand, the generated FGD gypsum will have around 88% purity if Eskom adopted the 85% purity standard. Therefore, it will be available for cement and/or agricultural markets. However, it will be a challenge to sell the gypsum because of the low growth rate of markets.

3) Gypsum Supply Quantity

Major gypsum consumption areas (gypsum product manufacturing base) in South Africa are Cape province, where Gyproc 80% market share holder has its factory, and Gauteng State, where Marley, which is a 20% market share holder, has its factory. The FGD gypsum supply from Kusile alone will meet the South African cement industry's demand of 600,000 ton per annum (in the Gauteng Province). The cost of transportation for both Gyproc and Marley, from the Northern Cape Province to Gauteng, is approximately ZAR 500 per ton (i.e., ZAR 0.50/ton/km x 1000 km). Thus, the study excluded the Cape Province due to their distance from Eskom FGD gypsum sources (Kusile PS and Medupi PS).

(5) Interview with Local Company

The JICA Study Team had an interview with a local company to investigate the gypsum market in South Africa. The JICA Study Team requested interviews with Gyproc and Marley, but only Marley accepted the offer.

Marley is dealing gypsum products as architectural material. Marley obtains gypsum (synthetic and natural gypsum) from various mines because the company's mine was closed and rehabilitated. Marley is familiar with the Department of Mineral Resources - DMR Act of South Africa and the American standards.

Natural gypsum is sourced from Moscow and Spain. The acceptable quality is from 93% and an average of 95% of purity. As for synthetic gypsum, the accepted quality is from 85% to 100% and an average of 92% of purity. Natural gypsum is crushed and mixed with synthetic gypsum to achieve the required volumes for production. Marley produces 15 million squares of boards per year.

Marley buys gypsum at the following prices:

- FGD synthetic gypsum – ZAR 300/ton
- OMV (uranium plant gypsum) – ZAR 200 to 250/ton
- Water Treatment Plant (gypsum with more magnesium) – ZAR 90 to 200/ton
- Natural gypsum (from Moscow) – ZAR 450 to 550/ton
- Natural gypsum (from Spain) – ZAR 400 to 500/ton

(6) Possibility of Gypsum Disposal

1) Domestic Market

Generated FGD gypsum will have around 88% purity if Eskom adopted a purity of 85% resulting to a low marketability. On the other hand, if Eskom adopted a purity of 95%, the marketability for plasterboard will be high. However, the demand in Gauteng state will be fulfilled with FGD gypsum supply from Kusile PS. As a result, the possibility of disposal will be small. Cape Province, another area with a large consumption of gypsum, will also have low marketability because it will cost more for transportation.

2) Foreign Market

Medupi PS is located far from the shore, so the transportation of gypsum to the international port will be more than 1,000 km. This results in high transportation cost, thus foreign marketability is assumed to be very low.

(7) Proposal for Gypsum Handling and Exclusion of Exporting Facility

It was assumed that 20% of generated gypsum will be sold in the basic design for FGD, but the marketability is deemed very low with the above considerations. Thus, the JICA Study Team suggests not to sell the gypsum.

This change will result in cost reduction because of the omission of exporting facility and its initial cost. On the other hand, 20% of the generated gypsum originally assumed to be exported will be landfilled; thus, the cycle for consolidating land for landfill will be faster than the original plan.

7.1.6. B-BBEE

(1) Outline of B-BBEE

The Broad-Based Black Economic Empowerment Act (B-BBEE Act) was issued in 2003 and amended in 2015. The Black Economic Empowerment (BEE) Advisory Council was founded in 2009, and it consists of the President, Ministers, a representative from enterprises, trade union, and local government.

(2) Classification of Enterprises

The classification of enterprises is shown in Table 7.1-12. Under the B-BBEE Act, enterprises are categorized into three groups, i.e., Exempted Micro-Enterprises (EME), Qualifying Small Enterprises (QSE), and Generic Enterprises. EME is an entity with an annual turnover of ZAR 10 million or less. This group is only required to obtain “a worn affidavit” on an annual basis to indicate black ownership and annual turnover. An EME can get B-BBEE Level 4 or better automatically depending on their black ownership. QSE is entity with an annual turnover of ZAR 10 million or more but less than ZAR 50 million. This group is required to comply with all five BEE elements but less onerous than Generic Enterprises. Generic Enterprises are entities with an annual turnover of ZAR 50 million or more.

Table 7.1-12 Classification of Enterprises

Classification	Annual Turnover	Duty of Compliance with BBE Element
Exempted Micro-Enterprises (EME)	ZAR 10 million or less	No
Qualifying Small Enterprises (QSE)	ZAR 10 million or more but less than ZAR 50 million	All
Generic Enterprises	ZAR 50 million or more	All

Source: Prepared by the JICA Study Team based on amended Codes of Good Practice

(3) BEE Elements and Points

In order to measure BEE compliance for entities, Generic Enterprises and QSE scorecards are prepared separately. Requirements and points per BEE element on a Generic Enterprises scorecard is shown in Table 7.1-13. Five elements, namely ownership, management control, skills development, enterprise and supplier development, and socio-economic development, are set for measurement of BEE compliance. The ownership element measures the effective ownership, voting rights, and net economic interest of black people in the enterprise. The management control element measures the effective representation of black people in the board, top, senior, middle, and junior management levels of the enterprise. The skills development element measures the extent to which employers implement initiatives and designs to promote the development of job-related core competencies of their black employees. The enterprise and supplier development element measure the extent to which an enterprise implements initiatives to assist and accelerate the development of black Empowered Small, Medium, and Micro Enterprises (SMME), including referential procurement. The socio-economic development element refers to specific measures that enterprises and industries undertake to uplift the majority of South Africans through socio-economic development programs or organization.

Table 7.1-13 Requirements and Points per BEE Element on Generic Enterprises Scorecard

BEE Element	Requirements	Points
Ownership	25% + 1 vote to black shareholders	25
Management Control	Participation on junior to executive level management by black, black women, black disabled	19
Skills Development	6% of payroll on programs for black employees 0.3% of payroll on programs for disabled black employees 2.5% of learnerships for black employees	20 + 5
Enterprise and Supplier Development	80% Procurement from B-BBEE supplier 15% to 40% Procurement from QSE, 50% black owned and more than 30% black women owned supplier 3% of net profit after tax on enterprises and supplier development initiatives	40 + 4
Socio-Economic Development	1% of NPAT	5
Total		109 + 9

Source: Prepared by the JICA Study Team based on amended Codes of Good Practice

(4) BEE Level

The score achieved on the scorecard can translate to Broad Based BEE status level and BEE procurement recognition level. The matrix for translation to BEE level is shown in Table 7.1-14.

Table 7.1-14 Requirements and Points per BEE Element on Generic Enterprises Scorecard

Range of Total Points by Scorecard	Broad Based BEE status level	BEE Procurement Recognition Level
100 or more	1	135%
95 or more but less than 100	2	125%
90 or more but less than 95	3	110%
80 or more but less than 90	4	100%
75 or more but less than 80	5	80%
70 or more but less than 75	6	60%
55 or more but less than 70	7	50%
40 or more but less than 55	8	10%
less than 40	Non-compliant contributor	0%

Source: Prepared by the JICA Study Team based on amended Codes of Good Practice

(5) Priority Element

Three priority elements, i.e., ownership, skills development, and enterprise and supplier development, are specified as the principal effect and are set to 40% sub-minimum requirement to be complied. If an enterprise cannot comply with the 40% sub-minimum requirement of any the priority elements, the broad-based BEE status level of the enterprise will be discounted.

(6) BEE Legislation Requirements for Public Sector

In order to maximize its governmental commitments, to improve local supplier development, and to stream line its procedures, public sector entities have implemented the Supplier Development and Localization (SD&L) to their procurement policies. Accordingly, these entities are required to set local content, B-BBEE, and skills development targets as key evaluation criteria in the tenders awarded. These requirements are set on each tender awarded, and targets are measured as the contract is serviced. Suppliers are subject to penalties in the event of breach of these targets.

In order to be exempt from BEE legislation requirement, approval from NT is needed through Eskom. In conclusion, exemption of B-BBEE is not recommended due to the following reasons: i) it may cause project delay risk because the period for dealing with the mentioned approval differs from project to project, and ii) it may be difficult to understand B-BBEE exemption.

7.2. Procurement and Construction Philosophy

(1) Procurement of FGD

The composition equipment of FGD are to be classified onshore and offshore as shown in Table 7.2-1. There is a check mark on both onshore and offshore procurements for the raw materials or some parts that cannot be procured within the country but can be manufactured from imported raw materials and parts. Those with high proportions of materials in FGD are carbon steel materials, plates, and pipes, so many materials can be procured within the country. However, the items for instrumentation control relationships (DSC, etc.) boost up fans, and

GGH cannot be procured in South Africa, so the proportion of overseas procurement will increase.

Table 7.2-1 Procurement Material Information

No.	Items	Localization	
		Onshore	Offshore
1	Valves	✓	✓
2	Spray Nozzle	✓	✓
3	Pumps (Water)	✓	✓
4	Pumps (Slurry)	✓	✓
5	Agitator	✓	✓
6	Lining of Rubber	✓	
	Lining of FRP	✓	✓
7	Limestone Feeder	✓	
8	Oxidation Air Blower	✓	✓
9	Mist Eliminator	✓	✓
10	Spray Header	✓	
11	Tanks (Metal)	✓	
12	Tanks (Plastic)	✓	
13	Piping (Metal)	✓	✓
14	Piping (Plastic)	✓	
15	Absorber	✓	
16	Duct	✓	
17	Limestone Silo	✓	
18	Structural Steel	✓	
19	Expansion Joint	✓	✓
20	Damper	✓	
21	Insulation	✓	
22	Gypsum Conveyor	✓	
23	Elevator	✓	✓
24	HVAC	✓	
25	Lighting	✓	
26	Gypsum Dewatering System	✓	
27	Limestone Ball Mill	✓	
28	DCS	✓	✓
29	Electrical	✓	
30	Boost Up Fan	✓	✓
31	Gas to Gas Heater (with fine tube)	✓	✓

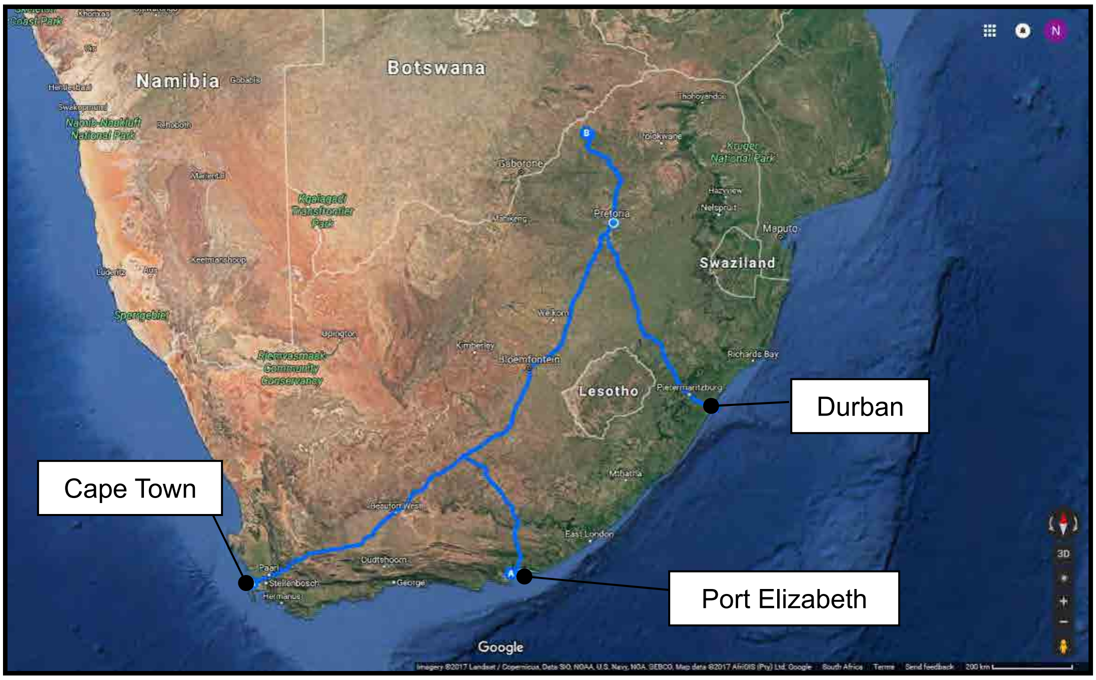
Source: Prepared by the JICA Study Team based on interview with local material companies

(2) Transport Route for Procurement of Offshore

According to the Eskom Basic Design 03 Construction Execution Plan, offshore procurement items are discharged from one of the following three ports in South Africa.

1) Durban: Located in the eastern area of South Africa approx. 900 km (about 18~27 hours) from the site by land transportation.
2) Port Elizabeth: Located in the southeast area approx. 1,400 km (about 28~42 hours) from the site.
3) Cape Town: Located in the southwest area approx. 1,700 km (about 34~51 hours) from the site.

The calculation of transportation time should take into consideration the effects of taking heavy equipment transportation by trailer. If one travels on the general road at a speed of 60 km/h to 80 km/h, including break time, the total transportation time is estimated to be the indicated times above. The transport route is shown in Figure 7.2-1. In addition, this driving route has dropped the route based on the basic design of Eskom into Google Maps.



Source: Taken by the JICA Study Team using Google Maps (taken in November 2017)

Figure 7.2-1 Transport Route Map

(3) Construction of FGD

The large heavy machinery to be used for FGD construction can be procured in South Africa. There are four main construction companies that own large heavy machineries, namely Mammoet, Liebherr, Sarens, and Tubular. Among these, Tubular has actual performance of producing and installing FGD at Kusile PS. The man lift (Telescopic Diesel Booms) can be rented from two companies, Eazi Access and Total Access Hire, near the Medupi TPS. Pictures of the major heavy equipment are shown in Figure 7.2-2.

Crawler Crane LR-13000 (1856 t)	Hydraulic Crane RT-880E (72.6 t)
	
Crawler Crane RG912 (800 t)	Telescopic Diesel Boom JLG-800S (26.38 m)
	

Source: Prepared by the JICA Study Team, quoted from the website of Mammoet, Tubular, and Eazi Access

Figure 7.2-2 Heavy Machinery Information

(4) Ability of Workers

In the welding technology and alignment work, more than Category 4 is needed in the process of steel structure manufacturing.

7.3. Risk Analysis

7.3.1. Risk of Stakeholder

For full operation of six FGDs that will be constructed in the project, it is necessary to timely implement and complete the MCWAP 2 project. Eskom has a meeting with DWS, which is in charge of the MECWAP 2 project, to discuss and make agreements in case the MCWAP 2 project will be delayed. In conclusion, regarding the water security of Medupi TPS operation including FGD, DWS is predicted to secure the needed amount of water in the required duration based on the water utilization license that will be obtained in May 2019.

7.3.2. Risk of Implementation Organization

(1) Incapability of the Project Executing Agency

Delay of the project implementation may rise due to the incapability of the project executing agency.

If the executing agency is not capable enough for appropriate process of daily works, timely decision making, or coordination with relevant authorities, the project implementation may be seriously delayed. Such an incapability may also lead to a dispute with the project management consultant (PMC) or the contractor regarding contractual or payment issues.

Eskom has experienced controlling and coordinating approximately 30 packages with boiler, turbine, generator, and auxiliary machinery construction work in the original Medupi PS construction.

The JICA Study Team assumes that the possibility is at low level and the impact of risk is at middle level.

(2) Corruptions in the Procurement Procedures of the Project Implementation Unit or the Contractor

Generally, corruption in the procurement processes of the Project Implementation Unit (PIU) or the contractor may rise in the projects, which may involve huge amounts of money. If this rises, corruption at any process of the project, such as procurement procedures of the PIU or the contractor, would prevent implementation of the project.

If this rises and is exposed, the Project may not proceed. The JICA Study Team assumes that the possibility is at low level, and the impact of risk is at high level.

7.3.3. Risk of the Project

(1) Strike of Labor

Delay and overbudget of the project may rise due to labor strikes. In South Africa, labor unions have great power, and they select to go on a long strike frequently. It can be a serious cause of both overbudget and delay of construction work. Usually, the contractor is exempted from responsibilities with risk of involving labor strikes as one of force majeure, in the case of projects under FIDIC contract. However, Eskom does not accept such exemption in the event that the sub-contractor participates in a labor strike. It means that the contractor may be burdened by all of the risks related to labor strikes.

There is a high possibility of strikes occurring, judging from the original Medupi PS construction work. It is one of the positive solutions to make the contractor prepare and monitor a strike mitigation plan. The JICA Study Team assumes that the possibility of this risk is at high level, and the impact of this risk is at high level.

(2) Bankrupt of Contractor

In the project, the local construction company with experience in construction in South Africa burdens some portion of the construction package. On the other hand, liquidated damages are well-known as a general risk in construction in South Africa.

It means that there is interruption risk due to cash flow problems. It is important to confirm the financing plan and to check the financial competitiveness of a construction company in finance. The JICA Study Team assumes that the possibility of this risk is at middle level, and the impact of this risk is at high level.

(3) No Achievement of Intended Performance

No achievement of intended performance may occur due to many reasons, e.g., construction defects. Unlike the EPC scheme, each of the EPS contractors and the construction contractors have limited liability.

There are some practices of separate EPS and construction contracts in the USA, so an experienced manufacturer as EPS contractor can make an appropriate construction manual. The JICA Study Team assumes that the possibility of this risk is at low level, and the impact of this risk is at middle level.

(4) Insufficient Level of Tariff Approved by NERSA to Cover the Necessary Cost of Eskom

There is a risk that NERSA may not approve Eskom's application for the revision of the tariff that reflects the cost and the appropriate level of profit. If the tariff approved by NERSA is lower than that requested by Eskom, it may lead to financial difficulty and lower operational performance of Eskom.

Actually, Eskom resorted to legal action with NERSA after disapproval of Eskom's application in June 2018; therefore, Eskom may not hesitate to go to court in case they are forced by tariff that does not cover cost and appropriate benefits. The JICA Study Team assumes that the possibility of this risk is at middle level, and the impact of this risk is at high level.

(5) Negative Impact on Existing Flue Gas System

A negative impact on the existing flue gas system may occur due to lack of experience and/or capacity of engineering company. Incapability of engineering (design) works may lead to erosion and lack of pressure.

The existing (under construction) Medupi PS has a high quality. The equipment for FGD shall also be designed and supplied by a well-experienced manufacturer. By doing this, it will allow Medupi PS to keep its high reliability even after FGD construction. The JICA Study Team assumes that the possibility of this risk is at middle level, and the impact of this risk is at high level.

7.3.4. Risk Management Framework

The JICA Study Team prepared a draft Risk Management Framework (RMF) sheet as appendix 7.1.

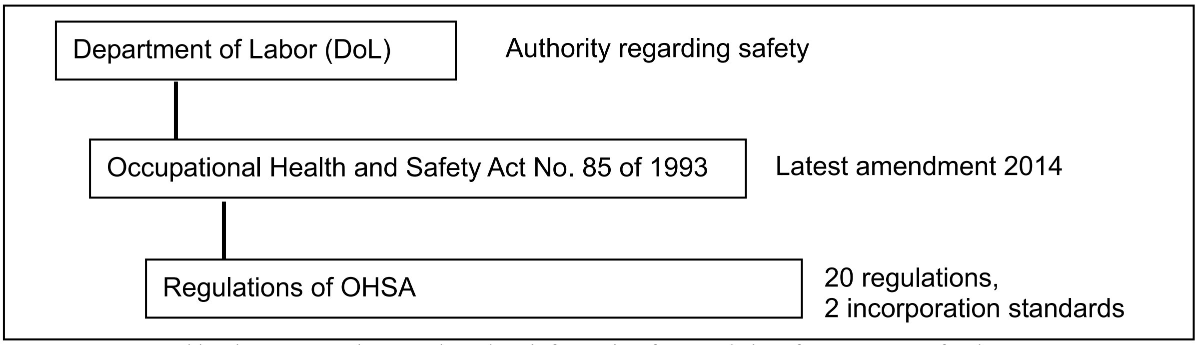
7.4. Safety Measures

7.4.1. Safety Regulation in South Africa

(1) Legislation Regarding Safety in South Africa

The legislation regarding safety in South Africa is shown in Figure 7.4-1.

The primary act regarding safety is the Occupational Health and Safety Act (OHSA) No. 85 of 1993. There are some acts prior to the promulgation of OHSA in South Africa, i.e., the Machinery and Occupational Safety Act No. 6 of 1983, the Machinery and Occupational Safety Amendment Act No. 40 of 1989, and the Machinery and Occupational Safety Amendment Act No. 97 of 1991. OHSA replaced those acts with the enhancement of health consideration to workers.



Source: Prepared by the JICA Study Team based on information from website of Department of Labor

Figure 7.4-1 Legislation Regarding Safety in South Africa

Table 7.4-1 Regulations under Occupational Health and Safety Act

No.	Name of Regulation	Promulgation
1	General Safety Regulations, 1986	May 1986
2	Environmental Regulations for Workplaces, 1987	October 1987
3	Driven Machinery Regulations, 1988	February 1988
4	General Machinery Regulations	August 1988
5	Facilities Regulations, 1988	August 1988
6	Electrical Machinery Regulations, 1988	August 1988
7	Certificate of Competency Regulations, 1990	March 1990
8	Electrical Installation Regulations, 1992	
9	Lift, Escalator and Passenger Conveyor Regulations, 1994	April 1994
10	Hazardous Chemical Substances Regulations, 1995	August 1995
11	Diving Regulations, 2001	January 2001
12	Regulations for Hazardous Biological Agents	December 2001
13	Major Hazard Installation Regulations	July 2001
14	Asbestos Regulations, 2001	February 2002
15	Explosives Regulations	January 2003
16	Noise Induced Hearing Loss Regulation	March 2003
17	Construction Regulations, 2003	July 2003
18	General Administrative Regulations, 2003	June 2003
19	Incorporation of Safety Standards into Electrical Installation Regulations, 2009	March 2009
20	Electrical Machinery Regulations, 2011	March 2011
21	Incorporation of Health and Safety Standards into the Electrical Machinery Regulations, 2011	March 2011
22	Driven Machinery Regulations, 2015	

Source: Prepared by the JICA Study Team based on information from the website of Department of Labor

The primary role of system strengthening and regulation for health and safety in South Africa is performed by the OH&S Inspectorate within the DoL. Compliance with building regulations falls within the ambit of local authorities. The CIDB Act also allows CIDB to play a regulatory and/or promotional role.

(2) OH&S Inspectorate

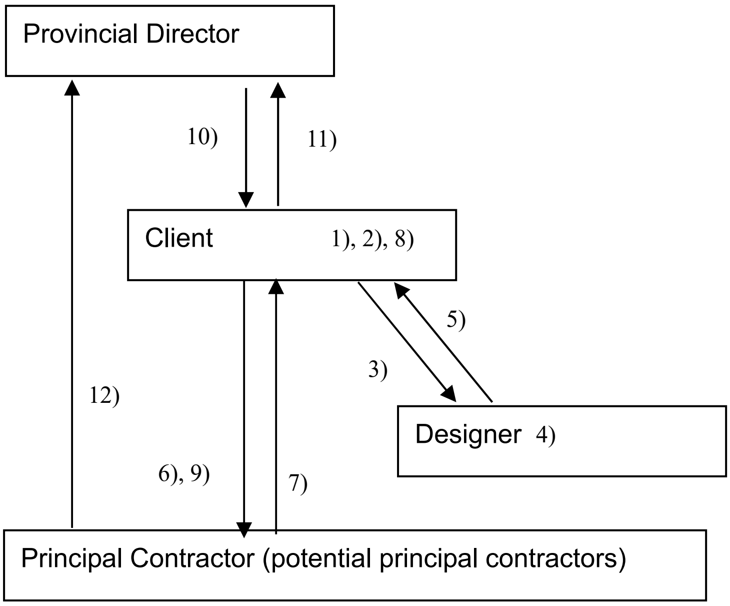
The OH&S Inspectorate is responsible for the enforcement of occupational health and safety, and is positioned within the DoL. Currently, the DoL Inspectorate's influence is mainly downstream, i.e., on the construction site, and their role is passive.

(3) Compensation Commissioner

The Compensation Commissioner (CC), which is also positioned within the DoL, is responsible for the implementation of the Compensation for Occupational Injuries and Diseases Act No. 130 of 1993 (COID Act), which regulates all aspects of workers' compensation insurance. The main objective of this Act is "to provide for compensation for disablement caused by occupational injuries or diseases sustained or contracted by workers in the course of employment, or for death resulting from such injuries or diseases." The Act requires employers to report occupational injuries within seven days of such injuries occurring and occupational diseases within fourteen days of diagnosis.

(4) Procedure for Health and Safety Before Commencement of Construction work

The procedure for health and safety before commencement of construction work is shown in Figure 7.4-2. At first, the client must prepare both baseline risk assessment and site-specific health and safety specification. The designer of structure should take health and safety specifications into account. The client must include health and safety specifications in the tender documents so that the tenderers can estimate the cost of health and safety measures properly. The principal contractor must prepare the health and safety plan. Before commencement of construction work, the client submits an application for the construction work permission with the following three documents attached: health and safety specification, health and safety plan, and baseline risk assessment.



1) Preparation of baseline risk assessment (Article 5(1)(a))
2) Preparation of site-specific health and safety specification (Article 5(1)(b))
3) To Provide designer with specific health and safety specification (Article 5(1)(c))
4) To make available in a report regarding all relevant health and safety information (Article 6(1)(c))
5) To design with taking into consideration of the health and safety specification (Article 6(1)(b))
6) To include specific health and safety specification in the tender document (Article 5(1)(f))
7) To provide and demonstrate to the client site specific health and safety plan, based on health and safety specifications (Article 7(1)(a))
8) To discuss and negotiate with the principal contractor the contents of the principal contractor's health and safety plan (Article 5(1)(l))
9) To approve that plan for implementation (Article 5(1)(l))
10) Submission of application for construction work permit (Article 3(1))
11) Issue of construction work permit (Article 3(3))
12) Submission of notification of construction work

Source: Prepared by the JICA Study Team based on Construction Regulations, 2014

Figure 7.4-2 Procedure for Health and Safety Before Commencement of Construction Work

(5) Designated Items to be Taken Countermeasure on Construction Works

The designated items to be given safety measures on construction works are stipulated in Article 10 to Article 29. Designated items to be given health and safety countermeasures are shown in Table 7.4-2. There are 20 items designated.

Table 7.4-2 Designated Construction Works to be Given Health and Safety Countermeasures

	Item		Item
Article 10	Fall protection	Article 20	Bulk mixing plant
Article 11	Structures	Article 21	Explosive actuated fastening device
Article 12	Temporary works	Article 22	Cranes
Article 13	Excavation	Article 23	Construction vehicles and mobile plant
Article 14	Demolition work	Article 24	Electrical installations and machinery on construction sites
Article 15	Tunneling	Article 25	Use and temporary storage of flammable liquids on construction sites
Article 16	Scaffolding	Article 26	Water environments
Article 17	Suspended platforms	Article 27	Housekeeping and general safeguarding on construction sites
Article 18	Rope access work	Article 28	Stacking and storage on construction sites
Article 19	Material hoists	Article 29	Fire precautions on construction sites

Source: Sorted by the JICA Study Team based on Construction Regulations, 2014

7.4.2. Safety Countermeasures

The JICA Study Team prepared a comparison table between OHSA and JICA safety guidelines as shown in appendix 7.2.

For the preparation of a safety plan, it is possible to meet with the requirements of JICA safety guidelines by following both the South African legal institution regarding safety and the Eskom Contract Regulation.

It is necessary to make a contractor refer to JICA guidelines for safety protocols in formwork, rebar work, concrete work, and hoisting because the South African legal institution regarding safety does not include guidelines regarding those. Regarding other work, contractors can comply with JICA guidelines by following the South Africa legal institution, i.e., “Construction Regulations-2014”, “1031 - OHS - General Safety Regulations, 1986”, and “109 - OHS - Explosives Regulation”.

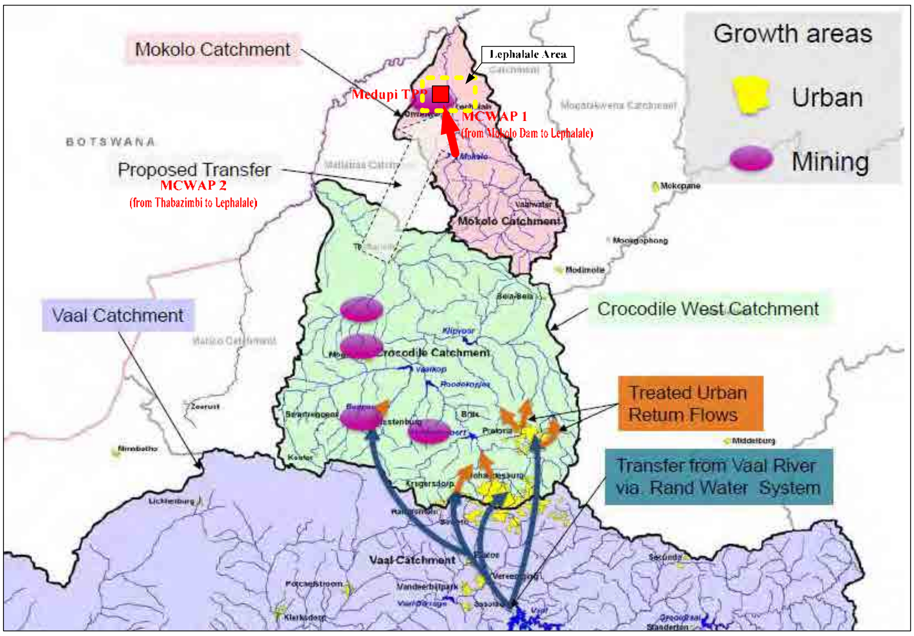
Chapter 8 Water Resource and Limestone Transportation

8.1. Water Resources

The water of the Lephalale area where the Medupi TPS locates is currently supplied from the Mokoro River. Water supply to the Lephalale area from the Crocodile River will be started by the Mokolo and Crocodile (West) Water Argumentation Project Phase 2 (MCWAP2) in 2025. There is Waterberg coalfields, where is almost half of South Africa's in-situ coal reserves in the Mokolo River catchment. It is expected that The Waterberg coalfields will be the country's major coal resource, once the current mining areas will be depleted in the future. For this reason, development by Eskom, Exxaro, and Sasol, etc. is planned and implemented in the Lephalale area at the time, and future water demand is expected to increase significantly.

The existing water resources of the Mokoro and Crocodile River catchments those supply to the Lephalale area cannot satisfy the future water demand of the Lephalale area. Therefore, DWS plan to increase water supply volume from the Vaal River catchment to the Lephalale area from the current water supply volume through MCWAP2.

Figure 8.1-1 shows the location of the Lephalale area, the Mokolo River catchment, the Crocodile River catchment, the Vaal River catchment, the existing the Mokolo and Crocodile (West) Water Argumentation Project Phase 1 (MCWAP1) pipeline, and the planned MCWAP2 pipeline.

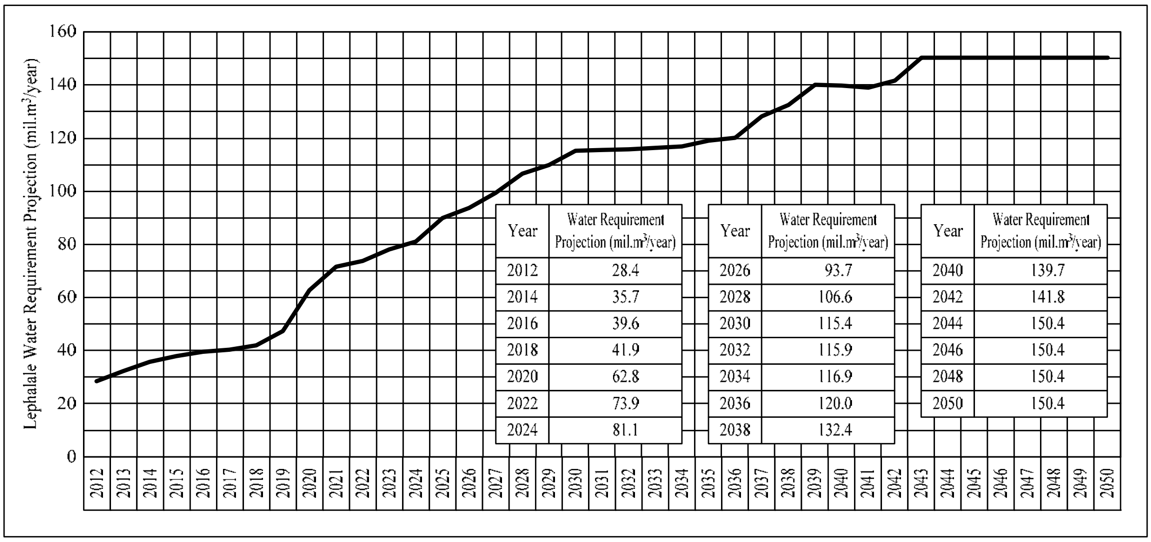


Source: Presentation Material of Water Resources Assessments, DWS, 30 November 2017

Figure 8.1-1 Location Map of Study Area

Water requirement prediction of Lephalale area is shown in Figure 8.1-2. Water requirement of Lephalale area is expected to drastically increase from 42.1 million m^3/year as of 2019 to 111.3 million m^3/year as of 2050.

Supply water from the Mokolo River and the Crocodile River catchments is insufficient for future water requirement in the Lephalale area. Therefore, it is necessary to supplement the shortage of water supply through increasing the water supply from the Vaal River catchment. Regarding mentioned shortage of water, it is expected to be dissolved through both expansion of the existing waste water treatment plant and construct a new waste water treatment plant those the DWS are in planning.



Source: DWS, 21 February 2018

Figure 8.1-2 Water Requirement Prediction of Lephalale Area

8.1.1. Collected Data and Information

The JICA Study Team examined the water requirement for Medupi TPS based on observed hydrological data of the Mokolo and Crocodile rivers as following.

(1) Description of Dams

Source of water supply to Medupi TPS are the Mokolo dam of Mokolo river, the Klipvoor, Vaalkop, and Roodekopjes dams of the Crocodile river, and the remaining basin of the Crocodile river. Summary of the above four dams collected from the DWS is shown in Table 8.1-1.

Table 8.1-1 Description of Four Dams

Item	Dam			
	Mokolo	Klipvoor	Vaalkop	Roodekopjes
River	Mokolo	Crocodile	Crocodile	Crocodile
Location	S 23° 59' 06" E 27° 43' 25"	S 25° 7' 53" E 27° 48' 33"	S 25° 18' 31" E 27° 28' 28"	S 25° 24' 25" E 27° 34' 39"
Catchment Area (km^2)	4,220	6,160	6,098	6,027
Full Supply Level (El. m)	911.98	989.07	980.71	1006.57

Low Water Level (El. m)	871.82	972.91	969.30	985.00
Net Reservoir Capacity (mil. m^3)	145.77	40.73	51.32	96.35

Source: DWS

(2) Inflow Discharge into Four Dams (Mokolo, Klipvoor, Vaalkop, and Roodekopjes Dams)

The inflow discharge of the Mokolo, Klipvoor, Vaalkop, and Roodekopjes dams were calculated and controlled by DWS. The average inflow discharge of Mokolo, Klipvoor, Vallkop, and Roodekopjes dams are 4.48 m^3/sec, 3.74 m^3/sec, 1.60 m^3/sec, and 8.71 m^3/sec, respectively.

It means that inflow discharge to the Mokolo dam is 156 million m^3/year (=4.94 m^3/sec x 60 sec/min x 60 min/hour x 24 hour/day x 365 day/year). The inflow discharge to the other three dams, i.e. Klipvoor, Vallkop, and Roodekopjes dams, should be corrected because it includes return water from waste water treatment works (WWTW).

JICA Study Team collected record of the monthly mean inflow discharge of four dams from October 1980 to June 2017.

The monthly mean inflow discharge of the four dams is attached as Appendix 8.1.

(3) Reservoir Water Level at Four Dams (Mokolo, Klipvoor, Vaalcap, and Roodekopjes Dams)

The reservoir water level at Mokolo, Klipvoor, Vaalkop, and Roodekopjes dams were recorded by DWS.

JICA Study Team collected record of the reservoir water level at four dams from October 1980 to June 2017.

The reservoir water level at four dams is attached as Appendix 8.2.

(4) Reservoir Height–Volume (H-V) Curve

The relationship between the reservoir water level and the reservoir volume of the Mokolo, Klipvoor, Vaalkop, and Roodekopjes dams were observed by DWS. The H-V curves of Mokolo, Klipvoor, Vallkop, and Roodekopjes dams are created by the observed reservoir water level and reservoir volume data.

Reservoir height – volume (H-V) curve that is prepared based on observed reservoir water level and reservoir volume data is attached as Appendix 8.3.

(5) Reservoir Evaporation from Four dams (Mokolo, Klipvoor, Vaalcap, and Roodekopjes Dams)

The reservoir evaporation of each dams were observed by DWS. The monthly average reservoir evaporation of the Mokolo, Klipvoor, Vallkop, and Roodekopjes dams are shown in Table 8.1-2.

The annual average evaporation from reservoir is about 3 mm/day to 4 mm/day.

Table 8.1-2 Monthly Mean Reservoir Evaporation of Four Dams

Unit : mm

Dam	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Mokolo	5.09	5.02	4.84	5.13	5.32	4.72	3.77	3.16	2.54	2.55	3.25	4.42	4.15
Klipvoor	3.78	3.92	4.27	4.84	4.99	4.31	3.70	3.04	2.43	2.50	3.17	3.86	3.73
Vaalkop	3.36	3.32	3.53	3.62	4.09	3.50	2.69	2.22	1.66	1.76	2.12	2.83	2.89
Roodekopjes	3.32	3.34	3.48	3.58	3.88	3.46	2.94	2.51	1.95	1.93	2.43	3.07	2.99

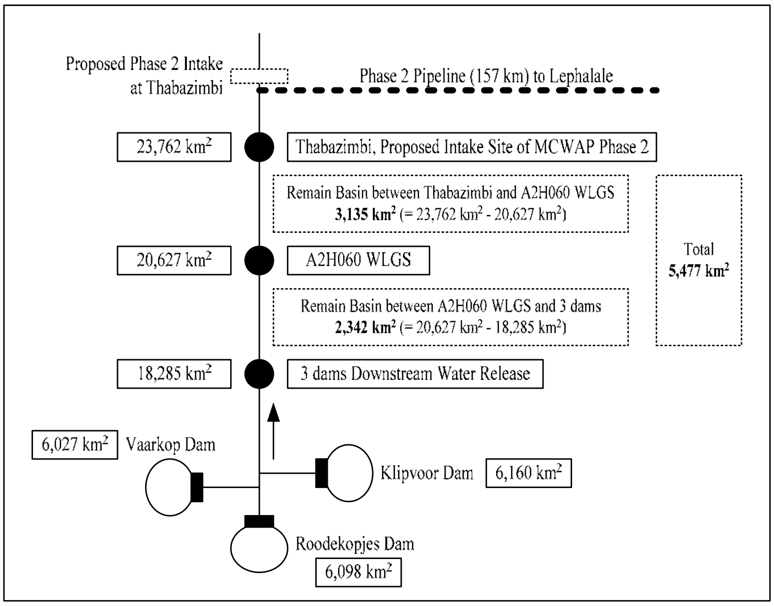
Source: DWS

(6) Discharge of Remain Basin of Crocodile West River Catchment

The area of the remain basin between three dams and Thabazimbi is 5,477 km2 (= 2,342 km2 + 3,135 km2). This remain basin is independent from discharge from three dams because its source is rainfall at downstream of three dams. This remain basin join at water intake of MCWAP2.

Schematic diagram of remain basin between three dams and Thabazimbi is shown in Figure 8.1-3.

Collected data and calculated discharge of remain basin are attached as Appendix 8.4.



Source: Prepared by JICA Study Team

Figure 8.1-3 Schematic Diagram of Remain Basin between Three dams and Thabazimbi

(7) Actual Water Use of Four Dams (Mokolo, Klipvoor, Vaalkop, and Roodekopjes Dams)

1) Mokolo Dam

Water of Mokolo dam is used as water use for industry and town. Water volume of 30 million m^3/year supplies to Lephalale area through pipeline of MCWAP1. Some water is discharged to downstream irregularly.

Mentioned water use is monitored by DWS. Collected data regarding water use and the other discharge to downstream are attached as Appendix 8.4.

Pipeline discharge is supplied about 0.35 m^3/sec without monthly fluctuation. The Medupi TPS is currently running three units (Unit No. 4, 5, 6), and the amount of water used is 0.09 m^3/sec (=0.03 m^3/sec x 3 units).

Downstream water release from Mokolo dam has abound discharge during the rainy season from December to May.

2) Klipvoor Dam

The purpose of Klipvoor dam is water supply for irrigation.

The discharge for irrigation water is monitored by DWS and its record is attached as Appendix 8.4.

The discharge for irrigation is 3.59 m^3/sec annual average basis.

3) Vaalkop Dam

Water of Vaalkop dam is used for industry and town, and some water is discharged as downstream river release regularly.

The discharge for both water use and downstream river release are monitored by DWS and its record is attached as Appendix 8.4.

The discharge for water use and downstream river release is 1.07 m^3/sec and 1.23 m^3/sec annual average basis, respectively.

4) Roodekopjes Dam

Water of Roodekopjes dam is used for irrigation, and some water is discharged as downstream river release regularly.

The discharge for both irrigation and downstream river release are monitored by DWS and its record is attached as Appendix 8.4.

The discharge for irrigation and downstream river release is 2.05 m^3/sec and 1.34 m^3/sec annual average basis, respectively.

5) Sort of Water Use at Downstream of Crocodile West River

Sum of mentioned water use is 6.71 m^3/sec (=3.59 m^3/sec + 1.07 m^3/sec + 2.05 m^3/sec). It means that water use at downstream of Crocodile West River is 212 million m^3/year (=6.71 m^3/sec x 60 sec/min x 60 min/hour x 24 hour/day x 365day/year).

8.1.2. Progress of MCWAP2

The purpose of MCWAP2 is to supply water from the Crocodile River to the Lephalale area, includes water supply to Medupi TPS. The plan as of December 2018 that was prepared by Trans-Caledon Tunnel Authority (TCTA) is scheduled to be completed in 2025. The following is an outline of MCWAP2 prepared by TCTA.

The MCWAP2 entails the construction of an abstraction weir and a water transfer system (pump station(s) and approximately 160 km pipelines), as well as the associated infrastructure and the implementation of measures to mitigate the impact of the project on both the natural and social environment. The objectives of the MCWAP2 is to secure water supply through supplementing water from Crocodile West catchment due to developments of the Waterberg Coalfields with growth of energy demand in the future. The Waterberg Coalfields have been identified as a strategic development node for the country under Special Infrastructure Programme-1 (SIP-1). The coal extracted is immediately saleable, positively benefiting energy security and economic growth, resulting in job creation, tax revenue and social infrastructure. Water infrastructure is needed as a catalyst to achieve this social and economic development in the area.

MCWAP2 is comprised of an abstraction weir and low lift pump station in the Crocodile River at Vlieëpoort near Thabazimbi, and will deliver 75 million m^3 per annum at a rate of 8 m^3/sec at a head of 300 m to Steenbokpan. It also includes a River Management System infrastructure which focuses on the management and monitoring of water levels and flows from Hartbeespoort dam, Roodekopies dam, and other smaller dams in the Crocodile West River. Implementation of the River Management System. Introduction of mentioned river management and monitoring system must be completed 18 months before commissioning of the scheme.

MCWAP2 will provide monitoring and control systems including MCWAP1 infrastructure.

The main work schedule of MCWAP2 is as shown in Table 8.1-3.

Table 8.1-3 Main Work Schedule of MCWAP2

Work	Month/Year
Implementation Agreement signed	Oct 2018
Water Supply Agreements signed	Nov 2018
Guarantee Framework Agreement signed - DWS, DoE, NT, TCTA	Oct 2018
Environmental Authorisation	March 2019
Professional Service Provider Appointment (Design & Construct)	Jan 2019
Tender Design concluded	Dec 2019
Construction Tender award	Sept 2020
Construction start	Jan 2021
Commissioning	Jun 2024
Water delivery	Jan 2025
Defect Notification Period concluded	Dec 2025
Rehabilitation	Dec 2025
Project Close Out	June 2026

Source: TCTA

8.1.3. Return Flow of Waste Water Treatment Works

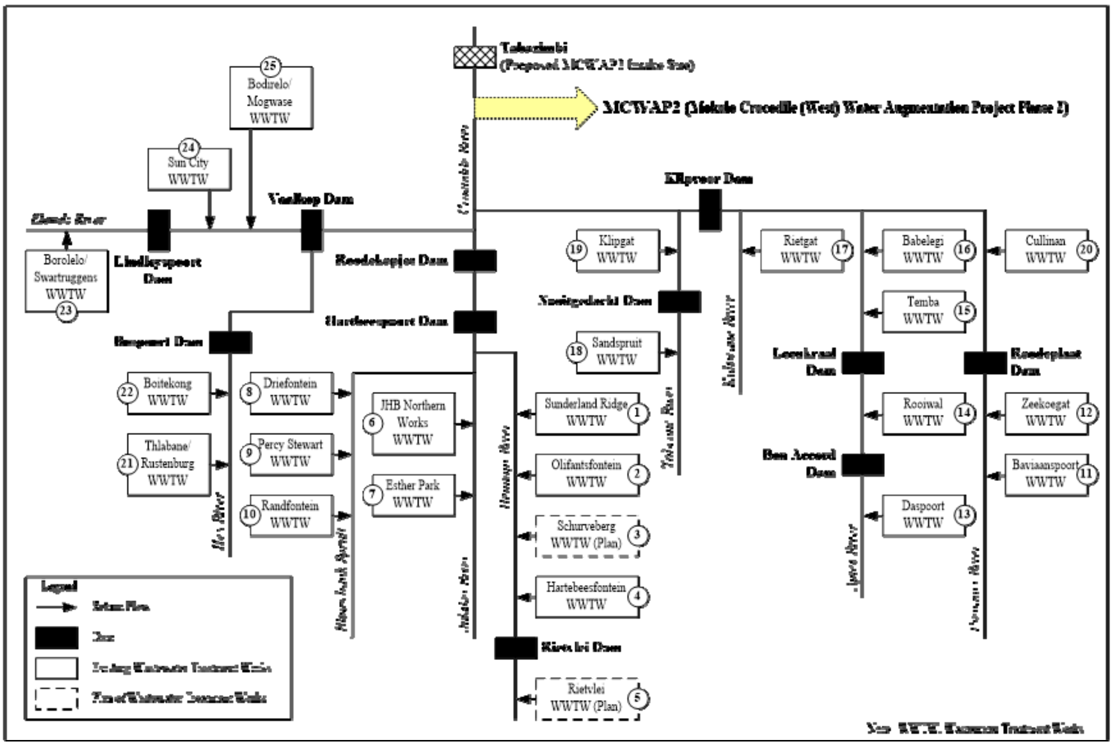
(1) Estimation of return water volume from Waste Water Treatment Works

Domestic water to Johannesburg and Pretoria, and mining water are supplied by rand water system (RWS). The RWS is Project of water transfer from Vaal River catchment to Crocodile River catchment. The supplied water by RWS is used for domestic water, mining water, then is treated through waste water treatment works (WWTW) and returns to Crocodile River catchment. Mentioned Figure 8.1-1 shows the flow image from Vaal river catchment to Crocodile West river catchment as blue highlighted multi arrow lines.

There are 23 existing WWTWs in order to treat water that is supplied through RWS in the Crocodile River catchment. In addition, construction of new two WWTWs are in planning. Figure 8.1-4 shows a schematic diagram of the existing and planned WWTWs in the Crocodile River catchment.

According to DWS, total capacity of WWTWs as of 2016 and 2030 is approximate 500 million m^3/year and approximate 970 million m^3/year, respectively. In precondition as return water volume is half of total capacity, return water as of 2016 and 2030 is estimated approximate 250 million m^3/year and approximate 485 million m^3/year, respectively.

Collected data and detailed estimation policy is attached as Appendix 8.6.



Source: Prepared by JICA Study Team

Figure 8.1-4 Schematic Diagram of Existing and Planned WWTWs

(2) Inflow discharge of Crocodile West Catchment without return water from WWTWs

The future return flow is predicted as described in mentioned above but the return flow from the existing WWTW is already reflected of the dam inflow in the Crocodile River basin. Although it possesses WWTW construction status and return flow records as of 2016, there is no information up to the construction year of WWTW. As for the current inflow record of dams, there are mixed periods of with return flow and without return flow from WWTW.

Therefore, in order to ensure consistency of the dam inflow data, the transition of return flow is examined for each dam. The verification of the transition of return flow is carried out by the runoff coefficient (coefficient of rainfall and dam inflow).

Because runoff coefficient is nearly constant, and it should not change year by year. The change in the runoff coefficient is judged to be due to return flow. Roodekopjes dam has changed runoff coefficient in 1994 and 2009, Klipvoor and Vaalkop dams have a change runoff coefficient in 1994.

Therefore, average of inflow before 1994 is assumed inflow discharge of Crocodile West Catchment without return water from WWTWs equivalent. In mentioned assumption, each inflow discharge of Roodekopjes, Klipvoor and Vaalkop dams are 1.8 m^3/sec, 0.45 m^3/sec, and 1.84 m^3/sec, respectively. It means that total inflow discharge of Crocodile West Catchment without return water from WWTWs is estimated 4.09 m^3/sec (=1.8 m^3/sec + 0.45 m^3/sec + 1.84 m^3/sec) and 129 million m^3/year (=4.09 m^3/sec x 60 sec/min x 60 min/hour x 24 hour/day x 365 day/year)

8.1.4. Water Resources Plan

The JICA Study Team confirmed Medupi TPS can be stably secured even after six FGDs will be installed as following.

According to Eskom and TCTA, the total water uses of 6 units TPS and FGD is 13.4 million m^3/year. The breakdown of TPS and FGD are 6.0 million m^3/year and 7.4 million m^3/year, respectively. Water use for Medupi TPS is shown in Table 8.1-4.

In case that gas cooler will be attached with FGD in purpose of water saving, the water use decreases from 7.4 million m^3/year to 5.0 million m^3/year for FGD 6 units.

Table 8.1-4 Water Use for Medupi TPS

Plant	Water Use (6 units)		Water Use (per 1 unit)	
	million m^3/year	m^3/sec	million m^3/year	m^3/sec
Without Gas Cooler				
TPS	6.0	0.19	1.0	0.03
FGD	7.4	0.24	1.2	0.04
Total	13.4	0.42	2.2	0.07
With Gas Cooler				
Thermal Power Plant	6.0	0.19	1.0	0.03
FGD	7.4	0.23	1.2	0.04
Gas Cooler	-2.4	-0.08	-0.4	-0.01
Total	11.0	0.34	1.8	0.06

Source: Prepared by the JICA Study Team

There are two water sources for Medupi TPS, i.e. 10.9 million m^3/year from Mokolo dam (existing, MCWAP1) and 2.5 million m^3/year from the Crocodile river at Thabazimbi (in planning, MCWAP2). The water supply plan to Medupi TPS by MCWAP1 and MCWAP2 is shown in Table 8.1-5.

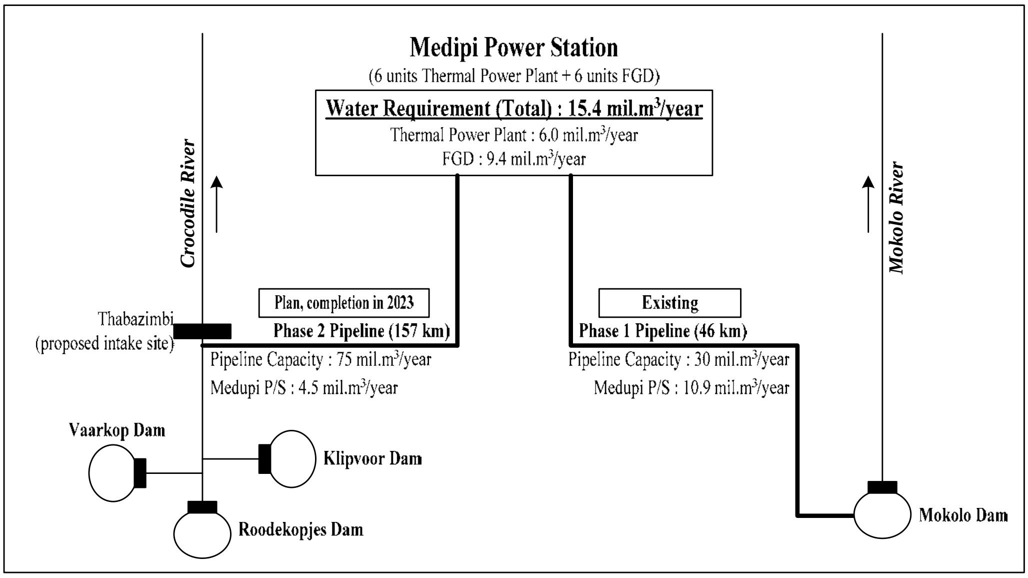
Table 8.1-5　Water Supply Plan for Medupi TPS

Item	MCWAP1	MCWAP2
River	Mokolo	Crocodile
Location of Intake	Mokolo Dam	Thabazimbi
Pipeline Length	46 km	157 km
Pipeline Capacity	30 mil. m^3/year	75 mil. m^3/year
Water Supply Plan for Medupi TPS without Gas Cooler (6 units Coal Fire TPS + 6 units FGD)	10.9 mil. m^3/year	2.5 mil. m^3/year
Water Supply Plan for Medupi TPS with Gas Cooler (6 units Coal Fire TPS + 6 units FGD)	10.9 mil. m^3/year	0.1 mil. m^3/year

Source:　Prepared by the JICA Study Team

According to an interview from the TCTA, when water supply from MCWAP1 (Mokolo River) falls in shortage, water supply from MCWAP2 (Crocodile River) supplements its shortage. On the contrary, when water from MCWAP2 falls in shortage, water supply from MCWAP1 supplements its shortage.

The schematic diagram of the water supply plan to Medupi TPS is shown in Figure 8.1-5. Pipeline capacity of MCWAP2 is 75 million m^3/year.



Source:　Prepared by the JICA Study Team

Figure 8.1-5　Schematic Diagram of Water Supply Plan for Medupi TPS

(1)　Water Balance Calculation

1)　Water Supply from Mokolo Dam

Water supply from Mokolo Dam to the Lephalale area is 30 million m^3/year (2.50 million m^3/month) through the MCWAP1 pipeline. On the other hand, the inflow discharge to Mokolo Dam is 156 million m^3/year (12.98 million m^3/month) It means that there is enough margin for water use in Lephalale area.

2) Water Supply from Crocodile West Catchment

a) Comparison between downstream water use of the dams and inflow discharge to the dams

As of 2016, the downstream water use of the dams is 212 million m^3/year (17.67 million m^3/month). On the other hand, the inflow discharges to the dams both of from the dam own basin and from the WWTW in Gauteng province are 129 million m^3/year (10.75 million m^3/month) and 250 million m^3/year (20.83 million m^3/month) respectively. It means that total inflow discharge is 379 million m^3/year (31.58 million m^3/month).

Therefore, there is a water volume that is acceptable for the water use of 75 million m^3/year (6.25 million m^3/month) by MCWAP2 on a monthly and annual basis. Actual data regarding the inflow discharge from WWTW shows its monthly fluctuation is not much.

b) Consideration of dry season risk

Inflow discharge of dams from the dam own basin decreases by zero m^3/month in months when has little amount of rainfall during the dry season. In this case, the inflow discharge to the dam is 250 million m^3/year (20.83 million m^3/month) from the WWTW in Gauteng province. On the other hand, because water use 287 million m^3/year (23.92 million m^3/month=17.67 million m^3/month +6.25 million m^3/month), water supply to MCWAP2 falls in a shortage of 37 million m^3/year (3.09 million m^3/month).

c) Risk mitigation through extension and expansion of WWTW

In Gauteng province, the extension and expansion of WWTW is ahead in stages. Inflow discharge from WWTW is expected from 250 million m^3/year (20.83 mil.m^3/month) as of 2016 to at least 485 million m^3/year (40.41 million m^3/month) as of 2030. In case the growth rate of WWTW is constant, it is assumed that the shortfall of 37 million m^3/year (3.09 million m^3/month) will be resolved as early as 2019.

In addition, downstream water uses of the dam as of 2016 is 212 million m^3/month (17.67 million m^3/month). EIA of MCWAP2 describes no mention regarding increasing water for irrigation, which accounts for the majority of water use. It is speculated that there will be no significant increase in irrigation in the future.

3) Conclusion

As for the inflow as of 2016, there will be a shortage of water supply to MCWAP2 in the dry season, however it will be dissolved in 2019 due to the expansion of the WWTW in Gauteng province.

8.2. Limestone/ Gypsum Transportation

8.2.1. Introduction

Eskom conducted the Medupi FGD BD, which was prepared and submitted by Steinmüller Engineering (and Black & Veatch) in 2014. While the handling concept of the limestone and gypsum by railway is not discussed in the report, Eskom also ordered a task to Bosch Holding Consortium (Bosh Holdings, Thabile Engineering, Thabo Consulting, and Nemai Consulting) to design the yard and off/loading facility concept (hereinafter referred to as the "Medupi Yard Concept Report"), and the report was submitted in 2015.

In this clause, Medupi FGD BD and Medupi Yard Concept Report Volume 1 "Rail Yard and Services" were submitted on 13 March 2015, which were reviewed in view of transportation by railway. A transportation plan will be proposed based on those reports.

8.2.2. Railway Service Overview in South Africa

In South Africa, the railway operator is different for freight trains and for passenger trains.

(1) Freight Railway Service

Transnet is a state-owned company (SOC). Transnet is wholly owned by the Government of the Republic of South Africa (RSA) and is structured to provide transport and handling services through its five operating divisions, namely Transnet Freight Rail (TFR), Transnet Rail Engineering (TRE), Transnet National Ports Authority (TNPA), Transnet Port Terminals (TPT), and Transnet Pipelines (TPL). The company is the custodian of freight rail, ports, and pipelines.

As for freight railway, TFR is the operator. The network of freight railway is shown in the figure below. The railway network spreads around South Africa and creates a robust network for suspended railway operation. The freight rail network is owned by Transnet and is managed, maintained, and operated by the TFR division.

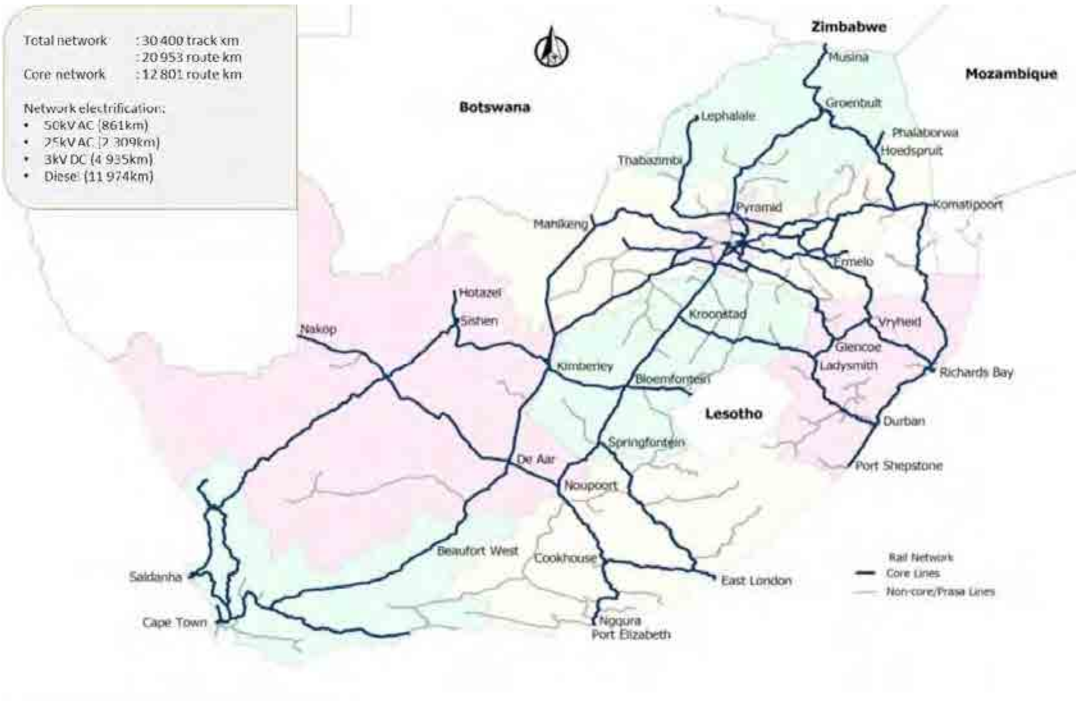


Figure 1: Infrastructure Overview Map

Source: Long Term Planning Framework 2016, TFR

Figure 8.2-1 Freight Railway Infrastructure Overview Map

In South Africa, freight railway service is remarkably performed in large scale. The longest freight train is approximately 4 km long, with five locomotives and 340 wagons at the most. The service is well-known as the world's longest freight train. The carried volume by TFR in five years is summarized in the table below. Current transport volume is reached at 219 million tons in 2017.

Table 8.2-1 Freight Volume Carried in Five Years

	Year				
ITEM	2013	2014	2015	2016	2017
General freight (mil. ton)	82,6	88,0	90,6	84,0	88,1
Export coal (mil. ton)	69,2	68,1	76,3	72,1	73,8
Export iron ore (mil. ton)	55,9	54,3	59,7	58,1	57,2
Total rail (mil. ton)	207,7	210,4	226,6	214,2	219,1

Source: Results Announcement (2017), TFR

FGD needs a large volume of limestone, and it planned to be transported by railway in Medupi FDG BD in view of efficient transportation.

(2) Passenger Railway Service

Passenger Rail Agency of South Africa (Pty) Ltd (hereinafter "PRASA") is the railway operator for passenger trains. It consists of the metropolitan network known as Metrorail in six major cities in South Africa, i.e., Johannesburg, Pretoria, Cape Town, Durban, East London, and Port Elizabeth. The rail network in the metropolitan areas, which is an operated passenger train is owned by PRASA. Intercity railway transportation is also serviced by PRASA as Shosholoza Mayl, connecting major cities and the TFR line is also utilized in the outskirts of the city.

8.2.3. Review of Medupi FGD Basic Design (BD)

(1) General Idea of the Handling Plan at the FDG Site

The basic idea of limestone handling and storage in the Medupi FGD of Project Design Manual "9.1.1 Limestone Handling and Storage" is as follows:

Limestone will be received via rail (either via bottom discharge containers handled by an overhead crane, or via bottom discharge wagons) or truck (side tippers). Limestone will be conveyed to a stockpile via belt conveyors and stocked out via a traveling tripper and boom stacker into a 30-day capacity longitudinal storage pile.[1].

The main components of construction in the limestone handling system between the rail unload and the limestone stockpile are the gantry crane and hopper off‐load system, belt feeder, underground link conveyor, limestone stockout conveyor with tripper, and limestone stacker[2].

However, the origin of the limestone to be procured is not mentioned in the report.

In contrast, it is not clearly mentioned that dewatered gypsum as byproduct of FGD is to be transported by railway in the design manual, "9.1.2 Gypsum Handling and Storage". In this regard, the following two items are recommended to be examined in detail in the report:

- Arrangement and configuration of the gypsum material handling facilities
- Arrangement and configuration of the commercial-grade gypsum in temporary storage facilities (e.g., end user rail infrastructure)

Therefore, the destination of the gypsum needs to be examined in further study and transport route shall be set accordingly. In this regard, transportation of gypsum is not planned in the Interim Report.

(2) Implementation Plan

The services of a specialty railroad contractor will be utilized to construct the limestone receiving and gypsum loadout rail facilities <u>that will be completed just prior to, or in parallel with, the limestone and gypsum material handling conveyors, and prior to Unit 6 FGD commissioning</u>.[3]

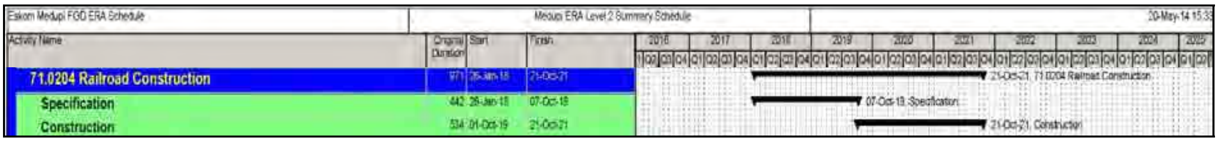
[1] Project Design Manual (2014), pp.9-1, "9.1.1 Limestone Handling and Storage", Eskom
[2] Construction Execution Plan (2014), pp.27, Eskom
[3] Construction Execution Plan (2014), pp.25, Eskom

Railroad is proposed to be packaged separately in the Medupi FGD Project (Package No.15[4]), and it is clearly mentioned as "*Majority of railroad work will be under separate contract outside FGD project*[5]", so the yard development consists the timeline as follows:

- 12 months for bids and award;
- 9 months for floating; and
- 24 months for installation.

The total timeline of railroad construction is assumed to be 45 months. The detailed component of railroad construction is not clear but the construction duration is good enough to construct ordinary freight station.

Table 8.2-2 Medupi FGD Execution Schedule



Source: Eskom (2014)

[4] Construction Execution Plan (2014), Table 7-1 in pp.30, Eskom

[5] Project Procurement Plan (2014), pp.2, Eskom

8.2.4. Review of Medupi Rail Yard and Off/Loading Facility Concept Report

In this subsection, the key design assumptions and operation plan in Medupi Yard Concept Report will be described.

(1) Key Concept

The key concept is listed in the Medupi Yard Concept Report as follows: All the points-sets in the yard are automatically controlled and signaled with the Central Traffic Control.

- Annual tonnages to be transported by rail for each commodity (1,200,000 t/a of limestone and 400,000 t/a of FGD Gypsum);
- TFR operating a drop-off/pick-up type of mainline service;
- Car-type wagons used for the transportation of limestone (type of coupler system still to be determined) and FDG Gypsum;
- Private shunt locomotive required to perform the shunting in the yard (outsourced to Transnet);
- Limestone offloaded by either a single wagon rotary tippler or a single wagon side tippler;
- 342 operational days (365 days less 5 days holiday, 2 days single line operations, and 16 days shutdown of corridor for maintenance);
- Limestone trains will arrive full and will depart empty in 60 car-type wagon consists hauled by four Class 39 diesel-electric locomotives in a head-end traction configuration;
- FGD Gypsum trains will arrive empty and depart full in 50 car-type wagon consists hauled by three Class 39 diesel-electric locomotives in a head-end traction configuration; and
- The maximum number of trains that can be accommodated within the Medupi Rail Yard at any time is four.

"Car-type wagon" indicates the open wagon as explained in 8.2.5(1)3) Type of Wagon and Payload.

(2) Limestone Handling Plan at the Medupi FGD Site

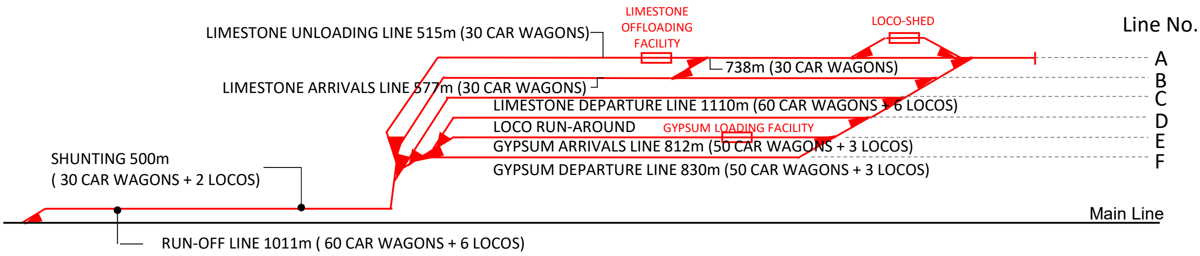
The design criteria according to Medupi Yard Concept Report is summarized in the table below.

Table 8.2-3 Alignment Design and Permanent Way Criteria in the Yard

Category	Item	Value
Main Line	Gauge	1,065 mm
	Rails	48 kg/m
Alignment Design	Minimum curve radius	200 m
	Maximum gradient	1:800 (1.25%)
	Mainline turnout	60 kg/m 1:12
	Yard turnouts	48 kg/m 1:9
	Track intervals	5.5 to 12 m

Source: Medupi Yard Concept Design (2015), Eskom

The railway yard consists of six lines for limestone and gypsum handling. The track layout and the description of each track are illustrated in the figure below.



Source: Eskom, Edited by the JICA Study Team

Figure 8.2-2 Description by Track in Railway Handling Yard

The handling railway yard is planned with the following conditions and the function of the line is summarized in the table below. The yard is designed to be able to handle not only limestone but also gypsum.

- Number of tracks: 6 lines
- Track centers: minimum 5.5 m
- Limestone: 60 wagon-set operation, 30 wagons in one-time offloading
- Gypsum: 50 wagon-set operation, 10 wagons in one-time load
- Full limestone loaded by 60 wagons with arrival of 6 locomotives maximum
- Maximum of 2 shunting locomotives can be allocated
- The substructure is based on 26-ton axle load

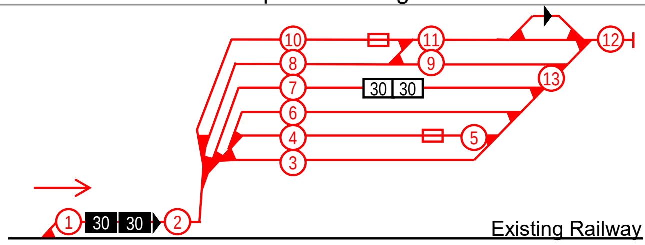
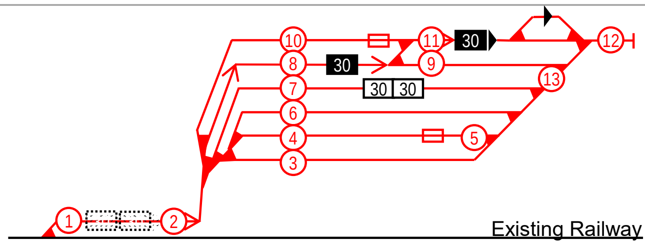
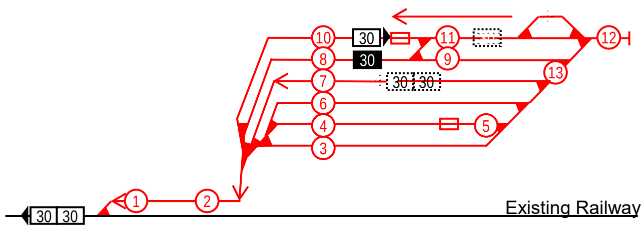
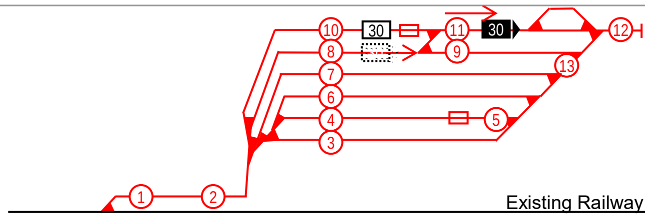
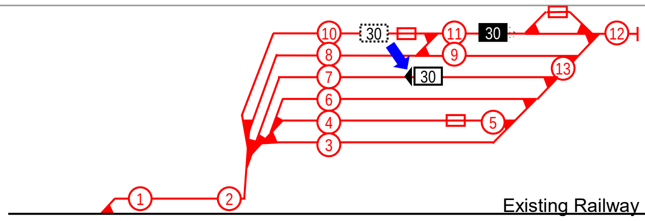
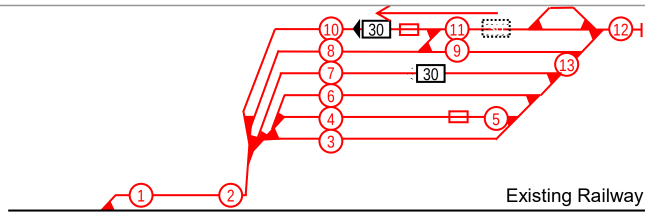
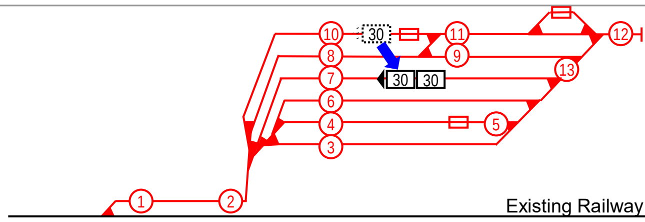
Table 8.2-4 Functions by Line in Railway Handling Yard

Line No.	Function	Remarks
A	Limestone Unloading Line	Unloading capacity: 30 wagons in one time
B	Limestone Arrival Line	-
C	Limestone Departure Line	-
D	Locomotive Run-around	-
E	Gypsum Arrivals Line	-
F	Gypsum Departure Line	Loading capacity: 10 wagons one-time load

Note: The Line Number is indicated in Table 8.2-4.
Source: Eskom, Edited by JICA Study Team

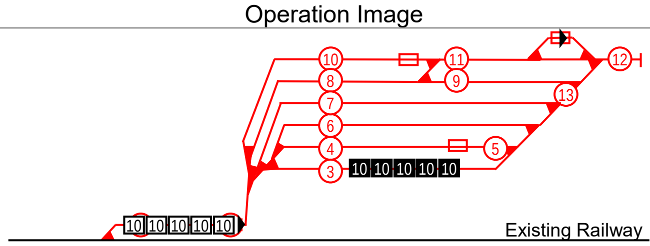
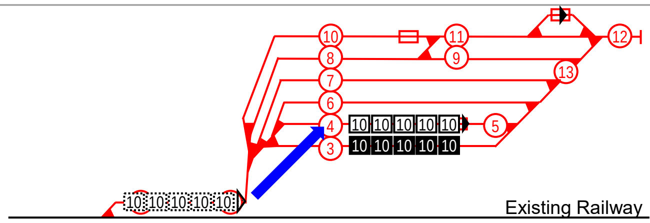
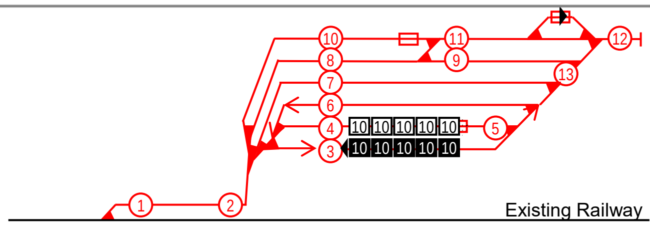
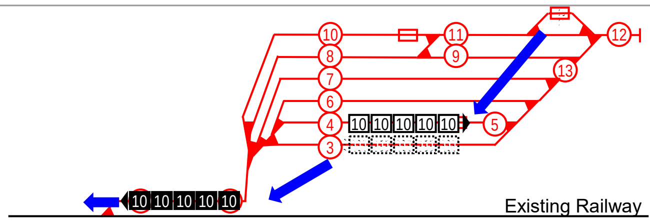
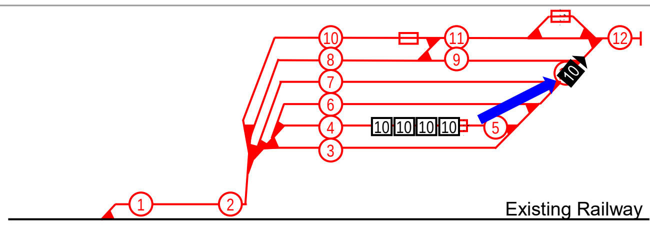
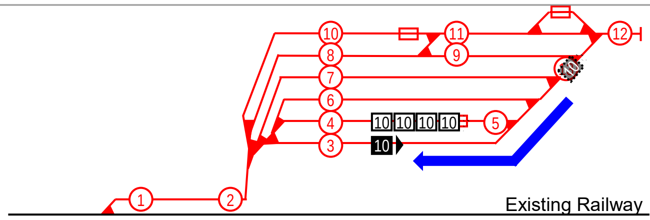
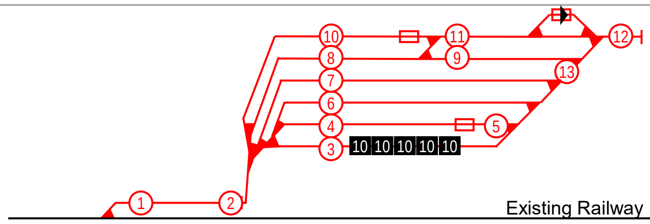
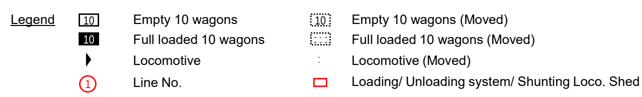
The sequences of limestone and gypsum are given in Table 8.2-5 and Table 8.2-6, respectively.

Table 8.2-5 Limestone Unloading Sequence in the Railway Yard

#	Description of the Handling Procedure	Operation Image
1	A full loaded 60 wagon limestone train arrival on Line 1.	
2	After weighing limestone, a full 60-wagon limestone train enters the yard along Line 1 and proceeds via Line 8 to Line 11, detaching the last 30 wagons to remain on Line 8.	
3	The front 30 wagons on Line 11 are pushed back to engage with the tippler and the loco uncouples to move via lines 12, 13, and 6 to attach to 60 empty wagons on Line 7 that were unloaded during the previous operation. On receiving permission to proceed, the train of empty wagons departs from Line 7. The 30 full wagons on Line 11 are unloaded, and the empty ones are pushed forward to Line 10.	
4	The shunting locomotive proceeds from its shed to Line 8, and pulls the 30 full wagons thereon to Line 11.	
5	The shunting locomotive moves over lines 12, 13, and 6 to Line 10 and moves the 30 empty wagons to Line 7.	
6	The 30 full wagons on Line 11 are unloaded, and the empty ones are pushed forward to Line 10.	
7	The shunting locomotive moves over lines 12, 13, and 6 to Line 10 and moves 30 empty wagons at a time to form a 60-wagon train on Line 7. Thereafter, the shunting locomotive moves back to the shed to be secured.	
8	Repeat Step 1. Process on arrival of the next full train	Legend 10 Empty 10 wagons 10 Full loaded 10 wagons Locomotive 1 Line No. 10 Empty 10 wagons (Moved) Full loaded 10 wagons (Moved) Locomotive (Moved) Loading/ Unloading system/ Shunting Loco. Shed

Source: Prepared by the JICA Study Team based on information from Eskom

Table 8.2-6   Gypsum Loading Sequence in the Railway Yard

#	Description of the Handling Procedure	Operation Image
1	Empty 50 set wagons upon arrival.	
2	A train of 50 empty wagons is pulled onto Line 4, the locomotive detaches.	
3	Moves over lines 5 and 6 to Line 3 where it couples to a rake of 50 loaded wagons, loaded during the previous operation.	
4	Once the necessary air brake test and wagon inspection are concluded and authorized to do so, the train departs the siding after weighing while the shunting locomotive moves from the shed over Line 13 to Line 4 via Line 5.	
5	Sequentially moves a maximum of 10 wagons to Line 13, the wagons are loaded as they move under the loading facility.	
6	Loaded 10 wagons will be moved to Line 3.	
7	Loading works will be repeatedly done five times and form 50 wagons set train on Track 5.	
8	The process is repeated upon the arrival of the next empty train (Return to 1).	

Source: Prepared by the JICA Study Team based on information from Eskom

(3) Feasibility of Train Operation in view of Limestone Handling Works in Medupi FDG Yard

1) Limestone

The expected item and time for limestone handling as preliminary estimates are listed in the table below. The total limestone handling time is estimated to be 360 minutes (6 hours).

Table 8.2-7 Preliminary Estimate of Limestone Handling Cycle Time in the Yard

#	Item	Required Time in Minutes
1	Train arrival and weighing lime, 60 wagons	120
2	Wagon spiriting, 60 wagons set train to two	15
3	Wagon unloading, 30 wagons	90
4	Full loaded wagon shunting	5
5	Locomotive shunting	25
6	The rest wagon unloading, 30 wagons	90
7	Wagon coupling, two 30 wagons set trains in one	15
	Total	360

Note: The item number matches Table 8.2-5

Source: Prepared by the JICA Study Team

2) Gypsum

The expected item and time for gypsum handling as preliminary estimates are listed in the table below. The total gypsum handling time is estimated to be 370 minutes (approx. 6 hours).

Table 8.2-8 Preliminary Estimate of Gypsum Handling Cycle Time in the Yard

#	Item	Required Time in Minutes
1	Empty 50 set wagons arrival	
2	Empty wagon shunting to Line 4	5
3	Locomotive shunting to line 3 attaching loaded wagon	15
4	Weighting gypsum	150
5, 6, 7	Gypsum loading by 10 set wagons	200
	Total	370

Note: The item number matches Table 8.2-6

Source: Prepared by the JICA Study Team

In the Medupi Yard Concept Report, *12 hours train handling time applicable within the yard*[6], and the estimated time is acceptable. It shall be noted that all the figures are for reference only, and the detailed estimation of the time is required for implementation.

8.2.5. Operation Plan

(1) Given Conditions

1) Volume of Commodities to be Carried by Railway

The commodities to be carried are limestone for FGD. The limestone requirement is summarized in the table below.

[6] Medupi Yard Concept Report (2015), pp.13, Eskom

Table 8.2-9 Summary of Six Cases for Lime-Gypsum Process

Purification of Limestone	Spec of Coal/ With / without Gas-Gas heater	Case no.	SO_2 at FGD outlet	SO_2 removal rate	Consumption of Limestone	Crocodile West Water**		Mokolo Water***	
						Water Flow	Effluent	Water Flow	Effluent
			mg/Nm^3	%	kg/h	m^3/h	m^3/h	m^3/h	m^3/h
85%	Design Coal	Case1	384.27	89.22	85,202.38	929.20	72.28	926.34	69.47
	Worst Coal	Case2	396.22	92.95	143,235.88	1,030.31	74.20	1,027.15	71.09
	Worst Coal/Gas-Gas Heater	Case3	389.67	93.14	143,556.27*	1,128.50*	73.99	1,125.04	70.59
96%	Design Coal	Case4	300.18	91.63	75,328.76	933.49	73.24	930.54	70.39
	Worst Coal	Case5	295.32	94.78	125,735.02	1,034.74	75.25	1,031.48	72.09
	Worst Coal/Gas-Gas Heater	Case6	289.08	94.94	125,964.87	1,132.82	75.04	1,129.25*	71.59

*Yellow hatched boxes stand for most consumption in 6 cases.
**Crocodile and Mokolo are the rivers of origin for water resorurce for limestone-gypsum process
Source: Prepared by the JICA Study Team (Based on the data in the Basic Design Study)

In this study, the highest case of limestone volume in the table, i.e., 143,556 kg/h, is used as the required limestone volume for railway transportation subject to be FDG introduced to all six units of Medupi PS. Thus, a rough estimate of 24 tons/hour/unit limestone will be required. The volume of limestone is calculated as follows:

- Required volume of limestone: 1.3 million tons/year
  i.e., 143 tons/ hour x 365 days x 24 hour/day

2) Operation Days in a Year

TFR operates freight railway service 24 hours a day, 7 days a week, except Christmas and Easter holidays (one week each). Furthermore, the permanent way shall be maintained periodically for proper train operation. There are ten days allocated for track maintenance as assumed according to the interview with TFR.

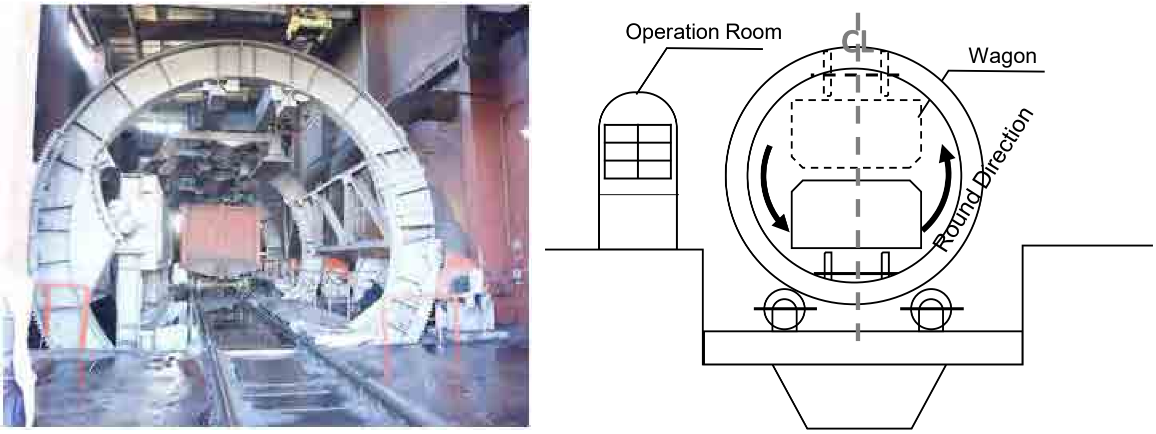
Also, the unexpected suspension due to the accident or limestone shortage in the supply side might be expected; thus, the date is assumed at 10% against the overall date in a year. As a consequence, the operation days is estimated at 300 days in conservative perspective.

- Operation days assumed in a year: 300 days (rounded down in 10 days from 304 days)
  i.e., 365 – 7 days for Christmas – 7 days for Easter – 10 days for track maintenance – 37 days (365 x 10%) for operation suspended due to accidents or limestone shortage.

3) Type of Wagon and Payload

The type of wagon is selected according to the feature of the commodity. According to TFR, the open wagon is common to transport gravel-shaped commodities. On the other hand, the powder-shaped ones need a tank-type wagon to prevent scattering while being transported. In this regard, it would be discussed to carry gypsum as a byproduct of the FGD system since the shape of this has not yet been fixed.

Also, the size of limestone has not yet been fixed since this will be milled at the Medupi FGD site. Therefore, the range of the size can be assumed not to scatter, so the type of wagon is assumed as either hopper wagon or open wagon (Car-type) with rotary car dumper (rotary tripper type; see Figure 8.2-3) for limestone and gypsum transportation. The typical dimensions for open wagon and hopper-type wagon owned by TFR are given in Figure 8.2-4 and Figure 8.2-5, respectively.



Source: Prepared by the JICA Study Team

Figure 8.2-3 Image of Rotary Car Dumper

Key Dimensions:
- Length between coupler: 12 m
- Height: 3.217 m
- Width: 3.0 m
- Tare (average): 20,820 kg
- Maximum Load: 58,000 kg
- Capacity: 67.5 m^3

Source: Prepared by the JICA Study Team, RR Picture Archives.net

Figure 8.2-4 Example of Open Wagon (Car-type Wagon)

Key Dimensions:
- Length between coupler: 12.5 m
- Height: 3.6 m
- Width: 3.0 m
- Tare (average): 20,000 kg
- Maximum Load: 44,000 kg
- Capacity: 66.9 m^3

Source: Prepared by the JICA Study Team, RR Picture Archives.net

Figure 8.2-5 Example of Hopper Wagon

According to the interview with Transnet, major wagons used for limestone transportation are RCD-type wagons. The capacity of a wagon varies by type, e.g., 52–58 tons/wagon for hopper wagon and 63 tons/wagon for RCD-type wagon according to TFR. The specified wagon is not concluded in the design report, and the capacity of the wagon shall be conservative in this stage.

In this perspective, the payload is assumed at 50 tons/wagon since the axle load along the route is 20 tons/axle with four axles as follows:

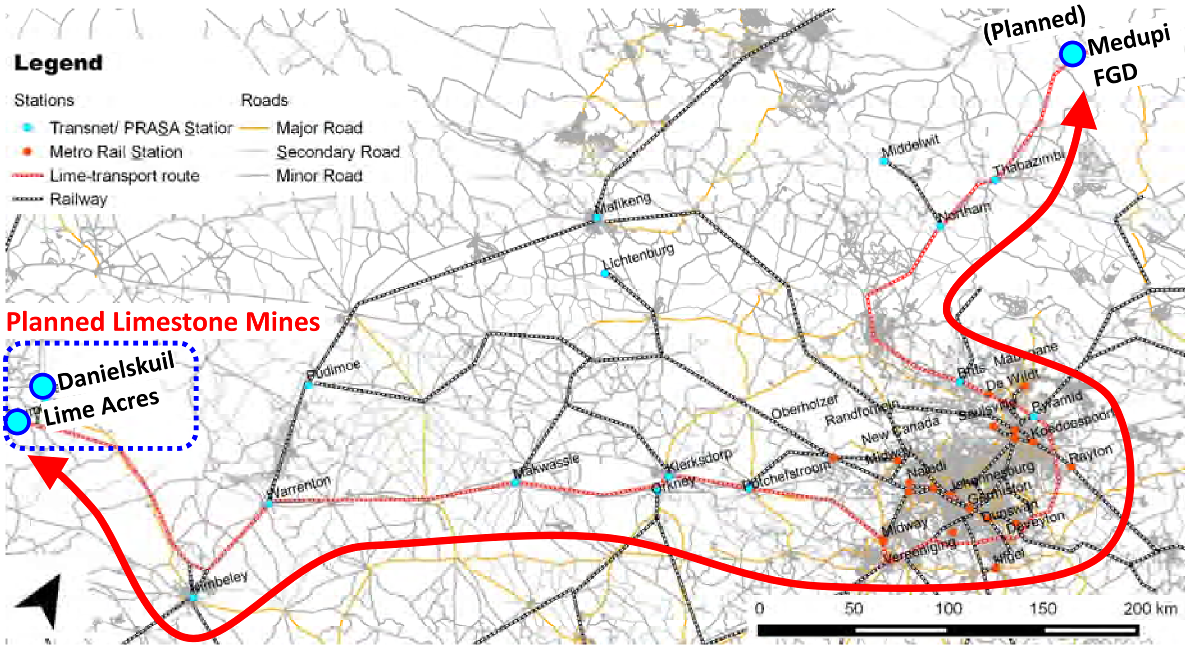
- Payload: 50 tons/wagon
  i.e., 20 tons/axle x 4 axles – 30 tons/wagon for tare load

(2) Operation Plan

In this subclause, the number of trains for lime transportation is discussed. The destination of gypsum as a byproduct has not yet been selected; therefore, the operation plan of gypsum will be discussed.

1) Limestone Transport Route

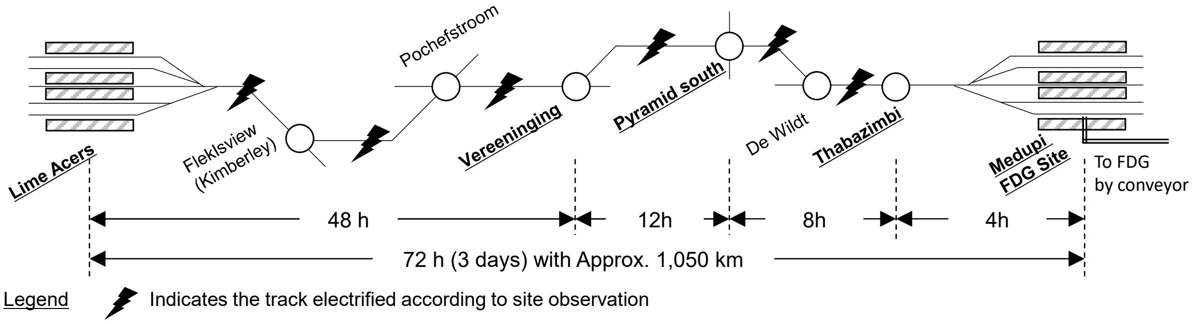
The railway network in South Africa is widely developed with a meter gauge (1,065 mm) for TFR. According to the interview with Eskom, major limestone mines are located in lime acers. The railway network and planned lime transport route are illustrated in the figure below. Freight trains detour the metropolitan area, e.g., Johannesburg, Pretoria, to ensure the line capacity and to mitigate the influence on the environment along the route.



Source: JICA Study Team arranged according to the interview to TFR

Figure 8.2-6 Lime Transport Route Plan (Lime Acers - Medupi FGD Site by Railway)

The schematic route map is shown in the figure below. Although most parts of the route have been electrified, the section between Thabazimbi and Medupi FGD site is not electrified. The total distance between Lime Acer as an origin and Medupi FGD site as a destination is approximately 1,050 km. It takes three days for railway transportation according to Transnet. The breakdown is also summarized in the figure below. It shall be noted that the lead time is a rough estimate only; thus, the details shall be confirmed in further steps.



Note:
1. All are approximate figures only and do not described the actual yard layout in Lime Acers and Medupi FGD site
2. Entire route consists a single track with passing loop introduced and 20 tons axle load designed at least
Source: JICA Study Team arranged according to the interview with TFR

Figure 8.2-7 Schematic Route Map and Lead time

2) Number of Trains per Day

The number of wagons needed per day and the number of trains per day are calculated as follows:

- Number of wagons needed to be carried: 84 wagons
  i.e., 1.3 million tons/year/50 tons/wagon/300 days/ year
- Number of trains per day: 1.4
  i.e., 84 wagons per day/60 wagons set per train
- Applied number of trains per day: 2

Two trains per day are proposed in the project, subject to the FGD introduced to all six units of Medupi PS. This is because: 1) major limestone suppliers are composed of two companies i.e., PPC and IDWARA; 2) according to the interview with PPC, the companies have less capacity to serve the demanded volume of lime (1.3 million tons per year); and, 3) there is a need to recover in case of fluctuation of lime volume.

The number of trains needed for lime transportation by the number of units FDG introduced is summarized in the table below as a reference.

Table 8.2-10 Number of Trains Needed to Carry Limestone by Number of Units FGD Introduced

Number of Units FGD Introduced in Medupi PS	Volume of Lime Needed (million tons per year)	Number of Trains Needed per Day
1	0.21	0.23
2	0.42	0.46
3	0.63	0.70
4	0.84	0.93
5	1.05	1.16
6	1.26	1.40

Source: Prepared by the JICA Study Team

(3) Proposed Train Composition

The number of wagons required is calculated in the last section. The number of wagon set is simply calculated as follows:

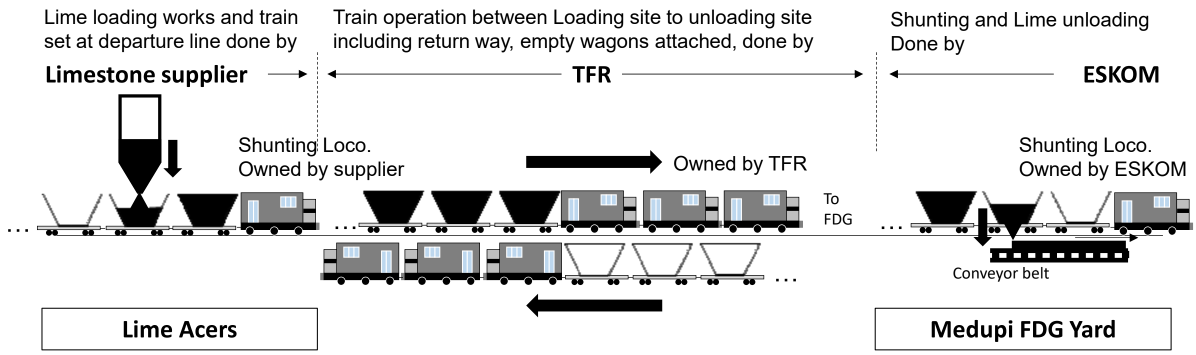
- Number of wagon set per train: 42 = 84 wagons/day/2 trains/day

In South Africa, long trains, such as those with over 100 wagons attached, are operated daily. Obviously, the planned 60-wagon set train can also be allocated as limestone transportation in the main line according to TFR.

(4) Line Capacity

So far, the line capacity has not reached the limit along the route, and there are rooms to allocate some trains (2~3 trains a day) for lime transportation according to TFR. In addition to that, as shown in Figure 8.2-6, there are several alternative routes between Lime Acers and Medupi FGD site. The transport route has not yet been fixed, and the alternative route can be set if line capacity is not enough to transport limestone.

Furthermore, as illustrated below in the operation structure, the railway transport will be serviced by the TFR in charge. All fares except loading/unloading works shall be conducted by the limestone supplier and Eskom, respectively. In this perspective, it is possible to transport 1.3 million tons per year by railway according to the transportation contract between TFR and Eskom.



Note: Number of locomotives is for reference only.
Source: Prepared by the JICA Study Team

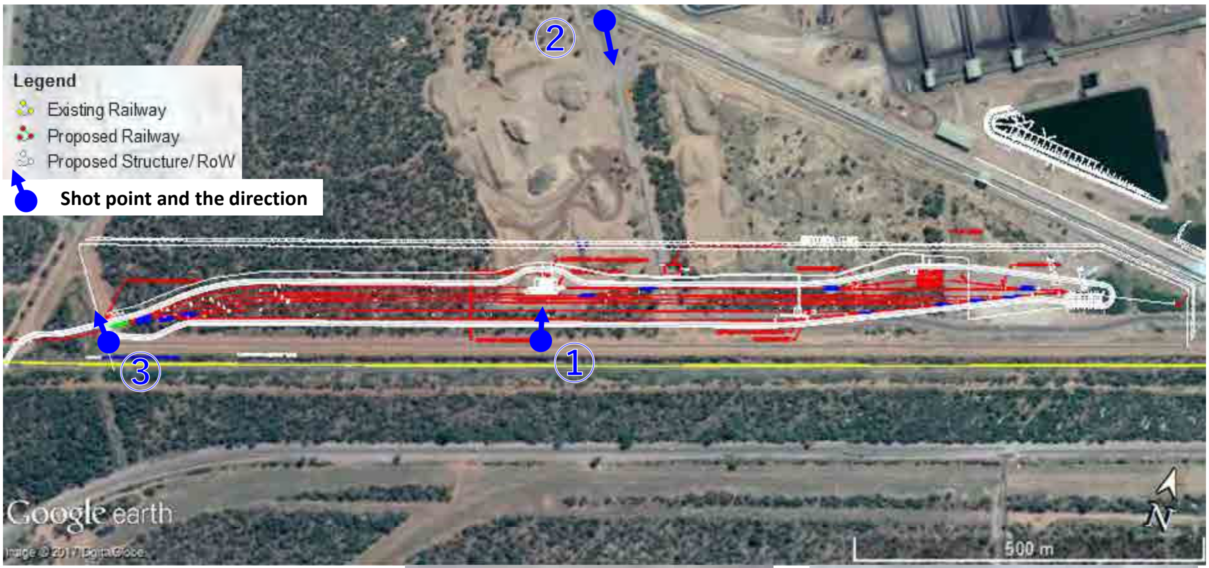
Figure 8.2-8 Demarcation of Lime Transportation of Supplier (TFR and Eskom)

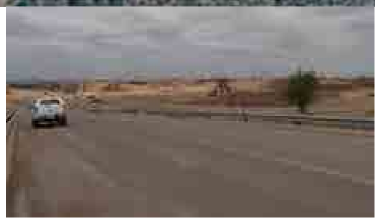
The penalty for not delivering on time is strictly set in the "service design" prepared by TFR, and it will be attached in the contract. In this perspective, it is possible to transport 1.3 million tons per year by railway.

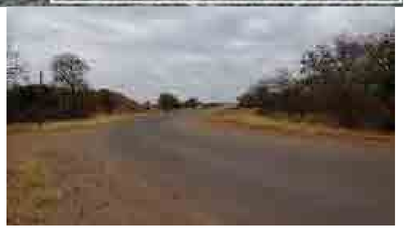
8.2.6. Site Condition

8.2.6.1 Medupi FGD Site

The site condition in the candidate railway yard in Medupi is summarized in the figure below.







1. Yard Construction Site (South) 2. Yard Construction Site (North) 3. Boundary

Source: Google Earth, Eskom, and the JICA Study Team

Figure 8.2-9 Current Condition of Medupi FGD Yard Area, as of September 2017

The candidate site for the yard is located along the existing TFR line. The branch point is approximately 2 km west away from the yard, and it goes parallel with the existing line having approximately 20 m distance and connects the yard.

No structures for the railway yard have been constructed so far. It will provide easy connection from the existing railway line to the candidate yard, and it will be a candidate area located beside the existing line. The area is located inside the right-of-way (RoW) in Eskom, and the foundation shall be arranged by ground cutting/excavation for railway yard use. However, it can be said that the area is appropriate for railway yard in the engineering perspective.

(1) Limestone Loading Site (Lime Acers, PPC)

The site condition of limestone loading located in Lime Acers is shown in the figure below.

Limestone Loading to Wagon Dimension-wised Stockyard Railway Yard Owned by PPC

Source: Taken by the JICA Study Team

Figure 8.2-10 Limestone Loading Site (Lime Acers, PPC) Condition, as of September 2017

It was confirmed that the limestone loaded wagon coupled with 20 wagons and 60 wagons would consist of three 20-wagon sets in the yard owned by PPC. The current maximum loading capacity is 2~3 trains per day, and the loading facility and yard are good enough to serve limestone as far as observation is concerned.

8.2.7. Project Cost of the Railway Yard at the Medupi FGD Site

(1) Overview of Medupi FGD BD

The cost of railway yard construction is summarized in the table below according to Medupi FGD BD. The total railway yard construction cost is ZAR 127 million (USD 12.2 million equivalent).

Table 8.2-11 Summary of Railroad Package and Cost Estimate

Item		Description/Value	
Contract Number		71 Civil Structural Construction and Erection	
		71.0204 Railroad Construction	
Package No.		15	
Cost Breakdown	Material	ZAR 71,118,000	(USD 6,805,550)
	Labor	ZAR 44,615,800	(USD 4,269,455)
	Subcontract	ZAR 124,000	(USD 11,866)
	Equipment	ZAR 11,270,700	(USD 1,078,536)
	Others	ZAR 0	(USD 0)
	Total	ZAR 127,128,500	(USD 12,165,407)
% of Capital Requirement		0.7%	
Total Capital Requirement (Ref)		ZAR 17,677,731,800	

Source: Capital and O&M Cost Estimates (2014), Eskom

8.2.8. Overview of Medupi Yard Concept Report

The summary of expenses of capital expenditures (CAPEX) and operating expenditures (OPEX) are given in Table 8.2-12 and Table 8.2-13, respectively. The CAPEX increased by almost double compared to the Medupi FGD BD, but the breakdown is not given in the report. Therefore, it cannot be determined if the increased amount is appropriate or not.

Table 8.2-12 CAPEX Costing Summary

TOTAL RAILWAY YARD	ZAR		83 420 900,00
RAILWAY YARD INFRASTRUCTURE	ZAR	61 376 900,00	
RAIL WAY YARD (IN-MOTION WEIGHBRIDGE)	ZAR	1 056 000,00	
ROLLINGSTOCK (SHUNT LOCOMOTIVE)	ZAR	20 988 000,00	
TOTAL CIVIL SERVICES and INFRASTRUCTURE	ZAR		104 111 810,00
CIVIL SERVICES	ZAR	104 111 810,00	
TOTAL ELECTRICAL CONTROL & INSTRUMENTATION	ZAR		4 975 000,00
YARD AREA LIGHTING	ZAR	4 975 000,00	
TOTAL STRUCTURAL AND BUILDING SERVICES	ZAR		12 051 250,00
DIESEL LOCO SHED	ZAR	7 391 250,00	
ADMINSTRATION BUILDING	ZAR	3 412 500,00	
SECURITY OFFICE	ZAR	250 000,00	
FUEL STORAGE AND DISPENSING	ZAR	997 500,00	
TOTAL FIRE PROTECTION AND PREVENTION	ZAR		28 200 000,00
FIRE PROTECTION AND PREVENTION	ZAR	28 200 000,00	
TOTAL CAPEX ESTIMATE MEDUPI RAIL YARD AND ASSOCIATED INFRASTRUCTURE	ZAR		**232 758 960,00**

Source: Medupi Yard Concept Report (2015), Eskom

Table 8.2-13 Rail Yard Operating Cost (OPEX)

RAIL OPERATIONS	
DESCRIPTION	Amount (ZAR)
Annual salaries of staff (Train operations only)	2 200 000.00
Annual maintenance cost – shunt locomotive	865 500.00
Annual fuel consumption (36642.86 liters @ ZAR 11 per liter)	403 100.00
ADD CONTINGENCIES (10%)	346 900.00
SUBTOTAL RAIL OPERATIONS	**3 815 500.00**
RAIL INFRASTRUCTURE MAINTENANCE	
DESCRIPTION	Amount (ZAR)
Patrolling (2 x permanent patrolman)	280 000.00
Maintenance	240 000.00
ADD CONTINGENCIES (10%)	52 000.00
SUBTOTAL RAIL INFRASTRUCTURE MAINTENANCE	**572 000.00**
SUMMARY ANNUAL TOTAL OPEX	**4 387 500.00**

Source: Medupi Yard Concept Report (2015), Eskom

Chapter 9 Technical Features and Design Consideration

9.1. Plant Design Consideration

9.1.1. Basis of Design

(1) Unit Performance

Unit performance is the same with the FGD BD report.

The performance basis that an engineering company should comply with is shown in Table 9.1-1.

Table 9.1-1 Performance Basis

Parameter	Value
Ambient Temperature	23.7 °C
Ambient Pressure	91.33 kPa (900 meters ground altitude above sea level)
Ambient Humidity	50%
Fuel Analysis	According to Table 9.1-2
Test Intolerance/Uncertainly	Not allowed
FGD System Pressure Loss	2.5 kPa (10 in. Wc)
Outlet SO_2 Concentration	400 mg/Nm^3 at 6% O_2, dry basis utilizing the worst case coal without attemperating air
Maximum Chloride Level in the FGD Slurry	30,000 ppm

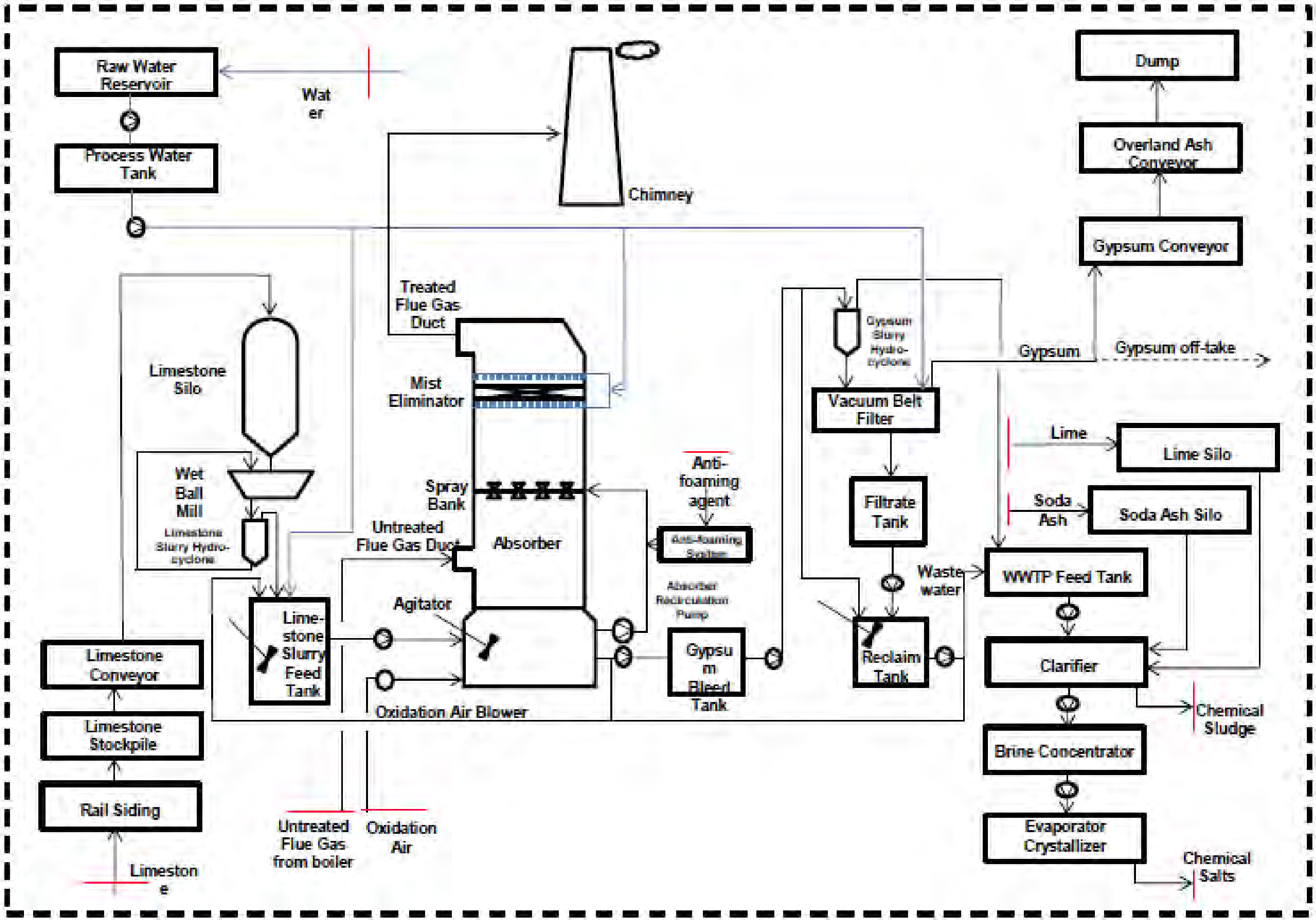
Source: FGD BD Report, Project Design Manual

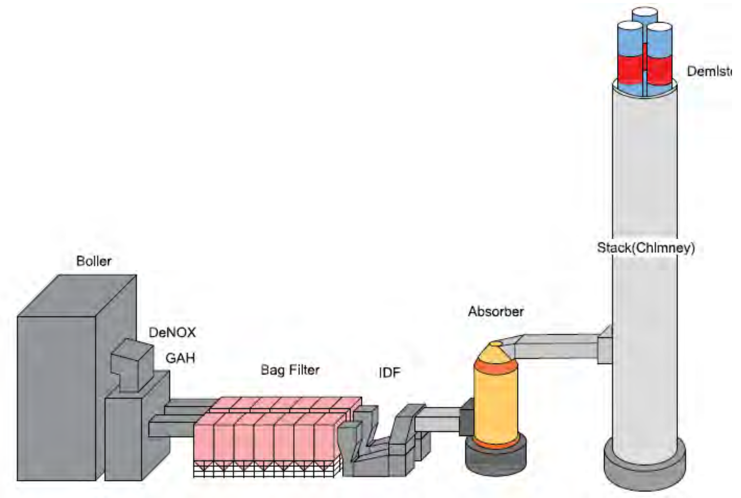
(2) System Descriptions

The system descriptions are the same with the FGD BD report.

The FGD system diagram and the flue gas system diagram after installation of FGD are shown in Figure 9.1-1 and Figure 9.1-2 respectively.

Figure 9.1-1 FGD System Diagram





Source: JICA Study Team

Figure 9.1-2 Flue Gas System Diagram after Installation of FGD

(3) Fuel Specification

The system descriptions is amended with the FGD BD Report.

Coal fuel specification and liquid fuel specification are shown in Table 9.1-2 and Table 9.1-3, respectively.

Table 9.1-2 Fuel Specification (Coal)

Parameters	Unit	Design Basic	Minimum	Maximum
Higher Heating Value (HHV) Air Dried at 25 °C	MJ/kg	20.5	19.0	21.5
Total Moisture	%	10.5	5.0	12.0
Ultimate Analysis Air Dried Basis				
Inherent Moisture	%	2.0	1.5	2.5
Ash	%	35.0	31.0	38.0
Total Carbon	%	50.7	50.3	53.4
Hydrogen	%	3.0	2.4	3.6
Nitrogen	%	1.0	0.7	1.5
Sulfur	%	1.2	0.8	1.8
Carbonates (CO_3)	%	1.1	0.6	1.8
Chlorine	%	<0.1	-	-
Fluorine	%	<0.05	-	-
Oxygen	%	6	5.9	7.6
Total	%	100	-	-
Approximate Analysis				
Volatile	%	25.9	24.1	29.1
Fixed Carbon	%	37.1	37.7	40.6
Physical Property				
Hardgrave Grindability Index		51	45	56
Abrasiveness	mgFe/kg	500	200	500
Coal Size > 100 mm	%	0	-	-
Coal Size > 40 mm	%	5	-	10
Coal Size < 1 mm	%	25	-	35
Coal Burn-out time*	sec	2.3	2.1	2.6
Ash				
Silicon (as SiO_2)	%	57.46	52.69	62.24
Aluminum (as Al_2O_3)	%	26.24	24.03	28.46

Iron (as Fe_2O_3)	%	5.79	4.98	6.61
Titanium (as TiO_2)	%	1.24	1.11	1.36
Phosphorus (as P_2O_6)	%	0.47	0.34	0.6
Calcium (as CaO)	%	3.19	1.9	4.48
Magnesium (as MgO)	%	1.11	0.62	1.61
Sodium (as Na_2O)	%	0.07	0.00	0.29
Sulphur (as SO_3)	%	2.60	1.41	3.79
Manganese	%	0.06	0.04	0.08
Potassium (as K_2O)	%	0.76	0.54	0.99
Ash Characteristics				
Initial Deformation Temperature (Reduction)	°C	N/A	1.25	N/A

Source: FGD BD Report, Project Design Manual

Table 9.1-3 Fuel Specification (Liquid)

Parameters	Unit	Design Basic
Flash point (PMCC) min	°C	60
Water (v/v) max	%	0.5
Sediment (v/v) max	%	0.1
Total sediment in residual fuels by standard aging (v/v)	%	0.1
Viscosity at 50 °C, min	cSt	90
Viscosity at 50 °C, max	cSt	150
Viscosity at 100 °C, max	cSt	20
Conradson carbon residue mass, max	%	15
Ash mass, max	%	0.1
Sulphur mass, max	%	3.5
Copper strip corrosion rating (3 hours at 100 °C), max	-	-
Density at 20 °C, max	kg/m^3	991
Pouring point (winter), max	°C	9
Aluminum, max	mg/kg	30
Silicon, max	mg/kg	-
Aluminum and silicon, max	mg/kg	80
Vanadium, max	mg/kg	400
Iron	mg/kg	50
Acid number	-	Nil
Stability: Accelerated dry sludge, (m/m), max	%	0.1
Stability: Existent dry sludge (m/m), max	%	0.1
Energy content, min	MJ/kg	41

Source: FGD BD Report, Project Design Manual

(4) Water Quality

The water quality for raw water is the same with the FGD BD Report.

The water quality (MCWAP Phase 1: Mokolo Water System) and water quality (MCWAP Phase 2: Crocodile Water System) are shown in Table 9.1-4 and Table 9.1-5, respectively.

Table 9.1-4 Water Quality (MCWAP Phase 1: Mokolo Water System)

Constituent/Water Quality	Unit	Raw Water Maximum	Raw Water Minimum	Raw Water Average	Design Basis
Turbidity	NTU	3.6	0.7	1.5	1.8
Suspended Solid	mg/L	10.0	10.0	10.0	12.0
pH		9.5	6.0	8.1	8.8
Conductivity, K_{25}	μ S/cm	112.3	66.7	88.6	106.3
Alkalinity to pH8.3, P-alk as $CaCO_3$	mg/L	15.0	1.0	5.7	6.9
Alkalinity to pH4.5, M-alk as $CaCO_3$	mg/L	36.9	22.1	31.3	37.6
Total Alkalinity T-Alk as $CaCO_3$	mg/L	50	22.1	32.6	39.1
Magnesium Hardness MgH, as $CaCO_3$	mg/L	22.3	5.0	17.5	21.0
Calcium Hardness CaH as $CaCO_3$	mg/L	36.0	10.1	15.9	19.1
Total Hardness, TH as $CaCO_3$	mg/L	56	18	32	38.5
Sodium, Na	mg/L	15.2	5	6.2	7.4
Potassium, K	mg/L	1.5	1.1	1.3	1.6
Ammonia, NH_3	mg/L	1.5	0	0.6	0.7
Chloride, Cl	mg/L	24.8	5.3	10	12
Sulphate, SO_4	mg/L	3.7	0.5	1.8	2.2
Fluoride, F	mg/L	0.2	0.1	0.1	0.2
Nitrate, NO_3	mg/L	-	-	-	-
Oxygen Absorbed (OA) as $KMnO_4$	mg/L	3.3	1.2	2.3	2.7
Reactive Silica as SiO_2	mg/L	99.2	4.9	15.8	19
Strontium, Sr	μ g/L	90.0	90.0	90.0	108.0
Barium, Ba	μ g/L	20.0	20.0	20.0	24.0
Iron, Fe	μ g/L	5.0	5.0	5.0	6.0
Manganese, Mn	μ g/L	5.0	5.0	5.0	6.0
Boron, B	μ g/L	70.0	20.0	42.5	51.0

Source: FGD BD Report, Project Design Manual

Table 9.1-5 Water Quality (MCWAP Phase 2: Crocodile Water System)

Constituent/Water Quality	Unit	Raw Water Average	Design Basis
Turbidity	NTU	14.3	17.16
Suspended Sloid	mg/L	29	34.8
pH		9	9.1
Conductivity, K25	μ S/cm	792	950.4
P-Alkalinity as $CaCO_3$	mg/L	30.3	36.36
M-Alkalinity as $CaCO_3$	mg/L	208.7	230.44
Total Alkalinity T-Alk as $CaCO_3$	mg/L	208.7	250.44
Magnesium Hardness MgH as $CaCO_3$	mg/L	99.2	119.0
Calcium Hardness CaH as $CaCO_3$	mg/L	107.0	128.4
Total Hardness, TH as $CaCO_3$	mg/L	206.2	247.4
Sodium, Na	mg/L	84.0	100.8
Potassium, K	mg/L	13.0	15.6
Ammonia, NH_3	mg/L	0.36	0.44
Chloride, Cl	mg/L	89.7	107.6
Sulphate, SO_4	mg/L	74.8	89.8
Fluoride, F	mg/L	0.53	0.64
Nitrate, NO_3	mg/L	3.9	4.68
Oxygen Absorbed (OA) as O_2	mg/L	0.94	1.13
Reactive Silica as SiO_2	mg/L	10.9	13.8
Strontium, Sr	mg/L	0.20	0.24

Barium, Ba	mg/L	0.08	0.10
Iron, Fe	mg/L	0.20	0.24
Manganese, Mn	mg/L	0.02	0.02
Boron, B	mg/L	0.27	0.32

Source: FGD BD Report, Project Design Manual

9.1.2. FGD Design and Performance

(1) FGD System Performance

The FGD system performance is the same as the FGD BD Report.

The performance design condition that an engineering company should comply with is shown in Table 9.1-6.

Table 9.1-6 Performance Design Basis (100% BMCR)

Parameter	Unit	Design Basis Design Fuel	Design Basis Worst Fuel (L/G Dimensioning)	Design Worst Fuel with Tempering Air (Absorber Dimensioning)
Maximum Inlet Flue Gas Temp	°C	200	200	200
Inlet Flue Gas Rate	Nm^3/hr, wet	2,427,840	2,495,520	2,814,610
Inlet Flue Gas Temperature	°C	137	137	137
Inlet Flue Gas Pressure Range	kPa	91.62	91.64	91.71
Max Inlet SO2	kg/h	8.262	13.32	13.32
	mg/Nm^3 (dry, mg/Nm^3 at 6% O_2)	3.406	5.339	5.378
Max Inlet PM	kg/h	121.3	124.7	123.85
	mg/Nm^3 (dry, mg/Nm^3 at 6% O_2)	50	50	50
Max Inlet HCl	kg/h	388.3	399.2	396.3

Source: FGD BD Report, Project Design Manual

(2) Specification of Limestone

The specification of limestone is the same as the FGD BD Report.

The specification of limestone that an engineering company should apply on their design work is shown in Table 9.1-7.

Table 9.1-7 Specification of Limestone

Parameter		Design Basis Range Value	Design Basis Value Range
$CaCO_3$	% min	85	96 (94-97)
$MgCO_3$	% Max	-	2.2 (2-3)
SiO_2	% Max	-	2.5 (2-3)
Other Inlet	% Max	-	2 (1-4)
Bond Work Index	kWh/kg Max	12 (11-13)	12(11-13)
Size Range	mm	19×0	19×0

Source: FGD BD Report, Project Design Manual

(3) Requirement for Flue Gas Emission

The requirement for flue gas emission is the same as the FGD BD Report.

The requirement for flue gas emission that an engineering company should comply with is shown in Table 9.1-8.

Table 9.1-8 Requirement for Flue Gas Emission

SO_2	dry Max	mg/NSm^3	400
	Max	ppmdv	136.52
PM total	Removal Efficiency	% min	95
Fine Particulate Matter PM10	Removal Efficiency	% min	50
HCl	Removal Efficiency	% min	98

Source: FGD BD Report, Project Design Manual

(4) Requirement of By-product Quality

The requirement of by-product quality is the same as the FGD BD Report.

The requirement of by-product quality that an engineering company should comply with is shown in Table 9.1-9.

Table 9.1-9 Requirement of By-product Quality

		Design for 85% Limestone	Design for 93% Limestone
$CaSO_4$ $2H_2O$	% min	83	88
$CaSO_3$ $1/2H_2O$	% max	0.12	0.12
Free Moisture	% max	15	15
Water Soluble Chloride	mg/kg max	111	111
Mean Particle Distribution	μ m min	35 (D-50)	35 (D-50)

Source: FGD BD Report, Project Design Manual

(5) Precondition for Civil Design

The precondition for civil design is the same as the FGD BD Report.

However, disclosure of existing boiler foundation to bidder is needed with the adoption of GC, because it is necessary to consider the support for GC with attention against interference between mentioned support and existing boiler foundation.

9.1.3. Code and Standard

The design and specification of work shall be in accordance with applicable South African codes, local codes, and ordinances, Eskom specific codes, or international codes. Where no South African or Eskom specific codes are available, British standard codes will be used. If British Standard Codes are not available, American or international codes will be used.

ASME is available as standard of performance test procedure for FGD.

Available South African codes and Eskom specific codes regarding engineering, procurement and supply of FGD are shown in Appendix 9.1.

9.1.4. Specification of FGD

An EPS contractor shall design, procure, and supply six FGD absorbers in compliance with FGD Design and Performance.

An EPS contractor shall give Eskom loading data and gravity information in order to prepare tender document for civil work within six months from the day of commencement of FGD EPS contract.

9.1.5. Duct Work

An EPS contractor shall design, procure and supply six duct systems in compliance with FGD Design and Performance. The scope is limited between limestone stock yard and limestone silo, design between limestone reclaiming on rail and limestone stock yard is carried out in the scope of another package.

An EPS contractor shall give Eskom loading data and gravity information in order to prepare tender document for civil work within six months from the day of commencement of FGD EPS contract.

9.1.6. Sorbent Handling

An EPS contractor shall design, procure, and supply one common sorbent handling system in compliance with FGD Design and Performance.

An EPS contractor shall give Eskom loading data and gravity information in order to prepare tender document for civil work within six months from the day of commencement of FGD EPS Contract.

9.1.7. Sorbent Preparation and Feed

An EPS contractor shall design, procure and supply one common sorbent preparation and feed system in compliance with FGD Design and Performance.

An EPS contractor shall give Eskom loading data and gravity information in order to prepare tender document for civil work within six months from the day of commencement of FGD EPS Contract.

9.1.8. Civil and Building

(1) Civil

The planned location of the flue gas desulfurization (FGD) retrofit will be around the existing chimney and the foundation of the absorber and the support foundation of the bypass duct will be placed between the existing flue gas duct support foundation. Therefore, it seems that the planar shape of the foundation will make a difference for each unit, but the type of foundation is spread foundation of mat type, reinforced concrete structure basically.

The supporting ground of the foundation is a rock consisting of conglomeratic quartzite and the location of the TPS planned ground height of 902.250 masl to the average depth of 1.26 m is the rock boundary line with the topsoil. The thickness of the foundation is determined from the structural calculations and stability calculations using the equipment load of each equipment, but the foundation is conceivable rock-contact with bedrock basically.

The quantities table of civil engineering work is shown in Table 9.1-10.

Table 9.1-10 Quantities Table of Civil Engineering Work

01	0100	Demolition	
		Demolition	1,993.00 m^3
		01 Demolition	
02		Site Work	
	0200	Site Clearing, General, Mass & Structural Earthwork	228,626.00 m^3
	0210	Site Clearing	122,059.00 m^3
	0260	Excavation Utilities	51,050.00 m^3
	0261	Backfill Utilities	36,500.00 m^3
	0400	Paving & Surfacing	198,937.00 m^3
	0500	Underground Gravity Drains	760.00 m
	0700	Railroad Work	230.00 m
	4120	Fire and Safety Equipment	73.00 ea
		02 Site Work	
03		Foundations & Concrete	
	0230	Excavation Mass	62,423.00 m^3
	0250	Excavation Foundations	90,179.00 m^3
	0251	Backfill Foundations	23,921.00 m^3
	1100	Formwork Setting & Stripping	32,050.00 m^2
	1160	Formwork & False-work for Elevated Concrete	29,077.00 m^2
	1210	Reinforcing Steel for Cast in Place	5,707.97 mt
	1270	Embeded Anchor Bolts	79,775.00 kg
	1310	Concrete Placement for Cast in Place	109,269.00 m^3
	1360	Concrete Placement for Elevated Concrete	5,186.00 m^3
	1370	Mudmats	5,261.00 m^3
	1400	Concrete Finishing & Coatings	2,677.00 m^2
	1600	Precast Concrete	930.00 ea
	2200	Architectural Finishes	8,849.98 m^2
		03 Foundations & Concrete	

Source：Rev. 1 Capital and O&M Cost Estimates Medupi FGD Retrofit Project B&V Project No. 178771 B&V File 25.2000 ESKOM Doc No. 200 - 128137

9.1.8.2 Building

The quantities table of building construction work is shown in Table 9.1-11.

Table 9.1-11 Quantities Table of Building Construction Work

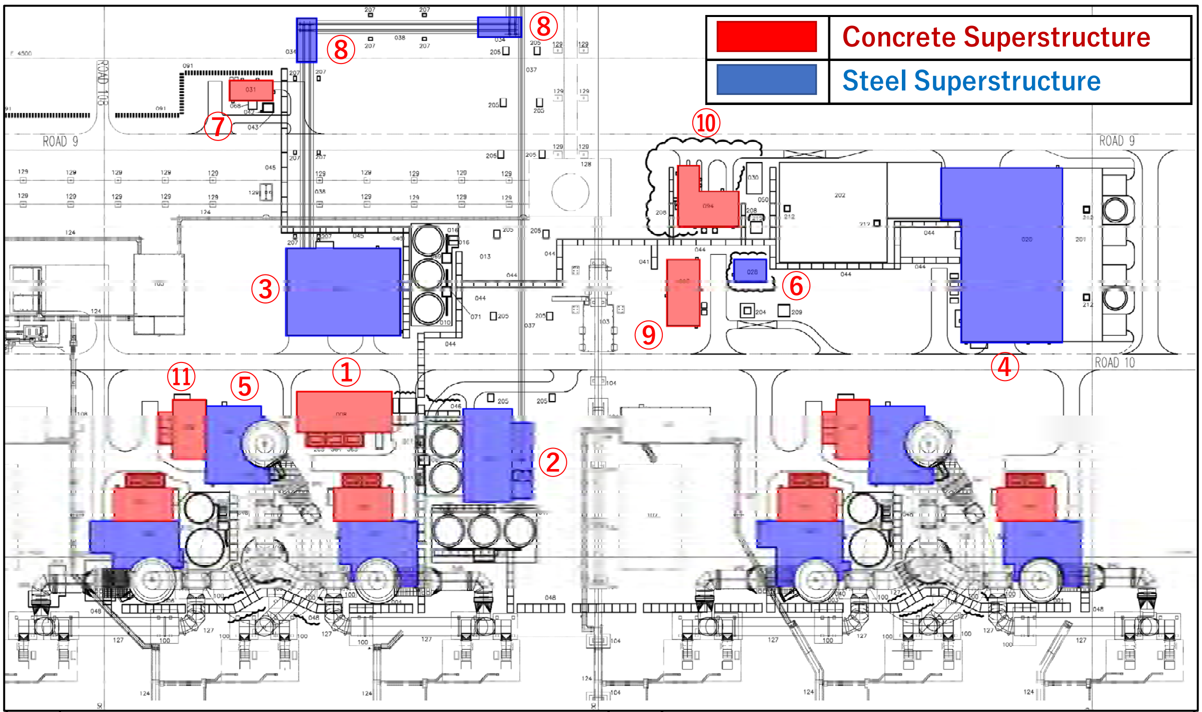
04		Buildings	
	1900	Concrete Misc.	1,524.98 m^2
	2200	Architectural Finishes	4,150.00 m^2
	2220	HVAC	838.00 ea
	4065	AQCS Equipment	1.00 ea
	4067	AQCS Ductwork	
	4120	Fire and Safety Equipment	9.00 ea
		04 Buildings	
05		Steel	
	0600	Site Improvements	100.00 ea
	0611	Site Finishing	100.00 ea
	2240	Siding	23,646.26 m^2
	2250	Roofing	23,786.22 m^2
	2400	Structural Steel Structures	13,270.48 mt
	2600	Misc Steel & Platforming	2,603.56 mt
	2601	Misc. Steel & Platforming	20,658.67 m^2
	2602	Handrail	14,176.73 m
	4067	AQCS Ductwork	944.00 mt
	4110	Material Processing Equipment, Systems and Skids	
		05 Steel	

Source：Rev. 1 Capital and O&M Cost Estimates Medupi FGD Retrofit Project B&V Project No. 178771 B&V File 25.2000 ESKOM Doc No. 200128137

According to the basic design, the superstructure of the building related to FGD retrofit is divided into two types, i.e.: concrete superstructure and steel superstructure.

Substation and common facilities correspond to buildings with concrete superstructures while machinery rooms correspond to buildings with steel superstructure.

Below is a layout of the building according to the superstructure.



①	FGD Common Substation BLDG	⑥	FGD Emergency Generation BLDG
②	Limestone Preparation BLDG	⑦	FGD Makeup Water Pretreatment BLDG
③	Gypsum Dewatering BLDG	⑧	Gypsum Transfer House
④	FGD ZLD Treatment BLDG	⑨	FGD Essential Service Substation
⑤	Unit# Absorber Pump BULDG	⑩	FGD Common Pump BLDG
		⑪	Unit# Absorber Substation

Figure 9.1-3 Layout of the Building According to Superstructure

Chapter 10 Organizational Structure of the Project

10.1. Current Organizational Situation of Eskom

10.1.1.1 Organizational Legislations of Eskom

(1) General

Eskom was converted into a state-owned enterprise as Eskom Holdings Limited, based on the terms of the Eskom Conversion Act 13 of 2001, which took effect on 1 July 2002. The sole shareholder of Eskom is the Government of the Republic of South Africa represented by the Minister of Public Enterprises. As a government-owned enterprise, management of Eskom is guided by the following legislations:

- Code of Corporate Practices and Conduct contained in the King Report on Corporate Governance for South Africa 2002 (King II Report)
- Protocol on Corporate Governance in the Public Sector 2002
- Companies Act 71 of 2008
- Public Finance Management Act 1 of 1999, as amended by Act 29 of 1999 (PFMA)

(2) Labor, Employment, Health, and Safety

Eskom operates in compliance with the following labor, employment, health and safety laws.

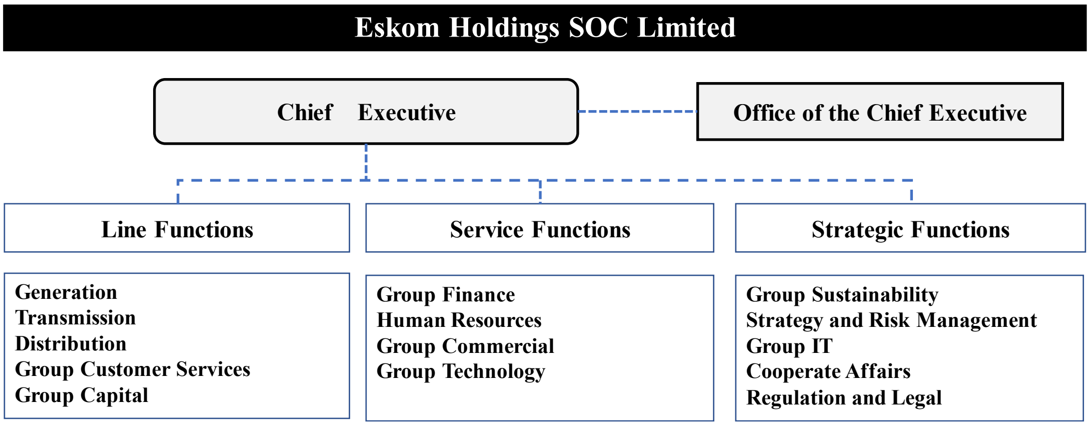
- Labor Relations Act 66 of 1995 (LRA), amended in 2002 by the Labor Relations Amendment Act, 2002
- Basic Conditions of Employment Act 75 of 1997 (BCEA), amended in 2002 by the Basic Conditions of Employment Amendment Act 2002
- Employment Equity Act 55 of 1998 (EEA)
- Skills Development Act 97 of 1998 (SDA)
- Unemployment Insurance Act, 2001 (UIA)
- Occupational Health and Safety Act 85 of 1993 (OHSA)
- Compensation for Occupational Injuries and Diseases Act 130 of 1993 (COIDA)

10.1.2. Organization Structure of Eskom

(1) Whole Organization Structure

The Eskom Group consists of the Eskom Holdings SOC Limited and a number of operating subsidiaries. Eskom Holdings SOC Limited has three major functional groups. They are the line functions that operate the business, the service functions that provide operation service, and the strategic functions that develop the enterprise. The group's head office is based in Johannesburg, although operations are across South Africa, with administrative offices in most major centers.

The organizational structure of Eskom is indicated below although the structure is to be revised to incorporate the recent appointments and changes[1]. Project organization for the construction of FGD at the Medupi TPS will be under the Group Capital Division, while the groups that oversee the operation and maintenance of current operating units and FGD in the future are under the Generation Distribution Division in the whole picture of the organizational structure of Eskom.



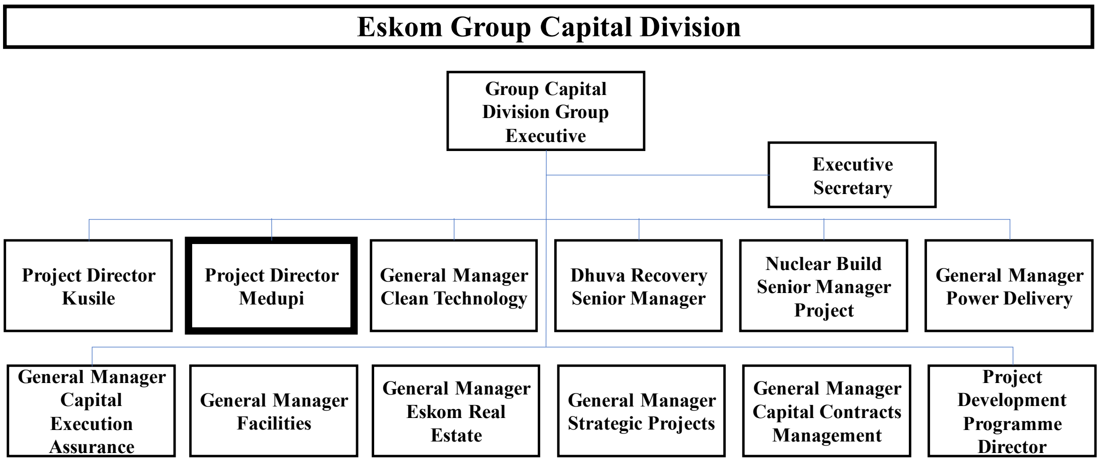
Source: Prepared by the JICA Study Team based on the *Eskom Integrated Report 2015*

Figure 10.1-1 Whole Organizational Structure of Eskom

(2) Organizational Structure of Group Capital Division

The mandate of the Group Capital Division is to create a center of excellence in the allocation and monitoring of all capital expenditures from a group level and in the planning, development, monitoring, and execution of mega projects. The project director of the Medupi Project is under the command of the Group Executive of the Group Capital Division.

[1] The organizational structure shown as Figure 10.1-1 is based on the information of *Eskom Integrated Report 2015*. It was confirmed that there is no change in the organizational structure at the time the JICA Study Team interviewed with Eskom personnel in November 2017.

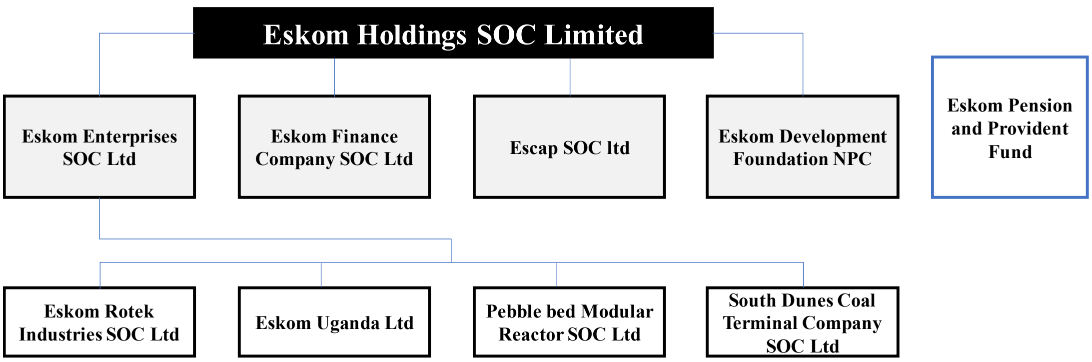


Source: JICA Study Team based on the information provided by Eskom

Figure 10.1-2 Organizational Structure of Group Capital Division

(3) Subsidiaries

Eskom has several subsidiaries. The Eskom Enterprises SOC Limited group provides lifecycle support and plant maintenance, network protection as well as support for the capacity expansion program for all Eskom Holdings SOC Limited divisions. Eskom Enterprises that operates primarily in South Africa provides operation and maintenance service to Medupi TPS as well. It has two subsidiaries that have interest in electricity operations and maintenance concessions in Mali, Senegal, and Mauritania as well as in Uganda. Eskom Finance Company SOC Limited grants home loans to Eskom employees. Escap SOC Limited, Eskom's wholly owned captive insurance company, manages and insures Eskom's business risk. The Eskom Development Foundation NPC is a wholly owned non-profit company that manages Eskom's corporate social investment. Major subsidies are indicated in Figure 10.1-3.



Source: JICA Study Team based on the *Eskom Integrated Report 2017*

Figure 10.1-3 Major Subsidiaries of Eskom

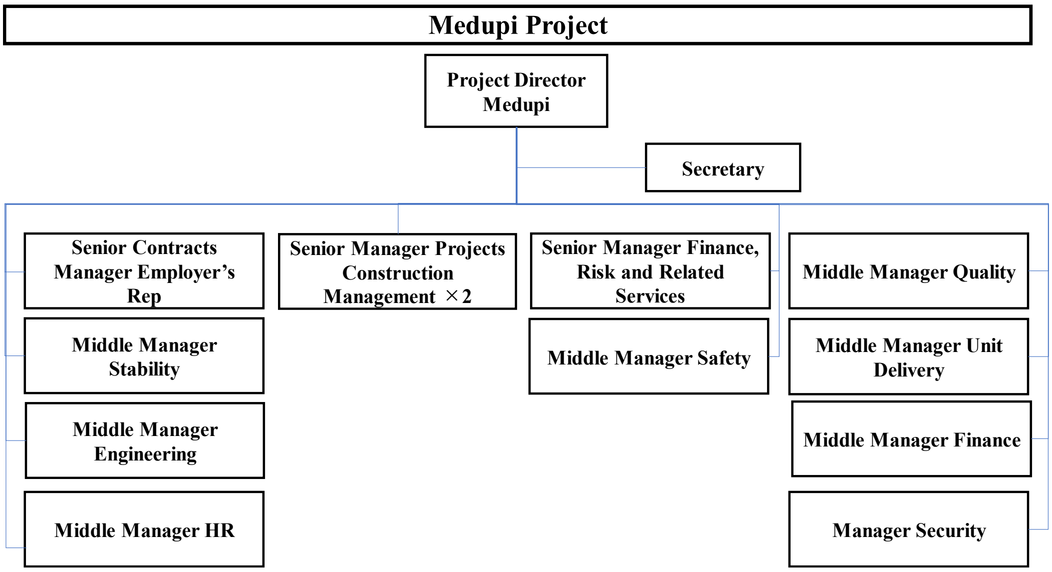
(4) Organizational Structure of Medupi TPS

At the site of Medupi TPS, the construction of units is taken care of by the team of the Medupi Project, while the operation and maintenance are overseen by the Generation Division.

1) Medupi Project

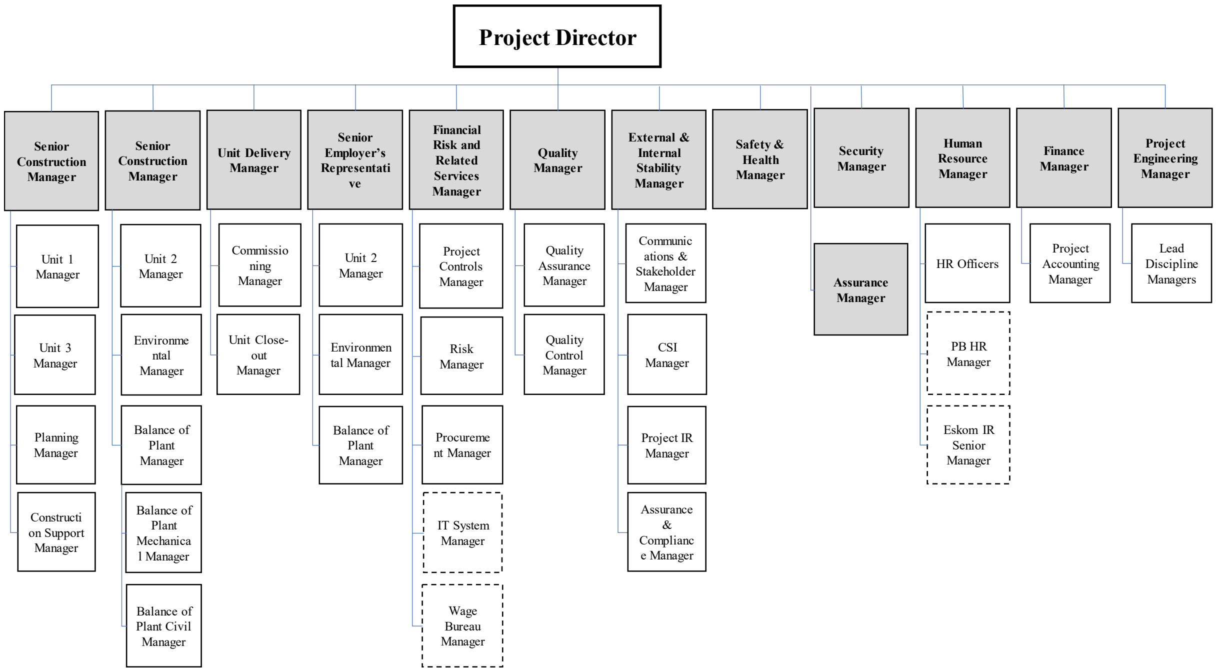
(A) Organization

The organization structure of Medupi Project is shown in Figure 10.1-4. Although the following organization structure was confirmed when the JICA Study Team interviewed with Eskom in November 2017, and the organization structure may be changed as a result of further consideration within Eskom.



Source: JICA Study Team based on the information from Eskom

Figure 10.1-4 Organizational Structure of Medupi Project



Source: Eskom

Figure 10.1-5 Organizational Structure of Medupi Project

(B) Staff Composition

The staff composition of Medupi Project is shown in Table 10.1-1.

Table 10.1-1 Staff Composition of Medupi Project

Discipline / Functional Area	Permanent	Fixed Term Contract	Third Party Contractors	Total
Construction Management	69	40	42	151
SHEQ	11	47	126	184
Project/Site Services, CSI	16	67	29	112
Contract Management	38	30	78	146
Project Controls	4	8	4	16
Commissioning	18	2	-	20
Engineering	83	2	21	106
Other Eskom Secondments	9	-	-	9
Finance	14	1	-	15
Commercial and Procurement	6	1	-	7
Human Resources	4	2	1	7
Trainees and Learner Artisans	62	-	-	62
Total	**334**	**200**	**301**	**835**

Source: Eskom

2) Generation Division at Medupi TPS

(A) Overview

a) Functional Groups

The Generation Division at Medupi TPS consists of three major functions, i.e.: Core Groups, Support, and P/Line. Although there are several groups under Core Groups, Operating Group, Maintenance Group, and Engineering Group play major roles in running the TPS. The organizational structure of the Operating Group, Maintenance Group, and Engineering Group is shown in Figure 10.1-6.

Distribution Division at Medupi Power Station

CORE GROUPS	SUPPORT	P/LINE
PSM Office Operating Maintenance Engineering Risk Management Coal Management Environmental Management FTC (Documentation)	Finance HR & EAL Commercial MM Medical Centre Fleet Management Protective Services	Pupil Tech (Maint/Eng/Chem) Interns LPO University Bursars

Source: JICA Study Team based on the information from Eskom

Figure 10.1-6 Functional Groups of Generation Division at the Medupi TPS

b) Staff Composition

The staff composition of Generation Division at the Medupi TPS is shown in Table 10.1-2.

Table 10.1-2 Staff Composition of Generation Division at the Medupi TPS

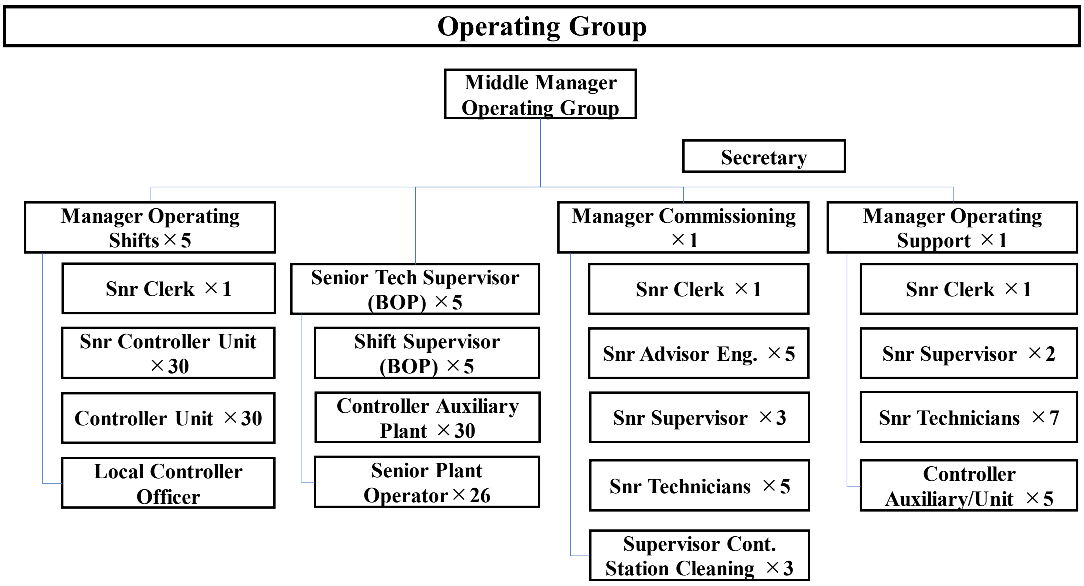
Function	Group	Actual	Signed Off OrganizationStructure	Actual Total	YED Projection
Core Groups	PSM Office (excl. PSM)	1	1	287	307
	Operating	121	145		
	Maintenance	50	66		
	Engineering	81	110		
	Risk Management	15	26		
	Coal Management	5	8		
	Environmental Management	3	3		
	FTC (Documentation)	10	-		
Support	Finance	7	12	92	-
	HR and EAL	2	8		
	Commercial	9	15		
	MM	7	15		

Function	Group	Actual	Signed Off OrganizationStructure	Actual Total	YED Projection
	Medical Center	1	2		
	Fleet Management	3	3		
	Protective Services	62	62		
P/Line	Pupil Tech (Maint./Engr/Chem)	13	20	59	-
	Interns	8	10		
	LPO	7	7		
	University Bursars	31	30		

Source: Eskom

(B) Operating Group

The organizational structure of Operating Group is shown in Figure 10.1-7.



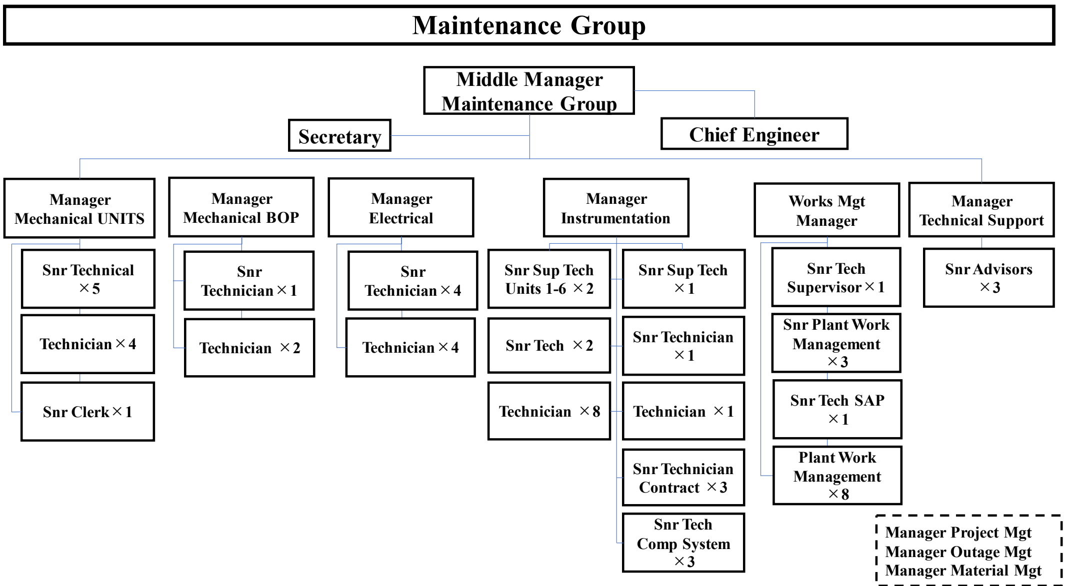
Note: The figures show the number of personnel

Source: JICA Study Team based on the information from Eskom

Figure 10.1-7 Organizational Structure of Operation Group at the Medupi TPS

(C) Maintenance Group

The organizational structure of Maintenance Group is shown in Figure 10.1-8.



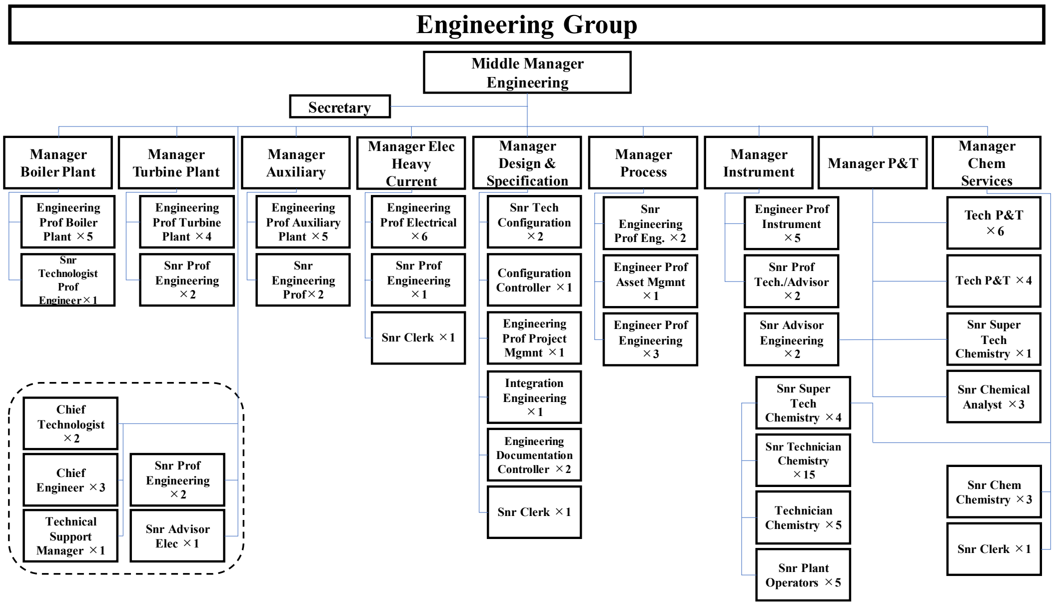
Note: The figures show the number of personnel

Source: JICA Study Team based on the information from Eskom

Figure 10.1-8 Organizational Structure of Maintenance Group at the Medupi TPS

(D) Engineering Group

The organizational structure of the Engineering Group is shown in Figure 10.1-9.



Note: The figures show the number of personnel

Source: JICA Study Team based on the information from Eskom

Figure 10.1-9 Organizational Structure of Engineering Group at the Medupi TPS

10.1.3. Organization for Operation and Maintenance

The staff composition for the commercial operation of Unit 6, Unit 5, and Unit 4 at the Medupi PPP, as of October 2017 is shown in Table 10.1-3.

Table 10.1-3 Staff Composition for Units 6, 5, and 4 Commercial Operation (October 2017)

Position	Required	Unit 6 Actual	Unit 5 Actual	Unit 4 Actual	Vacancy
Shift Manager	5			5	0
Snr Controller	15	5	5	5	0
SPO Boiler and Turbine	15	5	5	5	0
EOD LCO	5			5	0
SPO EOD	5			5	0
Supervisor BOP	5			5	0
Controller BOP	5			5	0
Controller BOP/Plant	5			5	0
Coal	3			3	0
Chemistry	15			27	0
Commissioning	5			8	0
Total	**83**			**98**	**0**

Source: Eskom

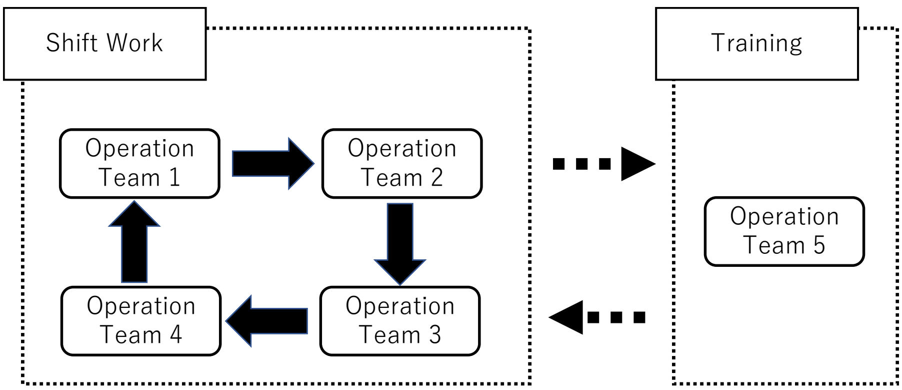
10.2. Organization for FGD on the Existing Plant

10.2.1. Kusile Power Station Case

(1) Organizational Set-up for Operation

At the Kusile Power Station, two FGDs are operated by a team consisted of one controller and one field operator. As of November 2017, when the JICA Study Team conducted site survey, although only Units 1 and 2 were in operation at the Kusile Power Station, the number of personnel required for the operation will be six (2 personnel × 3 teams) eventually after all the six FGDs are installed. It is assumed that the operation of FGD will be conducted by five shifting teams (four teams are in shifting work and another team is in training). After 12 hours of work by a team of six personnel, another team takes over the operation. Therefore, the number of personnel required for FGD operation is 6 personnel × 5 teams = 30 personnel. The overview of the operation structure of FGD at the Kusile Power Station is shown in Figure 10.2-1.

Cluster	Unit	Operations Team（per team）	
Cluster 1	FGD Unit 1 FGD Unit 2	Controller (1) Field Operator (1)	
Cluster 2	FGD Unit 3 FGD Unit 4	Controller (1) Field Operator (1)	
Cluster 3	FGD Unit 5 FGD Unit 6	Controller (1) Fielded Operator (1)	
Total		Controller (3) Field Operator (3)	6 personnel



Source: JICA Study Team based on the information provided by Eskom

Figure 10.2-1 Organization Setup for Operation at the Kusile Power Station

(2) Organization Setup for Maintenance

The Kusile Power Station has a special maintenance team that is responsible for FGD only. Maintenance of units and common equipment is conducted by other maintenance teams separately.

(3) Training for Operation and Maintenance of FGD

Technical personnel from GE-Alstom is currently at the FGD operation control room at the Kusile Power Station and provides technical guidance to Eskom personnel. There is an FGD operation simulator for the training purpose and thus, operators can learn and practice FGD operations by using it.

10.3. Organization of the FGD Installation under the Project

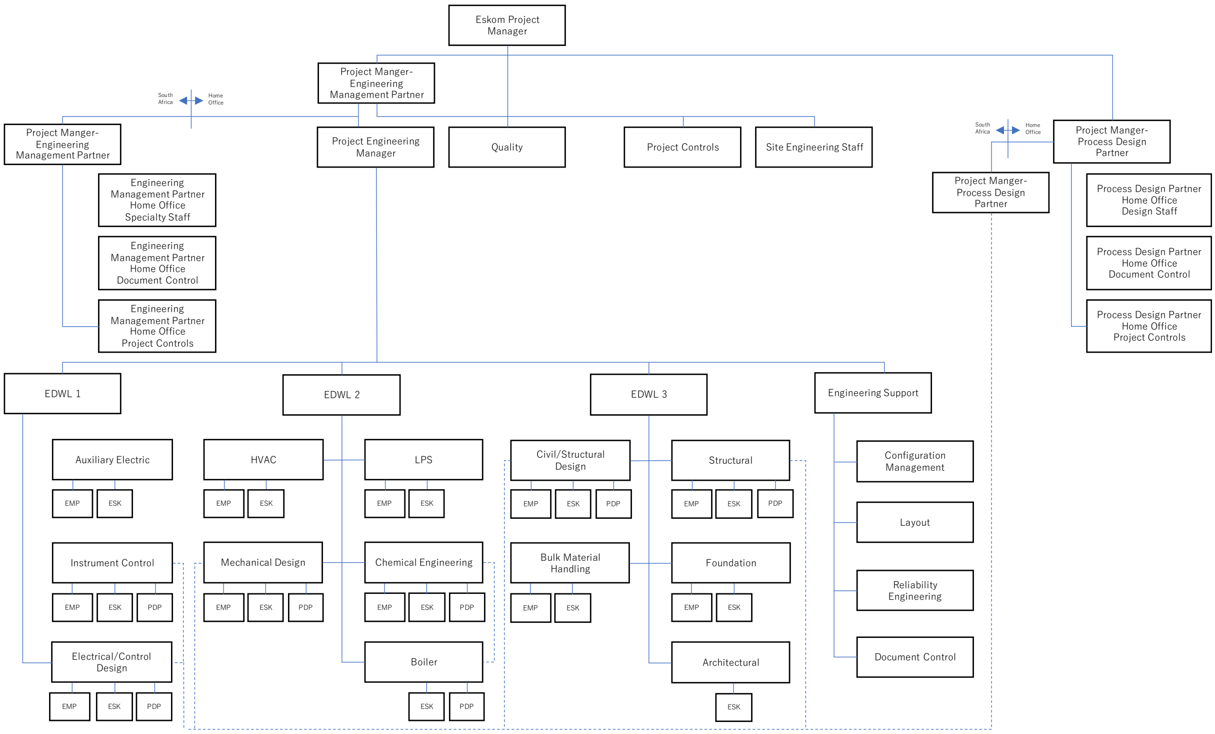
Since there are still many indeterminate factors at the stage of this preparatory survey regarding FGD installation, it is difficult to elaborate on the detailed project organization set-up, operation and maintenance organization structure, and their staffing at this moment. Therefore, in the following sections, firstly, the basic design is reviewed and then describe the current situation which was clarified through an interview with Eskom during the preparatory study period, and matters to be considered follow.

10.3.1. Project Organization Set-up

(1) Review of Basic Design Report[2]

It is assumed that the Project will be executed by a team led by Eskom and process design and engineering management will be supplemented by design partners that are to be determined prior to the commencement of the Project. Figure 1.3-1 is the project organization chart shown in the Medupi FGD BD.

[2] Project Execution Plan, Medupi FGD Retrofit Project (2014), Eskom



Source: Project Execution Plan, Medupi FGD Retrofit Project (2014), Appendix B, Eskom

Figure 10.3-1 Project Organization Chart

(2) Evaluation of the Project Organization Set-up in the Basic Design Report

According to Eskom, there is no intention of formulating a project organization structure following the idea indicated in the Basic Design Report, and the project organization structure will be formed based on the standard method of Eskom for the project. As a matter to be noted with regard to the project organization set-up, the current assumption of the time frame of the project is 84 months (about seven years) from the preparation stage of the loan agreement (LA) to the completion of the trial operation test at the site, and thus, the project organization set-up will also need to be changed according to the stage of the project. Special attention needs to be paid on the following points in this regard.

- The project organization set-up assumed by Eskom seems to be mainly for the construction stage. Project organization set-up needs to be planned taking into consideration that the necessary organization set-up will be varied in the course of project process from the launch of the project, design, procurement, construction, and to the handing over to operation and maintenance.

- It is recommended to clarify the decision-making methods and processes related to matters that may affect the entire project, such as project scope and schedule change. Responsibilities of each person in charge need to be cleared as well.

- It is assumed that three to four teams are formed and the construction work is carried out in parallel to shorten the construction period during construction stage. Since the project management will be complicated in this case, so it is necessary to consider an appropriate project organization set-up carefully in advance.
- The establishment of a Project Implementation Unit (PIU) that oversee the project implementation at the site should be considered[3].

(3) Current Plan for the Project Organization Set-up

1) Project Organization Set-up

As of December 2018, a number of people, including the project director, have been appointed concurrently with or exclusively for the Medupi Power Station Construction Project for this project. According to a hearing with Eskom, it is assumed that outside consultants will be hired in the future when there are no internal personnel available at Eskom headquarters, Medupi, and the Kusile Power Station and personnel required within Eskom. According to the interview with Eskom, a standard organizational system is set up for launching the project, and this FGD project will also be organized according to the standard.

2) Internal Governance Set-up within Eskom

Medupi FGD Project will be positioned under the Group Capital Division[4] of the whole Eskom's organization structure[5] and its Project Director is supposed to report to the Group Capital Executive. In case there are issues concerning major changes in the design, scope, schedule, and so on of the Project, the issue is firstly reported to the Group Capital Executive from the Project Director. Then it will be discussed by the Division Committee of Group Capital, Capital Committee chaired by Finance Division, and the Investment Committee for official approval and/or decision making as a corporate body. Investors relations will be handled by the treasury under the Group Finance.

[3] Refer to Figure 10.3-2

[4] There are two groups under Group Capital Division: "Project Development" and "Construction Management". FGD project will be positioned in the "Construction Management".

[5] Refer to Figure 10-1-1 Organization Structure of Eskom.

(4) Matters to be Considered

1) Establishment of a Project Steering Committee (PSC)

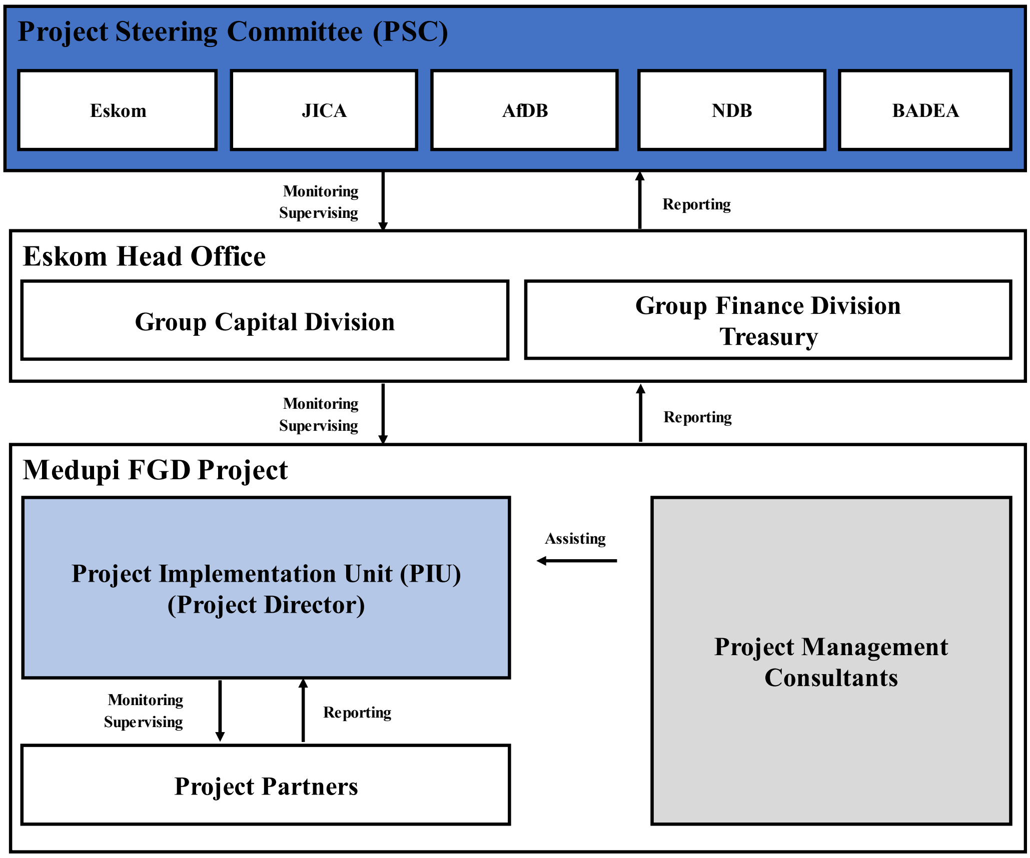
The Medupi FGD BD does not mention about the establishment of a Project Steering Committee (PSC) for the FGD Project. Concerning this, the basic idea of Eskom is that the FGD Project will be implemented without such a special body on top of the project implementation organization. However, given the fact that the Project is assumed to be implemented by funds provided by Japanese official development assistance (ODA) loan and co-financing of Japan International Cooperation Agency (JICA), African Development Bank (AfDB), New Development Bank (NDB), and Arab Bank for Economic Development in Africa is considered, it is required that all stakeholders that are in a position to oversee Eskom and fund providers get together and confirm the progress, share issues, and take actions if necessary in a coordinated manner to solve them. From this point of view, the JICA Study Team recommends the establishment of a PSC with the aim of smooth and stable progress of the Project. The outline of PSC is as follows:

Table 10.3-1 Overview of PSC

Role and Responsibility	a) To oversee the implementation of the Project in conformity with the Project's objective and scope. b) To assist in coordination among relevant ministries and agencies involved in the Project implementation. c) To monitor the progress of all outputs of the Project. d) To monitor the risk and issues, which may affect smooth implementation and outcome of the project and lead necessary countermeasures to be taken. e) To provide guidance and direction toward the implementation of the Project.
Committee Members	・ Eskom ・ JICA ・ African Development Bank (AfDB) ・ New Development Bank (NDB) ・ Arab Bank for Economic Development in Africa (BADEA)
Meetings	・ Once in half a year and any necessity arisen.

Source: JICA Study Team based on the Minutes of Discussions on Flue Gas Desulphurization Retrofit Project for Medupi Coal-fired Power Station between Eskom Holdings SOC Ltd. and Japan International Cooperation Agency, Annex II Main Points Discussed

Figure 10.3-2 shows the recommended organization structure of project organization set-up.



Source: JICA Study Team

Figure 10.3-2 Recommended Project Organization Setup

2) Employment of Consultants[6]

The *Guidelines for the Employment of Consultants under Japanese ODA Loans* (2012) mentions the necessity of the employment of consultants to be discussed between the Borrower and JICA, and the Terms of Reference (TOR) for their services will be determined, either prior to or during the negotiations on Japanese ODA loans. Although the selection of consultants is the Borrower's responsibility, at the same time, the Borrower is subject to international rules for ODA by consulting with JICA as to the selection procedures to which the Borrower can advance. Although Eskom side recognizes the necessity of hiring consultants, on the other hand, the method of selection of consultants, the term of reference (TOR) of their task, and the position in the project organization are not necessary in the common understanding between JICA side and Eskom side. Hence, it is urgently required to deepen the common understanding concerning the employment of consultant between both parties. Currently, Eskom is in a comprehensive consultancy contract with Steinmüller Engineering and Black & Veatch, and both companies are providing consultancy service not only for the projects at Kusile Power Station and the Medupi TPS, but also for other projects as well. Regarding the employment of consultant for the FGD Project, careful attention should be paid to the relationship with these consultancy companies.

[6] Employment of Consultant is described in Chapter 12.

The general consultant's service in ODA loan project is shown in Table 10.3-2.

Table 10.3-2 Services of Consultants

Preparation services (i) Detailed investigations and review of pre-investment studies; (ii) Preparation of detailed designs, specifications, and contract documents; (iii) Pre-qualification of contractors, suppliers, or manufacturers; (iv) Evaluation of bids and recommendations regarding award of contract; and (v) Studies and/or provide recommendations related to environmental and social matters, including implementation/review of environmental impact assessments.
Implementation services (i) Supervision of construction work; (ii) Technical and administrative services for the implementation and management of the project; and (iii) Studies and/or provide recommendations related to environmental and social matters, including environmental management, monitoring and audit.
Assistance in the start-up of facilities and operation Assistance in the operation and maintenance of the facilities after the project completion and the start-up of facilities and their operation for an initial period.
Other services necessary for the project (i) Advisory services, in connection, for example, with national and/or sectorial development plans and institution building; (ii) Assistance in implementation of recommendations, post-evaluation, and impact studies of the project; and (iii) Other borrower support services.

Source: Guidelines for the Employment of Consultants under Japanese ODA Loans (2012), pp.23-24, JICA

10.3.2. Engineering Stage

(1) Review of Basic Design Report[7]

1) Scope of Work under Engineering Stage

The scope of engineering work during the execution phase will include all tasks to finalize the design, support the development of technical procurement specifications, integration engineering between procurement packages, review and coordination of the detailed design provided by various contractors, and the detailed design of selected portions of the Project. The engineering work for the execution phase will include:

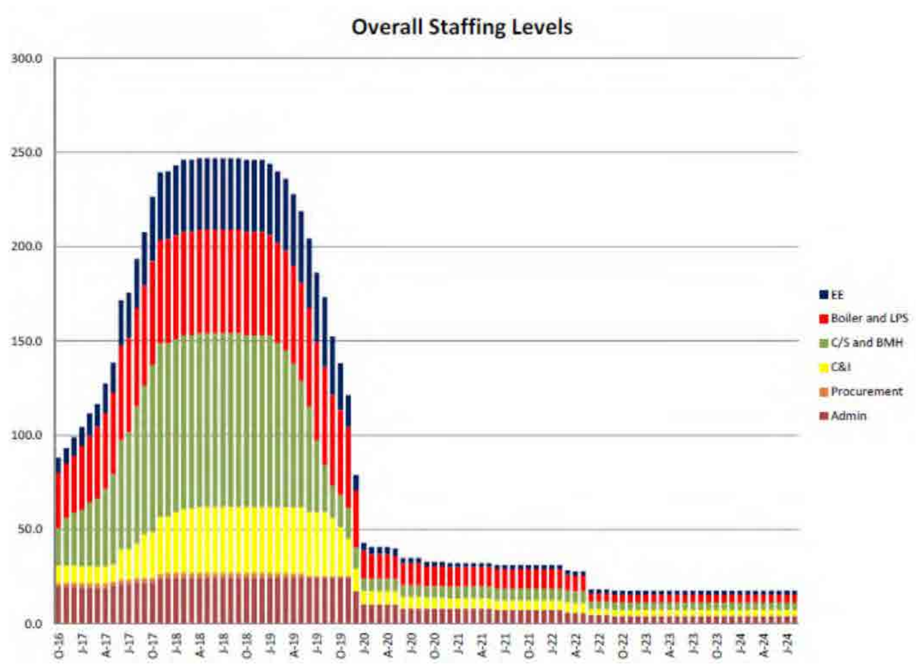
[7] Project Execution Plan, Medupi FGD Retrofit Project (2014), Eskom

- Design Engineering
  - Process Engineering
  - Civil-Structural Design Engineering
  - Bulk Materials Handling Engineering
  - Mechanical Design Engineering
  - Chemical Design Engineering
  - Electrical Design Engineering
  - Instrumentation and Control Design Engineering
  - Eskom Arrangement Design
  - Engineering Completion
- Engineering Deliverables List
- Equipment and Construction Procurement Specifications
- Bid Evaluation and Negotiation Support
- Design Reviews of Vendor Submittals and Fabrication and Construction Drawings
- Construction Support
- Startup and Commissioning Support
- Engineering Work to be Performed by Others

2) Organization Set-up during Engineering Stage

Medupi FGD BD[8] assumes that the Project will start with 88 full-time equivalent (FTE) personnel and the number of staff will reach a peak of 247 FTE by month 19 from the commencement of the Project. The required number of staff stabilized to around 30 after 38 months, and then around 20 in the latter stage of the Project. Since the work load at the initial design stage is huge, a lot of personnel will be required to engage in the Project in the first half of the Project.

[8] Project Execution Plan, Medupi FGD Retrofit Project (2014), p.4-25, Eskom



Source: Project Execution Plan, Medupi FGD BD, p.4-25, Eskom

Figure 10.3-3 Required Staff Assumption (Engineering)

(2) Current Plan for the Project Organization Set-up for Engineering Stage

Through the interview with Eskom, it was confirmed that there was no change in the basic idea about staffing in the design stage. Meanwhile, since detailed work items are to be considered and prepared in the design document prepared prior to the approval of the execution release approval (ERA), it is undecided how to divide these tasks and proceed the work receiving assistance from external design partners at current timing of this preparatory survey.

(3) Matters to be Considered

1) Appropriate Project Management

As mentioned above, at the design stage, a large number of personnel including not only Eskom staff but also external contractors (consultants) will be engaged in this Project. It is required to share the latest progress and issues among stakeholders always by several means such as holding regular meetings with the participation of all the project stakeholders, disseminating information by e-mail from the Project Implementation Unit (PIU), and so on. Also, since it is assumed that the volume of design document will be huge, it is necessary to have proper documents control system.

2) Skill Development on FGD Design

Although Eskom already has an experience in FGD installation at the Kusile Power Station, FGD is the new technology for Eskom staff. In this regard, it is required to have a system that engineers of Eskom can acquire knowledge and skill on FGD through engagement in this Project. Although the support from external contractors is assumed at the design stage, skill development of Eskom engineers on FGD needs to be considered at the same time.

10.3.3. Construction Stage

(1) Review of Basic Design Report[9]

1) Scope of Work under Engineering Stage

The Construction Project Management Team is led by a Site Project Manager (SPM) who maintains the overall responsibility for the Project. The Project Manager will oversee the discipline managers consisting of Industrial Relations Manager, Contracts Manager, Engineering Manager, Support Service Manager, HSE Manager, QA/QC Manager, Controls Manager, and Start-up Manager. The primary responsibilities of the Construction Project Management Team are[10]:

- Coordinate the construction activities between the construction contractors and engineering and procurement;
- Manage/administer the progress payment determination and approval for construction contracts;
- Manage/administer the receiving and warehousing of equipment and materials furnished to the construction contractors;
- Manage/administer an overall project site safety and loss control program, including safety, security, insurance, and fire/medical facility management;
- Manage/administer the overall site services program, including common facilities, cleanup, and maintenance;
- Perform overall project construction scheduling and cost control, including overall integrated construction CPM schedule;
- Manage/administer an overall project construction QA and control program. Eskom Group Technology – Engineering;
- Manage/administer an overall project construction environmental management plan and performance assurance program;
- Report status, progress, cost, and schedule to Eskom management;
- Manage/administrate overall project industrial relations including project stabilization agreement requirements;
- Manage/administrate plant start-up and commissioning program including turnover of systems and unit to Eskom operation staff;
- Project labor relations administration as follows:
  - Administer a project labor stabilization program
  - Promotion of labor harmony
  - Enforcement of uniform project work rules

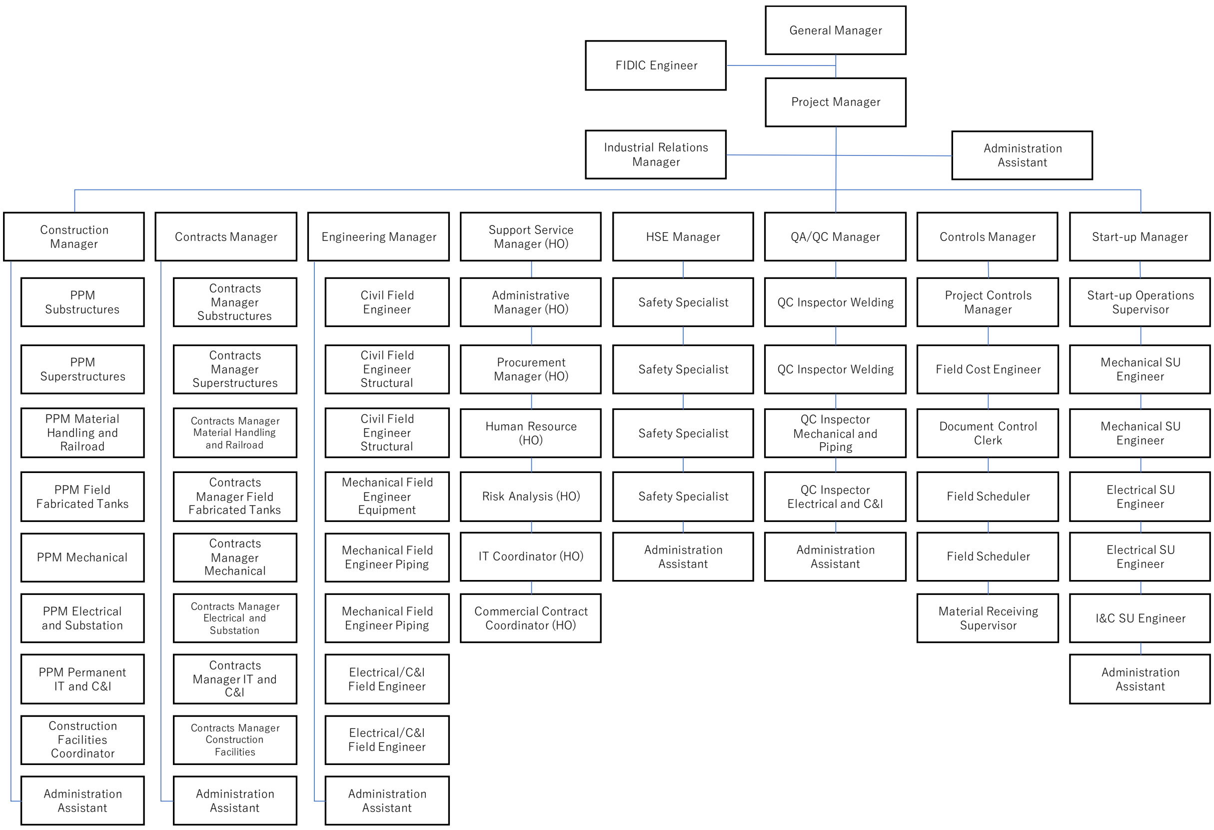
9 Construction Execution Plan, Medupi FGD Retrofit Project (2014), Eskom
10 Construction Execution Plan, Medupi FGD Retrofit Project (2014), pp.33-34, Eskom

- Maintain contact and communication with local labor leaders and representatives
- Participate and conduct regularly scheduled labor/management meetings
- Inform project management personnel of any labor related impact issues or problems; and
- Ensure that the stabilization program is properly communicated and followed by all contractors and project personnel.

2) Organization Set-up for Construction Stage

(A) Construction Management (CM) Team

The site construction management staff will consist primarily of Eskom personnel appropriated from the Medupi Project and from various Eskom departments. Eskom may contact third-party entities to fill positions that cannot be staffed internally. Figure 1.3-4 below is the Construction Project Management Team organization as shown in the Medupi FGD BD.



Source: Construction Execution Plan, Medupi FGD Retrofit Project (2014), Appendix C, Eskom

Figure 10.3-4 Construction Project Management Team Organization

(B) Construction Labor Execution Plan

It is estimated that approximately 1,250 workers are required at peak at the site. The CM Team and Industrial Relations Manager (IR Manager) will work together with the contractors to attract qualified labor to the Project and increase workers' motivation.

(2) Current Plan for the Project Organization Set-up for Engineering Stage

According to interviews with Eskom, it is planned that three or four construction teams are organized to shorten the construction period by proceeding construction work in parallel. The concrete organizational set-up, contract with external contractors, and the plan for labor recruitment are not decided and planned at the stage of this preparatory survey.

(3) Matters to be Considered

1) Safety Control, Quality Control, and Labor Management

At the construction stage, thorough safety management and quality control are required as a lot of labor will work in parallel at the site. It is necessary to have a mechanism to ensure all workers always have high awareness about safety and quality by having a training program not only at the start of the project but also by having it regularly during the project. Also, special attention needs to be paid to workers environment by building good relationships with labor through regular labor-management meetings, etc. This is effective for prevention of strikes by labor and the delay of construction schedule.

2) Communication among Stakeholders

At the construction stage, many workers will be engaged in on-site work. It is required to establish a mechanism that enables the latest progress and issues are shared by stakeholders at all times. Once an issue is identified, it is required that all stakeholders work together to solve the issue. It is also important to share accidents cases that occurred in the past at the construction stage among stakeholders and prevent similar troubles in advance.

3) Smooth Handover to Operation and Maintenance Team

To realize smooth turnover of FGD systems to operation and maintenance team, operation and maintenance personnel should be assigned from the plant start-up and the commissioning stage at the construction stage.

10.3.4. Operations and Maintenance Stage

(1) Review of Basic Design Report[11]

1) Scope of Work under Operation and Maintenance Stage

The FGD process is operated in each boiler unit and common system control room by FGD operators. In addition to the FGD process control by FGD operators, equipment control has to be done by inspectors by going around FGD plant and check the equipment.

(A) FGD Process Control

At the Medupi TPS, one control room is associated to each boiler unit. In addition to six control rooms, there is a control room for common system. Suppose that the FGD system adopts the same operation control structure, the respective systems to be operated at the unit control room and common control room and operators' responsibility are shown in Table 10.3-3.

Table 10.3-3 FGD Unit Specific System and FGD Unit Operator's Responsibility

Unit Control Room × 6		
FGD Unit Specific System		**FGD Unit Operator's Responsibility**
■ Absorbers ■ Absorber recycle pumps ■ Absorber bleed pumps ■ Oxidation air blowers ■ Process water pumps ■ Control of flue gas path dampers ■ Flue gas duct temperatures and pressures ■ Agitators ■ Reagent distribution	➡	● Overall supervision of the unit-specific equipment mentioned above ● Interaction with the inspectors for the respective cluster ● Absorber level control ● Absorber pH control ● Absorber density control ● Limestone feed to Absorbers ● Bleed pump and inlet valve control ● Oxidation air control ● Mist eliminator wash tank level control ● Mist eliminator wash sequences

Source: Project Operations and Maintenance Staffing Plan, Medupi FGD Retrofit Project (2014), pp.5-6, Eskom

[11] Project Operations and Maintenance Staffing Plan, Medupi FGD Retrofit Project (2014), Eskom

Table 10.3-4 FGD Common System and FGD Common System Control Operator's Responsibility

Common Control Room		
FGD Common System		**FGD Common System Control Room Operator's Responsibility**
■ Limestone storage silos ■ Limestone feeders ■ Ball mills ■ Reagent storage tanks ■ Reagent distribution pumps and common header ■ Reagent area sumps ■ Reclaim water pumps ■ Gypsum conveyors ■ Vacuum belt filters ■ Filter feed tanks ■ Wastewater treatment ■ Wastewater pre-treatment and post-treatment sludge removal ■ FGD/ZLD equipment cooling ■ ZLD equipment	➡	● Overall supervision of the unit specific equipment mentioned above ● Interaction with the inspectors for common systems ● Ball mill grinding water flow control ● Ball mill density control ● Reagent feed tank level control ● Filter feed pump pressure control ● Chloride bleed control ● Reclaim water tank level control ● Reclaim water pressure control ● Cake thickness control ● Cake wash flow control

Source: Project Operations and Maintenance Staffing Plan, Medupi FGD Retrofit Project (2014), pp.5-6, Eskom

(B) FGD Equipment Control

The following listed FGD equipment are subdivided into parts and further into single parts. They are maintained by inspectors and metalworkers regularly according to the maintenance plan to be developed. The main task of the inspector is the visual inspection of parts, as well as fasting checks, oil liquid level control, leakage control, position control or abrasion control. Tasks of metalworkers include installation of spare parts, oil changes, local lubrications or service flushing. In addition to the tasks of inspectors and metalworkers, there should be tasks that need to be conducted by suppliers such as exchange of motor or impeller of pumps.

Table 10.3-5 FGD Equipment for Inspection and Maintenance

■ Flue Gas Dampers for Absorber 1-6	■ Limestone Slurry Hydro-cyclone
■ Absorber 1-6	■ Vacuum Belt Filter 1-5
■ Emergency Drain Tank 1&2	■ Filtrate Receiver 1-5
■ Gypsum Bleed Tank 1&2	■ Vacuum Pump 1-5
■ Reclaim Tank 1&2	■ Filtrate Separator 1-5
■ Process Water Tank 1-3	■ Cloth Wash Tank 1-5
■ Limestone Slurry Feed Tank 1&2	■ Cake Wash Tank 1-5
■ Limestone Ball Mill Weight Belt Feeder 1-3	■ Filtrate Tank 1&2
■ Limestone Wet Ball Mill 1-3	■ Wastewater HC Feed Tank 1&2
■ Limestone Ball Mill Circulation Tank 1-3	■ Wastewater Hydro-cyclone 1-2

Source: Project Operations and Maintenance Staffing Plan, Medupi FGD Retrofit Project (2014), pp.7-8, Eskom

2) Operation and Maintenance Structure

(A) Operation Structure

Supposedly, the FGD system operation adopts the same operation control structure of units, one FGD unit operator will be attached to each six units control room and two FGD common system operators will be attached to the common system control room.

(B) Maintenance Structure

In addition to the operators in unit process control, inspectors and metalworkers are necessary for the maintenance of FGD equipment. Medupi FGD BD assumes that the following numbers of staff are required for each cluster and for the common system for continuous operation of the Medupi FGD Plant.

- Two inspectors for each absorber cluster (Cluster 1: Unit 1, Unit 2, Unit 4 /Cluster 2: Unit 3, Unit 5, Unit 6) (day and night shift)
- One inspector for remaining FGD equipment (day and night shift)
- One or two metalworks (night shifts when necessary)

Figure 10.3-5 shows the overview of the control room structure and the required number of staff for operation and maintenance.

Source: Project Operations and Maintenance Staffing Plan, Medupi FGD BD, p.4, Eskom

Figure 10.3-5 Operation and Maintenance Structure

(2) Evaluation of the Operation and Maintenance Structure in the Basic Design Report

The operation and maintenance structure of FGD proposed in the Basic Design Report was considered before the operation of FGD commenced at Kusile Power Station. As noted in the Basic Design Report, the suggested operation and maintenance structure is considered without maintenance manuals that normally prepared by FGD manufacturers, and thus, its description is quite general. While presupposing that operation and maintenance structure in the Basic Design Report was considered under such limited circumstances, further consideration is necessary for the following points:

- Number of control room (one control room is associated to each unit / one control room is associated to some units)
- Composition of operation team and shifting schedule (including training shift)

(3) Current Plan for the Staffing of Operation and Maintenance of FGD

Although the interview with Eskom did not indicate the current plan for operation and maintenance organization set-up, it was mentioned that the organization set-up for the operation and maintenance of FGD at the Kusile Power Station would be a reference. Unlike the organization set-up shown in the Medupi FGD BD, if the organization set-up of Kusile Power Station is adopted, a team consisting of one controller and one field operator will oversee two FGD absorbers. Concerning the maintenance of FGD, supposedly, the organization set-up of Kusile Power Station is adopted, a special maintenance team will be established which will be responsible for FGD maintenance only apart from the unit's maintenance team.

Eskom has accumulated experience of operation and maintenance of FGD at the Kusile Power Station and it is a more realistic option to follow the operation and maintenance structure of Kusile Power Station at the Medupi Power Station rather than following the structure proposed in the Basic Design Report. Currently, only one FGD is in commercial operation at the Kusile Power Station. The FGD operation at the Kusile Power Station seems to be smooth, and no technical and/or administrative concern is found in the discussion with the personnel in charge at the plant. On the other hand, it should be noted that since the FGD at the Medupi Power Station is scheduled to commence commercial operation sequentially from 2023 to 2025, it is necessary to consider systematic and gradual FGD operation and maintenance staff development and establishment of organization structure (including staff recruitment as necessary). Once the design of the FGD is fixed, it will be possible to consider more specific operation and maintenance structure and its staffing. It is recommended that discussion about operation and maintenance structure and its staffing plan is started at the early stage of construction stage with the operation and maintenance team at the Medupi Power Station.

(4) Matters to be Considered

1) Technical Support from Plant Manufacturer

Even after commercial operation of FGD is commenced, technical support from the plant manufacturer is necessary until its operation becomes stable. For this reason, it is required to clarify the condition of initial support service from plant manufacturer in the contract. It is preferred that plant engineers stay at the site for several months to several years, in order for them to provide technical guidance of the FGD operation and maintenance to the operation and maintenance staff.

2) Accumulation of Operation and Maintenance Skills inside Eskom

The basic idea of Eskom is that the operation of FGD is carried out by internal Eskom personnel and maintenance is outsourced to the external contractors. However, if Eskom relies too much on external contractors for maintenance, it would be difficult to accumulate knowledge and experience of the maintenance of FGD in Eskom internally. Eskom has several subsidiaries under its umbrella, among which Eskom Enterprise SOC Limited supports plant maintenance at several sites. It is an option that such subsidiary is utilized for the maintenance of FGD at Medupi TPS in order to accumulate knowledge and experience on FGD maintenance in Eskom internally.

10.4. Recruitment and Human Resource Development Plan for Operation and Maintenance of FGD

(1) Review of Basic Design Report[12]

1) Basic Strategy for Staff Training and Skills and Knowledge Transfer

It is planned that Eskom and its contracted design partner jointly develop key objectives for knowledge and skills transfer to be achieved at the commencement of the Execution Phase. After the objectives are defined, the details for implementation plan will be developed and documented in a written Skills and Knowledge Transfer Plan. Skills and Knowledge Transfer Plan will identify the competency objectives, methodologies (classroom and/or mentored learning), individual assessment plans, program coordination plan, and program reporting requirements. The following items will be included in the Skills and Knowledge Transfer Plan[13]:

- Contractor Training of Eskom Staff:
  - Operator training
  - Maintenance training
  - Engineering training at local and overseas locations
  - The number of trainees, time of training, and places of training are stated in the equipment specifications
- Training Plans and Schedules
- Safety Training
- Environmental Training
- QA/QC Training
- Lean Construction Training
- Craft Training
- Supervisor Training
- Management Training
- Industrial Relations Training
- Other Training

2) Additional Required Personnel for Operation and Maintenance of FGD

Based on the common industry practice, it is estimated that the number of staff additionally required for the operation, maintenance, and supervision of FGD is 89[14]. This number includes the personnel for FGD absorber unit, FGD common equipment including limestone receiving/uploading area, limestone preparation area, gypsum dewatering area, gypsum storage area, ZLD area, and ZLD solids waste disposal.

[12] Project Execution Plan, Medupi FGD Retrofit Project (2014), Eskom
[13] Construction Execution Plan, Medupi FGD Retrofit Project (2014), p.97, Eskom
[14] Capital and O&M Cost Estimates, Medupi FGD Retrofit Project (2014), Eskom

(2) Current Human Resource Development Plan for Operation and Maintenance of FGD

1) Recruitment of Staff for Operation and Maintenance of FGD

As mentioned above, it is estimated that the number of additional personnel required is 89 in the basic design. According to Eskom, there is no concrete plan for the recruitment of additional personnel at the stage of this preparatory survey. Eskom's basic idea is to carry out FGD's operation by Eskom personnel and maintenance work to be done by external contractors. Regarding operation, future consideration is needed if it can be covered by existing Eskom operation personnel or recruitment of additional staff is needed.

2) Training of Staff for Operation and Maintenance of FGD

In Kusile Power Station, technical personnel of GE - Alstom resides and provides technical guidance of FGD operation to Eskom operators. Likewise, at the Medupi TPS, FGD operators and maintenance personnel including contractors are assumed to have technical guidance from engineers dispatched by suppliers of FGD.

(3) Matters to be Considered

1) Sharing of Operation and Maintenance Experience of FGD at Kusile Power Station

Operation and maintenance of FGD at Kusile Power Station is commenced already prior to the Medupi TPS, and knowledge, skills, and lessons on FGD operation and maintenance learned at the Kusile Power Station should be shared with operation and maintenance team at Medupi TPS. From this point of view, it is an option that FGD operation and maintenance team personnel at Kusile Power Station provides technical guidance based on their own experience to the operation and maintenance team at Medupi TPS. Past troubles related to operation and maintenance occurred at the Kusile Power Station should be shared at Medupi Power Station to prevent the same.

2) Human Resource Development for Continuous Operation and Maintenance of FGD

In order to secure human resources related to the operation and maintenance of FGD in Eskom, continuous effort for human resources development is necessary. With cooperation from FGD plant makers, continuous capacity strengthening is required through the development of a systematic training course for FGD operation and maintenance and provision of regular training courses to FGD operation and maintenance staff including external contractors. In the future, it should also be considered that operation and maintenance team personnel at Kusile TPS and Medupi TPS become an instructor and teach his/her knowledge and skill on FGD operation and maintenance to junior staff.

10.5. Operation and Maintenance Cost[15]

(1) Estimated Number of Additional Labor

Based on the common industry practice, it is estimated that the number of permanent personnel additionally required for the operation, maintenance, and supervision of FGD is 89[16]. This number includes the personnel for FGD absorber unit, FGD common equipment including limestone receiving/uploading area, limestone preparation area, gypsum dewatering area, gypsum storage area, ZLD area, and ZLD solids waste disposal. It is a basic idea of Eskom that operation is undertaken by the permanent staff of Eskom while maintenance is outsourced, although the concrete number of contract labor provided by subcontractor(s) for maintenance is not necessarily estimated at the timing of preparatory survey by the JICA Study Team.

(2) Estimated Annual Cost for Additional Labor

Based on the number of additionally required permanent personnel estimated in the Basic Design Report, the estimated cost for permanent plant personnel will be ZAR 44,429,000 per year (average approximately ZAR 500,000 per person per year). While the contract labor cost is estimated based on the utility industry experience at 0.50% of direct capital cost that results in ZAR 88,389,000. The summary is shown in Table 10.5-1.

Table 10.5-1 Summary of Annual Labor Cost for Operation and Maintenance

Annual cost for permanent plant personnel	ZAR 44,429,000
Annual cost for contract labor	ZAR 88,389,000
Annual total cost for operation and maintenance	ZAR 132,818,000

Source: JICA Study Team based on the estimation of capital and O&M cost estimates, Medupi FGD Retrofit Project (2014), Eskom

[15] Operation and maintenance cost herein is only the labor cost. Other operation and maintenance cost are described in Chapter 13 Financial and Economic Analysis.
[16] Capital and O&M Cost Estimates, Medupi FGD Retrofit Project (2014)

Chapter 11 Environmental and Social Consideration

11.1. Outline of the Project

11.1.1. Project Component

The Medupi TPS has an installed generation capacity of 6 x 800 MW units and utilizes a super critical boiler and turbines technology designed to operate at higher temperatures and pressures, which allows for maximum efficiency of the power station. Medupi TPS has a design lifespan of 50 years. The six units at Medupi TPS have been designed and constructed to accommodate the installation of wet limestone FGD technology which is an SO_2 abatement technology.

The FGD system comprises the common plant and unitized plant. The common plant includes a limestone stockpile, gypsum dewatering plant, gypsum storage building, raw water pre-treatment building, wastewater plant, etc. Each of the six units will require its own absorber unit, absorber pump house, and absorber substation.

Input materials (reagents) are untreated flue gas, process water, oxidation air and limestone. The limestone is brought in by means of rail (initially track) and is delivered to the rail siding from where it is collected, handled and stockpiled until used in the FGD system. Outputs from the FGD process include the treated flue gas which is released to the atmosphere, gypsum (which will be dewatered) and wastewater. The wastewater will be treated, and the clean water will be re-used in the plant. By-products of the water treatment process (salts and sludge) will be disposed of in an appropriately lined facility. During the electricity generation process the coal will be combusted and sulphur within the coal will form SO_2. In addition to FGD infrastructures, waste disposal facilities (the existing ash disposal facility will be used as waste disposal (ash and gypsum) facility), rail yard sidling and the water pipeline from the off-take point on the MCWAP Phase 2 pipeline to FGD facilities are designed as main facilities.

11.1.2. Project Location

The Medupi TPS is located about 15 km west of the town of Lephalale in Limpopo Province. Refer to Figure 11.1-1 for the satellite map indicating the position of the Medupi TPS within the Lephalale municipal area. The power station is situated on about 883 hectares that was historically operated as a game and livestock farm, (Medupi TPS Environmental Impact Assessment (EIA) Report, Bohlweki, 2005)

Medupi TPS is placed about 580 km far from the nearest coast, Maputo, Mozambique. Thus, water needs to be secured from river or underground water for operation. The nearest tributary of the Limpopo River flows about 19 km west from the power station and the mainstream of the river is approximately 40 km away. In terms of water right of the Limpopo River, the river flows on borders with Botswana, Mozambique, and Zimbabwe.

Regarding fuel supply, coal field and mining sites are located nearby the site so that there will be no problem on supply. The surrounding area of the power station is grassland. Marapong Village is placed about 7 km northeast from the Medupi TPS, and is the nearest residential area.

Source: The JICA Study Team

Figure 11.1-1 Location Map of Medupi TPS

11.2. Baseline of Environmental and Social Conditions

11.2.1. Environmental and Social Status

(1) Environmental Conditions of the Project Site in Medupi TPS

Environmental and social baseline status of the study area is summarized in Table 11.2-1.

Table 11.2-1 Summary of Environmental and Social Status in Lephalale

Items	Description
Pollution	
Air Quality*1 and 2	Lephalale has been identified as a priority area for atmospheric emissions (DEA; 2012). The location of the Medupi Monitoring Station and the result of NOx, SO_2, O_3 and PM levels at this station in 2016 are shown in Figure 11.2-1, Figure 11.2-2, Figure 11.2-3, and Table 11.2-2, respectively. The main sources of air pollution are transportation activities, industrial production, construction, and livelihood such as Matimba TPS, Medupi TPS, Grootegeluk coal mine, veld fires, sewage works on the farm Nelsonkop, windblown dust from unvegetated areas and due to agricultural activities, household fuel combustion, and vehicle exhaust emissions. During the dry season with less rainfall, particulate concentration was relatively higher than rainy season due to impacts from the surrounding bare area. Although there were some excesses of the PM2.5 and PM10 daily limits during the dry season in 2016, the number of excesses of the PM2.5 and PM10 daily limits were recorded below their respective allowed number of exceedances per year.
Noise*2 and 3	The noise monitoring points around the Medupi TPS and the results are conducted as shown in Figure 11.2-4 and Table 11.2-3. The main sources of noise are road traffic around the Medupi TPS. According to the monthly monitoring report by Eskom, no exceedances were

Items	Description
	recorded, nor noise complaints received. There is also no complain of vibration, although no measurement.
Water Quality*[1 and 2]	Groundwater quality is monitored in and around the project site. The physical water quality for the sampled localities can generally be described as acidic to neutral. Fluoride (F) concentrations higher than 3 mg/l were measured at several monitoring points. F concentrations in groundwater can typically amount up to 3 mg/l but in the case of F leaching from fluoride-containing minerals to groundwater supplies, the range of 3–12 mg/l may be encountered (DWAF, 1996). Based on the baseline data of Medupi's environs, it was deduced that F occurs naturally in the area. Heavy metal concentrations (Cd, Co, Cu, Pb, Ni, and Zn) measured were mostly below the detection limit.
Solid Waste Management*[3]	Medupi TPS already has the appropriate licensing and authorization for disposal of the ash at the licensed Medupi Ash Disposal Facility, which has been granted for a period of four years.
Natural Environment	
Climate*[5]	Lephalale is influenced by the local steppe climate. There is not much rainfall in Lephalale all year long. The annual average temperature in Lephalale is 24.1 °C. In 2016, the total amount of annual rainfall is 310 mm. The driest months are July, August, and September with 0 mm of rainfall. In February, the precipitation reaches its peak, with an average of 93 mm.
Topography*[1 and 4]	The Waterberg Coalfield comprises a graben structure with the Eenzaamheid fault forming the southern boundary and the northern boundary being delineated by the Zoetfontein fault. Archaean granite rocks outcrop to the north of the Zoetfontein fault and sediments of the Waterberg Group outcrop to the south of the Eenzaamheid fault. The topography of the area is flat, varying between 900 and 922 m. The general topographical drainage system is poorly developed and drains in an easterly direction towards the Mokolo River (810 m).
Groundwater *[1 and 3]	The groundwater potentials of the formations located in the study area are limited in their pristine state due to low permeability, storage, and transmissivity. There are no artesian boreholes located within the study area.
Surface Water *[1 and 4]	The study area falls within the Mokolo River Catchment, which drains into the Limpopo River to the north. The Mokolo River Catchment covers an area of 8,387 km^2. The catchment stretches from the Waterberg Mountains through the upper reaches of the Sand River and includes the Mokolo Dam and a number of small tributaries that join the main Mokolo River up to its confluence with the Limpopo River. There is no creek within the Medupi TPS footprint. There is the Sandloop River, which flows into the Mokolo River, on the south side out of the Medupi TPS.
Vegetation and Ecosystem*[3]	Enumerating natural reserves nearby the power station, there are three sites: D'nyala Natural Reserve (2 km east from Lephalale Town located approximately 15 km east from the power station), Thiane Wildlife Sanctuary (30 km south from the power station), and Mokolo Dam Natural Reserve.
Social Environment	
Population*[6]	The Medupi TPS is positioned in the area under the jurisdiction of Lephalale Local Municipality, which forms part of the Waterberg District Municipality. Last known population in Lephalale is 115,767 (year 2011). The Lephalale Local Municipality covers an area of 13,784 km^2, and consists of 12 wards with 38 villages, two townships (Marapong and Onverwacht), and one town Lephalale. The Internally Displaced Persons (IDP) for the Lephalale area (2014-2016) indicates that there has been a 35.8% population increase within the Lephalale Municipality between 2001 and 2011.
Land Use*[4]	Principle land uses were identified as: •Agricultural land devoted mainly to game and cattle farming. •Residential and industrial areas – i.e., Onverwacht, the town of Lephalale; and •Grootegeluk Mine, which is owned by Kumba Resources Pty Ltd; •The Matimba Power Station; •Game farms and lodges including the Ferroland Private Game Reserve; and •Sewage works on the farms Zongezien and Nelsonskop. Within the 10 km radius, the same land uses are applicable.
Economic Activity*[1 and 4]	The Integrated Development Plan (IDP) in Lephalale also indicates focal areas for the municipality to be job creation, improved infrastructure and a transition to a low carbon

Items	Description
	economy. The Lephalale Municipal economy is largely dependent on mining and electricity generation as primary economic sectors. Agriculture and tourism feature as less significant economic contributors. The majority of the population resides in almost 40 rural villages. The key issues for address in terms of social upliftment include housing, social community facilities, provision of water and electricity.
Water Use*[1 and 4]	The water use within the catchment is predominantly agriculture (87%) and industry (13%) related. Currently, water availability and water use in the catchment are in balance. However, within the provisions of the National Water Act (Act 39 of 1998 as amended) as stipulated in the National Water Resources Strategy, there is a need to meet the water requirements of the Reserve (Basic Human needs and Ecological) in terms of water quantity and quality. Taking the requirements into account, there is insufficient water to maintain the current balance. The MCWAP scheme has been initiated in order to provide adequate water to supply the current and planned water users with allocations of water from the Mokolo Dam. Medupi Power Station already has an allocation for water from the MCWAP Phase 1 scheme. There is currently a Water Use License Application in process for additional water allocation to Medupi from the MCWAP Phase 2 scheme in order to supply for the planned FGD technology operation. This Water Use License is applied for at a strategic level by Eskom. The total water requirement will be of 13.4 million m^3 per annum.

Source *1 Original data was obtained from Final Scoping Report on Integrated Environmental Authorization Process for the Medupi Power Station Fuel Gas Desulphurisation (FGD) Retrofit Project 2015 prepared by Zithholele Consultant (Pty) Ltd

*2 Medupi Power Station Annual EHS Report, Eskom, 2016-2017

*3 Environmental Control Officer Monthly Environmental Report Medupi Power Station Project (2016-2017), NCC Environmental Services (Pty) Ltd

*4 Environmental Impact Assessment Report for the Proposed Establishment of a New Coal-Fired Power Station in the Lephalale Area, Limpopo Province, 2006 prepared by Bohlweki Environmental (Pty) Ltd

*5 http://rp5.co.za/Weather_archive_in_Ellisras

*6 Census 2011 Community Profile Database

1) Air Quality

The location of Medupi Air Quality Monitoring Station is shown in Figure 11.2-1.

Source: JICA Study Team

Figure 11.2-1 Medupi Air Quality Monitoring Station

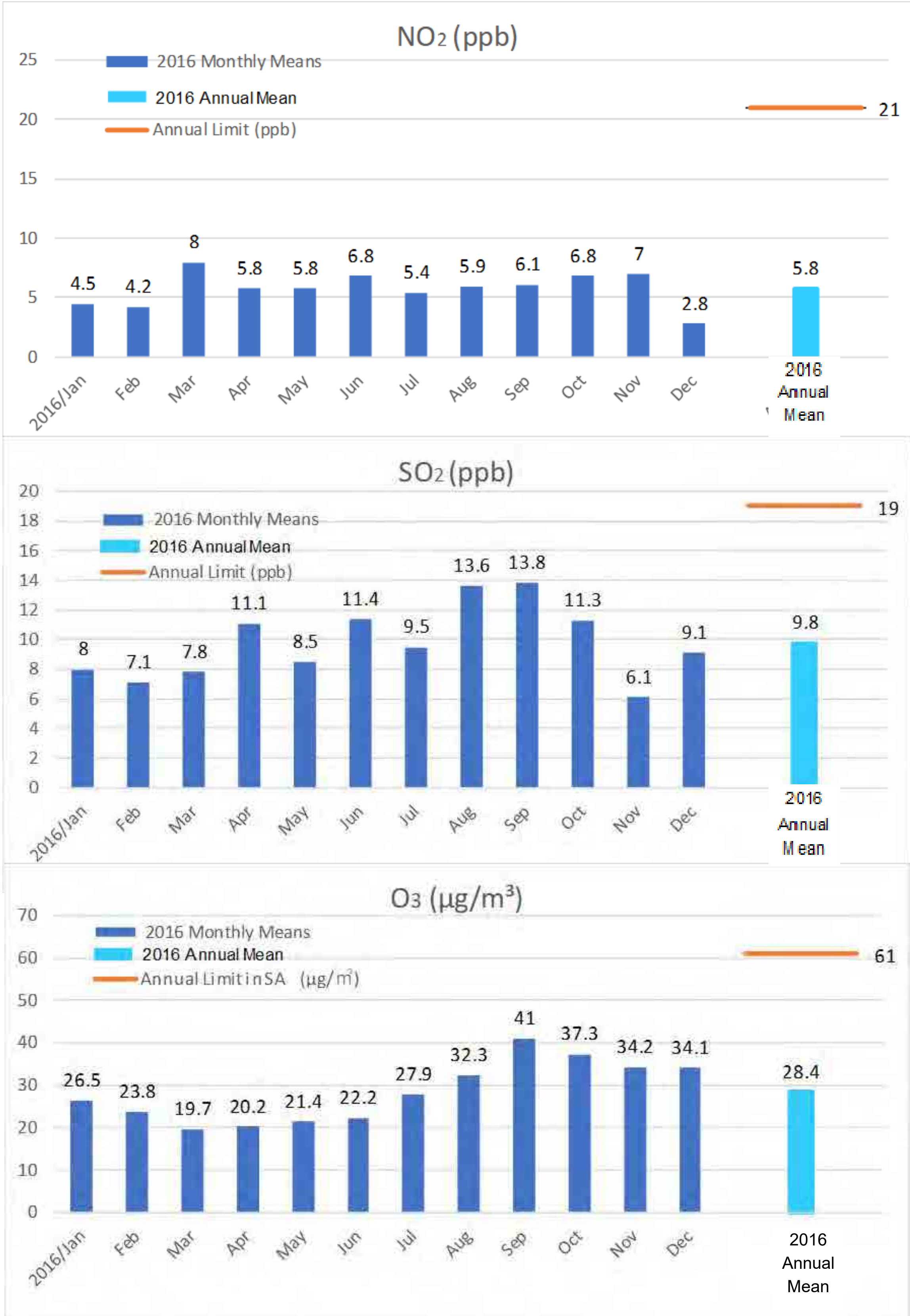
The monthly trends of NOx, SO_2, O_3 and PM levels at the Medupi Monitoring Station in 2016 are shown in Figure 11.2-2 and Figure 11.2-3.

All monitoring parameters in 2016 were in compliance with the yearly ambient standards. As for PM, although monthly average data stands at high concentration because of no rain during dry season in September, annual mean concentration was below the yearly ambient standard. The main sources of air pollution are transportation activities, industrial production, construction, and livelihood such as Matimba TPS, Medupi TPS, Grootegeluk Coal Mine, veld fires, sewage works on the farm Nelsonkop, windblown dust from unvegetated areas and due to agricultural activities, household fuel combustion, and vehicle exhaust emissions.

The number of excesses of daily or hourly limit at the Medupi Monitoring Station is shown in Table 11.2-2. Although there were some exceedances recorded from January to December 2016, the number of excesses of pollutants daily limits is recorded below their respective allowed number of exceedances per year, except O_3. There were no exceedances of the NO_2 hourly limit recorded from January to December 2016. Although there were some excesses of the NO_2 daily limits every month in 2016, the number of excesses of the NO_2 daily limits was recorded below the allowed number of exceedances per year. The PM2.5 and PM10 concentrations during dry season were relatively higher than the rainy season due to impacts from the surrounding bare area addition to the emission gas caused by human activities and excessed their daily limits in 2016. The number of excesses of the PM2.5 and PM10 daily limits is recorded below their respective allowed number of exceedances per year.

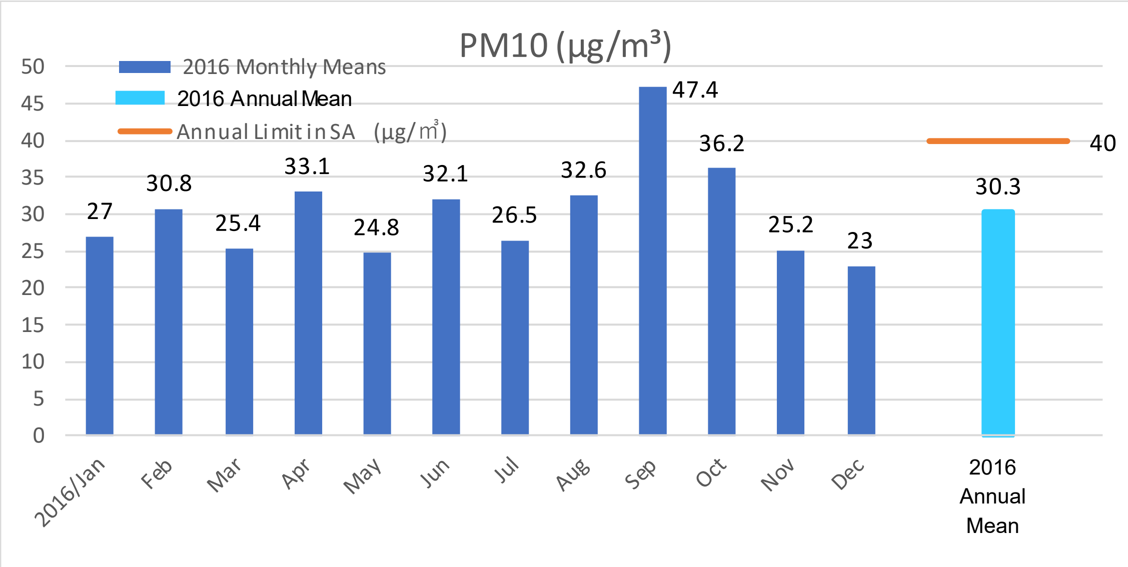
The number of exceedances of the O_3 8-hour moving average is above the allowed number of exceedances per year and therefore in non-compliance with the national ambient standard, although the annual mean is not over the yearly mean limit. Exceedance was recorded in September and October, which was the dry season. Additionally, the temperature raises in September and October, therefore, the influence of ultraviolet rays might be one of the causes of O_3 high concentration.

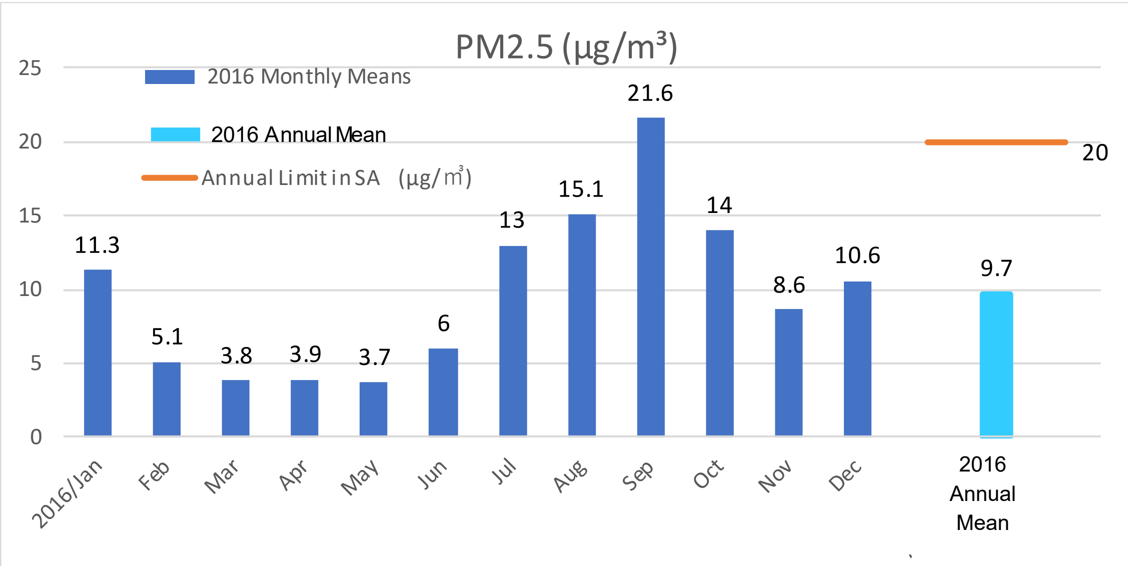
The national ambient air quality standards (Table 3.2-1) level is between the guidelines and interim target-1 of the World Health Organization (WHO) Air Quality Guidelines, which is referred by International Finance Corporation (IFC) Environmental, Health, and Safety (EHS) guidelines.



Source: Medupi Air Quality Monthly Report, Eskom, January 2016-July 2017

Figure 11.2-2 Pollutant Monthly Average Concentration (Year 2016)





Source: Medupi Air Quality Monthly Report, Eskom, January 2016-July 2017

Figure 11.2-3 Pollutant Monthly Average Concentration (Year 2016)

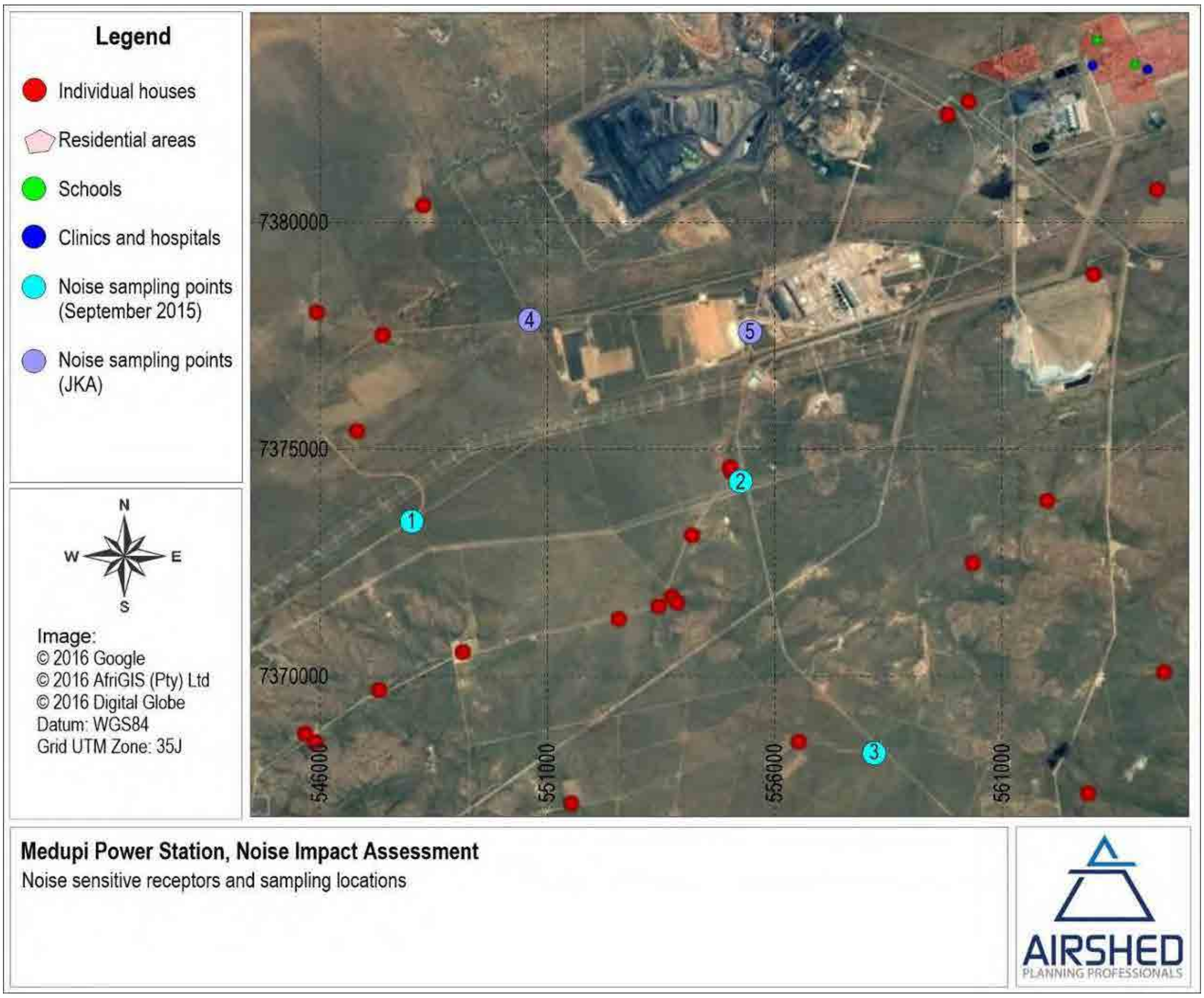
Table 11.2-2 Number of Exceedances of the National Ambient Air Quality Limits (Year 2016)

Parameter \ Year/Month	2016													Allowed number of exceedances
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Number of Exceedances	
SO_2 hourly	7	1	1	6	1	1	6	9	3	2	1	6	**44**	88
SO_2 daily	1	0	0	0	0	0	0	1	0	0	0	0	**2**	4
NO_2 hourly	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0
PM_{10} daily	0	0	0	0	0	0	0	0	2	0	0	0	**2**	4
$PM_{2.5}$ daily	0	0	0	0	0	0	0	0	1	0	0	0	**1**	4
O_3 8-hourly	0	0	0	0	0	0	0	0	14	17	0	6	**37**	11

Source: Medupi Air Quality Monthly Report, Eskom, January 2016-July 2017

2) Noise and Vibration

Ambient noise levels are monitored at five monitoring points as shown in Figure 11.2-4. The summary of noise monitoring record is shown in Table 11.2-3. The major sources of noise are associated with road traffic which does not include the project activities. The average of monitoring data exceeds the noise standard at some points. There are no complaints regarding noise and vibration from surrounding residents. The national noise standard has the same value as IFC EHS guidelines standard, which refers to WHO noise standard.



Source: Noise Specialist Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project, Airshed Planning Professionals (Pty) Limited, February 2018

Figure 11.2-4 Medupi TPS Noise Monitoring Points (2014,2015)

Table 11.2-3 Medupi TPS Noise Monitoring（Years 2014,2015）

Unit：dB(A)

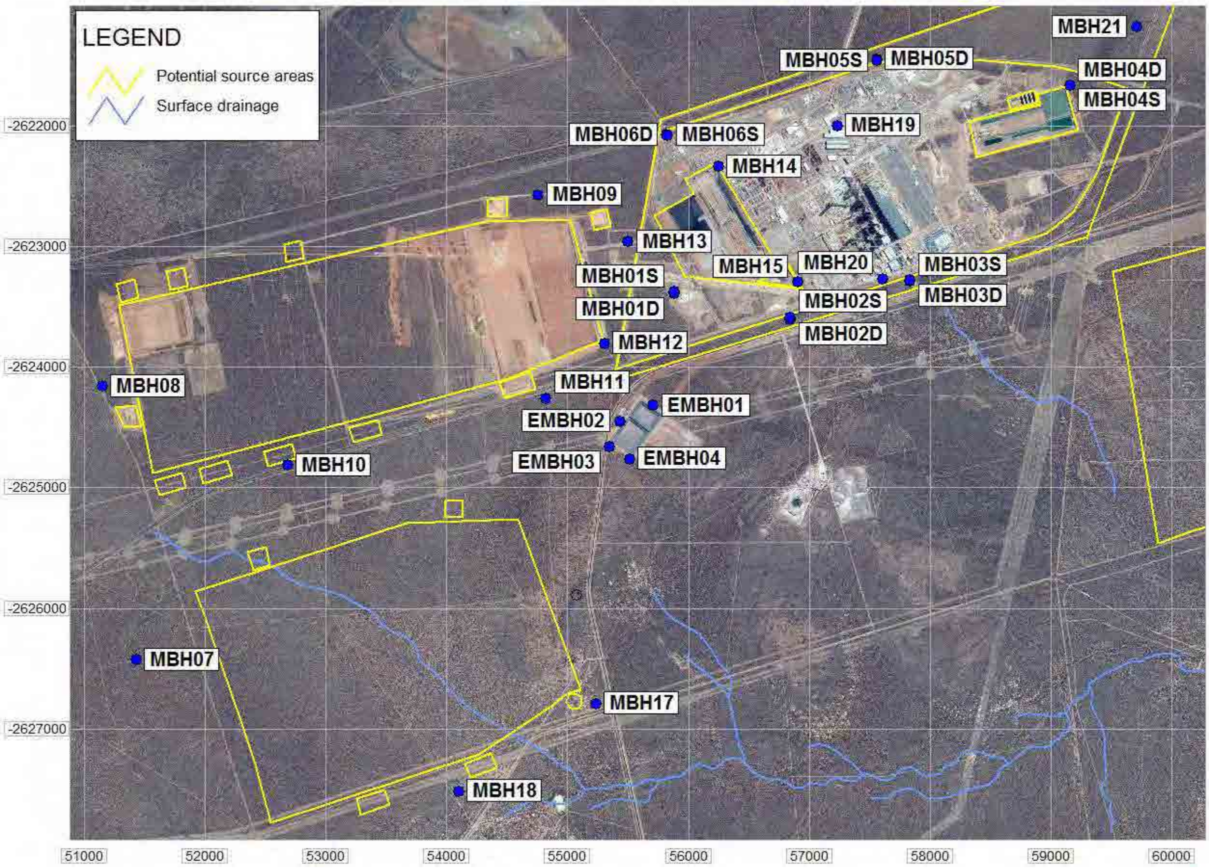
Location (Year)	1 (2015)	2 (2015)	3 (2015)	4 (2014)	5 (2014)	Standard Category: Urban district
Day time: 6:00-22:00	45.2	49.5	62.6	46.2	45.1	55
Night time: 22:00-6:00	43.5	40.1	34.4	47.2	39.6	45

Note： Standard and methodology are in compliance with SANS10103-2008.

Source: Noise Specialist Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project, Airshed Planning Professionals (Pty) Limited, February 2018

3) Groundwater Level and Quality

Groundwater quality and water levels are currently monitored by Eskom at Medupi TPS at 30 existing boreholes. The location of boreholes and representative monitoring results are shown in Figure 11.2-5, Table 11.2-4, and Table 11.2-5, respectively. The average groundwater levels varied between ±4 and 29 m below ground level. The physical water quality for the sampled localities can generally be described as acidic to neutral. Some of these boreholes are positioned around the Medupi FGD Retrofit Project area and could act as monitoring boreholes for the facility. The water quality of the existing boreholes is largely poor quality, with classes ranging from Class 0 to Class 4 water quality (Class 0: Ideal water quality, Class 1: Good water quality, Class 2: Marginal water quality, water suitable for short-term use only, Class 3: Poor water quality, and Class 4: Unacceptable water quality). Monitoring results of EC, TDS, Na, Cl, N, SO_4, Al, F, Fe and Mn exceeded the South Africa National Standard (SANS) 241 (2011). The past continuous monitoring results of these parameters also indicated high concentrations, because the water quality of study area has been polluted by stockbreeding. There is no complaint of groundwater pollution caused by Medupi TPS's activities. As for the high concentration of Fluoride (F), it was judged to be organized from nature.



Source： Medupi Power Station Annual EHS Report, Eskom, 2016-2017

Figure 11.2-5 Medupi TPS Groundwater Monitoring Points

Table 11.2-4 Groundwater Analytical Results (1)

Borehole Number	Physical Determinants			Chemical Determinants				
	pH	EC (mS/m)	TDS (mg/l)	MALK (mg/l)	Ca (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)
MBH2	5.22	10.4	76	9.48	1.51	6.15	2.96	7.97
MBH3	5.77	13.2	84	26.9	4.97	6.49	5.42	7.85
MBH3D	6.57	23.6	144	61.2	13.7	8.93	7.51	15.3
MBH4	6.29	16.5	86	86	8.03	7.81	8.19	7.74
MBH4S	4	1754	10208	<1.99	115	110	281	2885
MBH4D	8.17	356	1798	718	37.6	35.2	81.2	695
MBH5D	6.65	433	3468	167	272	44.7	142	472
MBH6D	6.09	77.4	518	115	28.6	15.8	16.4	119
MBH10D	5.67	32.6	226	51.4	8.99	10.4	9.4	35.3
MBH11	6.97	711	4386	678	191	173	264	1063
MBH12	6.51	450	2746	169	198	37.9	184	525
MBH13	6.96	519	3074	657	141	66.5	156	864
MBH14	6.82	203	1632	179	140	20.5	104	252
MBH15	7.53	683	5088	911	172	70	361	1108
MBH17	6.88	55.2	342	200	25.2	7.13	19.1	71.5
MBH18	7.84	278	1538	607	11.3	16.6	12.5	632
MBH19	6.75	681	4780	247	592	25.6	326	420
MBH20	4.75	19.1	144	5.03	6.46	5.82	4.92	15.3
MBH21	7.3	175	1086	504	129	37.4	41.1	206
SANS241: 2011 Max. Allowable Limit	9.7	<170	1200	-	-	-	-	200
Class 0 Max. Allowable Limit	9.5	<70	<450	-	<80	<25	<70	<100
Class 1 Max. Allowable Limit	10	150	1000	-	150	50	100	200
Class 2 Max. Allowable Limit	10.5	370	2400	-	300	100	200	400
Class 3 Max. Allowable Limit	11	520	3400	-	>300	500	400	1000
Class 4 Max. Allowable Limit	>11	>520	>3400	-		>500	>400	>1000
South African Water Quality Guidelines (SAWQG), Volume 5 – Agricultural Use – Livestock Watering Target Range	-	154	1000	-	1000	-	500	2000
Minimum	4.00	10.4	76	5.0	1.51	5.8	2.96	7.74
Maximum	8.17	1754.0	10208	911.0	592.0	173.0	361.0	2885.0
Average	6.46	341.6	2180	299.6	110.3	37.2	106.7	494.84

Note1: Surveyed in November 2016. The samples from other three boreholes (MBH08. MBHO9 and MBH07) were not taken because they were dry or water levels were too low.

Note2 : Department of Water Affairs and Forestry: DWAF Guidelines 1998 Water Category : Class0: Ideal water quality, Class1: Good water quality, Class2: Marginal water quality, water suitable for short-term use only, Class3: Poor water quality, and Class 4: Unacceptable water quality

Note3: Red highlighted figure means the result exceeds limits of upper level of SANS241:2011

Source: Hydrogeological Impact Assessment for Medupi FGD Retrofit Project, February 2018

Table 11.2-5 Groundwater Analytical Results (2)

Borehole Number	Chemical Determinants							Water Quality Class
	Cl (mg/l)	NO_3 as N (mg/l)	SO_4 (mg/l)	Al (mg/l)	F (mg/l)	Fe (mg/l)	Mn (mg/l)	
MBH2	13	0.423	14.1	<0.005	0.263	<0.004	<0.001	0
MBH3	17.2	0.293	10.8	0.211	0.917	<0.004	<0.001	I
MBH3D	18.7	0.212	33.7	<0.004	0.441	<0.001	<0.003	0
MBH4	8.41	0.258	11	<0.002	1.84	<0.001	<0.003	I
MBH4S	6815	0.194	<0.141	<0.002	<0.263	<0.001	<0.003	IV
MBH4D	788	0.538	38.2	<0.002	4.13	<0.002	<0.001	II
MBH5D	1187	0.196	291	<0.002	1.26	<0.001	<0.003	III
MBH6D	99.1	11.7	70.9	<0.002	5.02	<0.001	<0.003	II
MBH10D	77.7	0.476	4.25	<0.002	0.263	<0.002	0.001	0
MBH11	2002	0.718	350	<0.005	2.79	<0.005	<0.005	IV
MBH12	1152	0.42	453	<0.001	1.06	<0.005	<0.001	III
MBH13	1357	6.12	111	<0.002	4.98	<0.003	<0.001	III
MBH14	101	45.1	714	<0.007	4.08	<0.011	<0.001	IV
MBH15	757	368	836	<0.007	4.92	<0.009	<0.001	IV
MBH17	74.4	0.52	9.37	<0.005	2.1	<0.009	<0.001	0
MBH18	533	0.372	173	<0.005	8.96	<0.009	<0.007	II
MBH19	2174	0.914	96.9	<0.005	1.01	<0.009	0.37	IV
MBH20	29.8	3.57	17.6	0.713	0.88	<0.009	<0.001	I
MBH21	232	5.28	117	<0.005	2.29	<0.009	<0.001	II
SANS241: 2011 Max. Allowable Limit	300	11	500	0.3	1.5	0.3	0.5	
Class 0 Max. Allowable Limit	<100	<6	<200	-	<0.7	<0.01	<0.1	0
Class 1 Max. Allowable Limit	200	10	400	-	0.7-1.0	0.01-0.2	0.1-0.4	I
Class 2 Max. Allowable Limit	600	20	600	-	1.0-1.5	0.2-2.0	1.0-4.0	II
Class 3 Max. Allowable Limit	1200	40	1000	-	1.5-3.5	2.0-10.0	4.0-10.0	III
Class 4 Max. Allowable Limit	>1200	>40	>1000	-	>3.5	>10.0	>10.0	IV
South African Water Quality Guidelines (SAWQG), Volume 5 – Agricultural Use – Livestock Watering Target Range	1500	1000	100	5	2	10	10	
Minimum	8.41	0.194	4.25	0.211	0.263	<0.001	0.001	
Maximum	6815.0	368.0	836.0	0.713	8.96	<0.011	0.37	
Average	917.7	23.437	186.21	0.462	2.62		0.1855	

Note1: Surveyed in November 2016. The samples from other three boreholes (MBH08. MBHO9 and MBH07) were not taken because they were dry or water levels were too low.

Note2 : Department of Water Affairs and Forestry: DWAF Guidelines 1998 Water Category : Class0: Ideal water quality, Class1: Good water quality, Class2: Marginal water quality, water suitable for short-term use only, Class3: Poor water quality, and Class 4: Unacceptable water quality

Note3: Red highlighted figure means the result exceeds limits of upper level of SANS241:2011

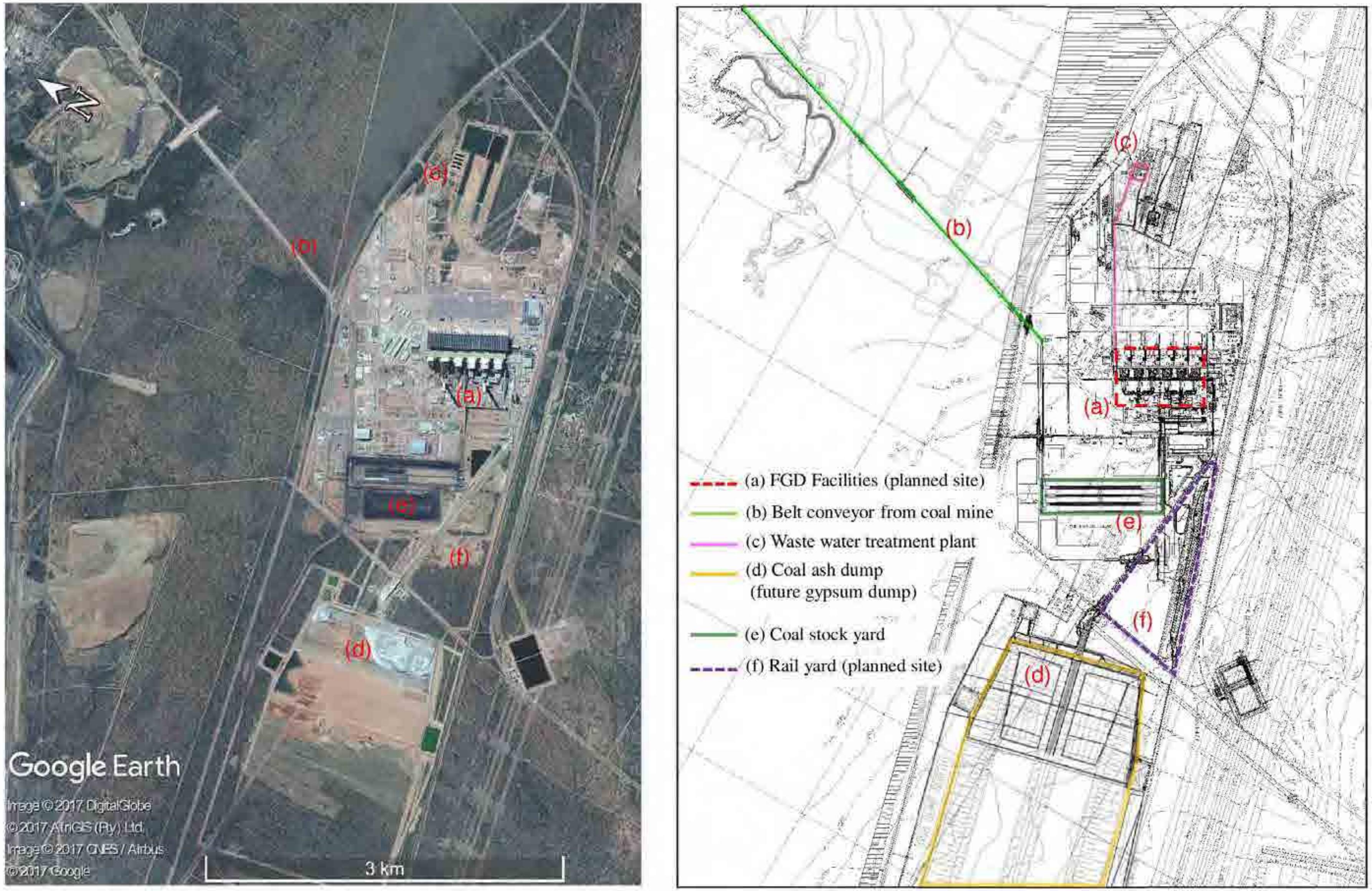
Source: Hydrogeological Impact Assessment for Medupi FGD Retrofit Project, February 2018

(2) Environmental Conditions of the Project Site in Medupi TPS

Project site condition and facilities layout in Medupi TPS are shown in Figure 11.2-6 and Figure 11.2-7, respectively. The Medupi Power Plant units have been designed and are under construction. The Medupi FGD system was designed to be installed next to power plant units in the Medupi TPS footprint. The pre-construction phase for the Medupi TPS included the removal of all vegetation and topsoil from the site in preparation for construction of FGD facilities. Vegetation and topsoil on the vacant-plot of land remain on the site. There is no residence in the vicinity of the Medupi TPS.

Source: Final Scoping Report on Integrated Environmental Authorization Process for the Medupi Power Station Fuel Gas Desulphurization (FGD) Retrofit Project 2015 prepared by Zithholele Consultant (Pty) Ltd

Figure 11.2-6 Project Site Situation in Medupi TPS



Source: Prepared by the JICA Study Team using Google Earth (taken in 2017 May)

Figure 11.2-7 Layout of Facilities in Medupi TPS Site

11.3. Legal and Institutional Framework in South Africa

11.3.1. Legislations in South Africa

(1) Environmental Laws and Regulations in South Africa

The legislations in South Africa related to the FGD project are listed in Table 11.3-1.

Table 11.3-1 Summary of Applicable Environmental Legislation

Legislation	Applicable Chapter/ Section and Contents
The Constitution of Republic of South Africa (Act No 108 of 1996)	Chapter 2: Bill of Rights
	Section 24: Environmental rights
	Section 25: Rights in property
National Environmental Management Act (Act No 107 of 1998)	Section 2: Defines the strategic environmental management goals and objectives of the government. Applies throughout the republic to the actions of all organs of the state that may significantly affect the environment.
	Section 28: The developer has a general duty to care for the environment and to institute such measures as may be needed to demonstrate such care.
National Environmental Management Act (Act No 107 of 1998): Environmental Impact Assessment Regulation, 2014	Government Notice 982: Defines the process of environmental impact assessment, 2014
	Government Notice R326: Amendment to Environmental Impact Assessment Regulations, 2017
	Government Notice R327, R325, R324: Triggering activities in terms of listing, 2017
National Environmental Management Waste Act (Act No. 59 of 2008)	Defines waste management activities which are required to carry out EIA process as a part of the waste management license application process
National Environmental Management: Air Quality Act, 2004 (No. 39 of 2004)	National Ambient Air Quality Standards, Government Notice 1210, Government Gazette 32816, 242 December 2009 The air quality standards published in Government Notice 1210 must be adhered to. Medupi has applied for an Atmospheric Emissions License as an independent process. At present the appeals response has been submitted to the relevant provincial authority (LEDET) and decision is awaited. GN 248; List of activities that trigger an air emission license
Atmospheric Pollution Prevention Act (No 45 of 1965)	Sections 27-35: Dust control and dust control areas.
	Section 36 – 40: Air pollution by fumes emitted by vehicles.
	Second Schedule: Scheduled processes. No 29 relates to power generation processes
National Water Act (No 36 of 1998)	Section 19: Water quality management
	Sections 21, 22, 26, 32 and 39: Water quantity management: water use
	Sections 27-29; Licensing of water use
Occupational Health and Safety Act, 1993 (Act No. 85 of 1993)	Section 8: General duties of employers to their employees
	Section 9: General duties of employers and self-employed persons to person other than their employees
Hazardous Substance Act, 1973 (Act No. 15 of 1973)	Provides for the definition, classification, use, operation, modification, disposal or dumping of hazardous substances
Lephalale Municipality Integrated Development Plan Final Draft 2013-2016	The Integrated Development Planning is regarded as a tool for municipal planning and budgeting to enable municipalities to deliberate on developmental issues identified by communities. The IDP points out the Medupi Power Station as a significant contributor to the economy of Lephalale and one of the key employers of the area.
Environment Conservation Act (No 73 of 1989)	Section 2: General policy
	Sections 19 and 19A: Prevention of littering by employees and subcontractors during construction and the maintenance phases of the proposed project.
	Sections 20 and 24: Waste management
	Section 25: Regulations regarding noise, vibration and shock
	Sections 21, 22, 25, 26 and 28: EIA regulations, including listed activities

Legislation	Applicable Chapter/ Section and Contents
	Section 28A: Exemptions
Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)	Relates agricultural natural resources and the conservation, management and use thereof, including soil conservation, declared weeds, etc.
National Environmental Management: Biodiversity Act (No 10 of 2004)	Relates to the management and conservation of South Africa's biodiversity.
Occupational Health and Safety Act (No 85 of 1993)	Section 8: General duties of employers to their employees. Section 9: General duties of employers and self-employed persons to persons other than their employees.
National Road Traffic Act (No 93 of 1996) GNR 225 of 17 May 2000	Transportation of dangerous goods and large components.
National Heritage Resources Act (No 25 of 1999)	Section 34: Structures; Structures which are older than 60 years may not be demolished without a permit issued by the relevant provincial Heritage Resources Authority. No structures older than 60 years were recorded in the Heritage Impact Study (Bohlweki: 2006: page 378). Any new construction sites outside of the existing Medupi Power Station footprint will need to adhere to this act.
	Section 35: Archaeology, paleontology and meteorites; Any archaeological or paleontological objects that are found on the site, must be reported to the provincial Heritage Resources Authority. The discovered archaeological or paleontological objects may not be removed from its original position and damaged, destroyed or altered prior to a permit being issued by the heritage resources authority. Any new construction sites outside of the existing Medupi Power Station footprint will need to adhere to this act.
	Section 36: Burial grounds and graves; Any graves that are discovered may not be destroyed, damaged, altered, exhumed or removed from its original position without a permit issued by SAHRA or a provincial heritage resources authority. Any new construction sites outside of the existing Medupi Power Station footprint will need to adhere to this act.
	Section 38(1)(c): Heritage Resource Management; As the proposed development area may exceed 5000 m^2, with the submission of the Heritage Impact Assessment to SAHRA, the responsible heritage resources authority has been notified of the project and provided with information relating to the project. Authorization to proceed with the development is required from SAHRA.

Source: South Africa Government

From the above acts and regulations, it is evident that the Medupi FGD project may require the following licenses and environmental authorizations:

- Environmental Authorization for a Full Scoping and Environmental Impact Assessment (EIA) in terms of the National Environmental Management Act, 1998 (Act No.107 of 1998) (NEMA) and the Environmental Impact Assessment Regulations of 2017;
- Atmospheric Emissions License (AEL) in terms of the National Environmental Management: Air Quality Act, 2004 (39 of 2004) (NEMAQA);
- Water Use License (WUL) in terms of Section 21 of the National Water Act, 1998 (Act No 36 of 1998) (NWA);
- Waste Management License as per the National Environmental Management Waste Act, 2008 (Act No. 59 of 2008) (NEM: WA).

11.3.2. EIA Regulations in South Africa

(1) Entities Subject to EIA

In 2014, new EIA Regulations were promulgated which replaced the previous EIA Regulations of 2010. The regulations were subsequently amended on 07 April 2017. These Regulations (GN R326) have three (3) Listing Notices (LN); LN 1 (GN R327) and LN 3 (GN R 324) provide for the Basic Assessment (BA) process and LN 2 (GN R325) for the Scoping and Environmental Impact Reporting (S&EIR) process.

Activities listed in terms of the EIA Regulations as amended in 2017 may not commence without Environmental Authorization from the competent authority, the Department of Environmental Affairs (DEA). The Environmental Authorization process, in terms of the investigation, assessment, and communication of the potential impact of activities must follow the procedure as described in the EIA Regulation (Government Notice No. R982, R324, R325 and R327 of 2014), promulgated in terms of Section 24, and 24(d) NEMA. The following listed activities may be triggered by the proposed FGD retrofit project:

Table 11.3-2 Listed Activities in terms of Section 24 and 24(d) of the NEMA

Activity number	Description of Listed Activity
Government Notice No.325 NEMA as amended on 07 April 2017 (LN2)	
3	The development and related operation of facilities or infrastructure for nuclear reaction including energy generation, production, enrichment, processing, reprocessing, storage or disposal of nuclear fuels, radioactive products, nuclear waste or radioactive waste.
7	The development and related operation of facilities or infrastructure for the bulk transportation of dangerous goods— (i)In gas form, outside an industrial complex, using pipelines, exceeding 1 000 meters in length, with a throughput capacity of more than 700 tons per day; (ii) In liquid form, outside an industrial complex, using pipelines, exceeding 1 000 meters in length, with a throughput capacity of more than 50 cubic meters per day; or (iii) In solid form, outside an industrial complex, using funiculars or conveyors with a throughput capacity of more than 50 tons per day.
12	The development of railway lines, stations or shunting yards excluding — (i) Railway lines, shunting yards and railway stations in industrial complexes or zones; (ii) Underground railway lines in a mining area; or (iii) Additional railway lines within the railway line reserve.
15	The clearance of an area of 20 hectares or more of indigenous vegetation, excluding where such clearance of indigenous vegetation is required for— (i)The undertaking of a linear activity; or (ii)Maintenance purposes undertaken in accordance with a maintenance management plan

Note: The listed activities on the above table are not the final activities, as the EIA process is still ongoing. Thus, the list will be updated with the DEIR and FEIR.

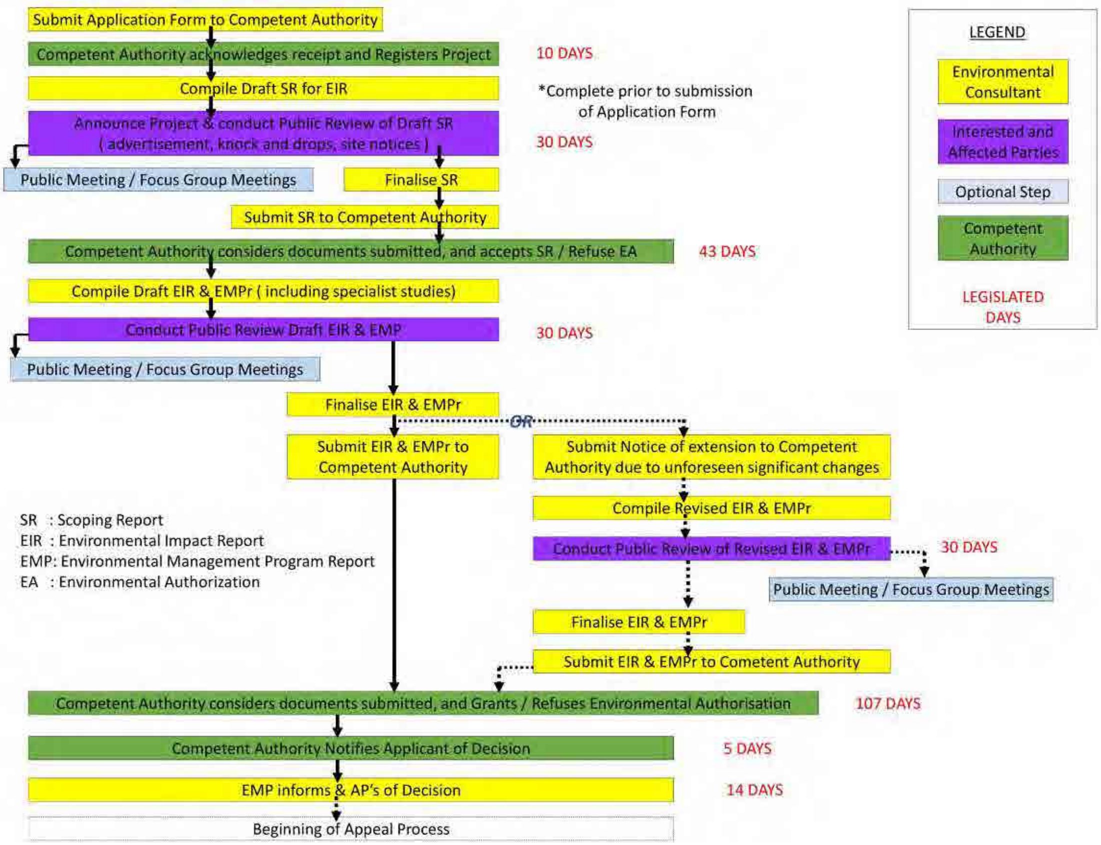
Source: Government Notice No.325 NEMA as amended on 07 April 2017 (LN2)

(2) Scoping and EIA Process

The EIA process is defined in NEMA (No.107 of 1998): Environmental Impact Assessment Regulations, (2014). The environmental studies followed a two-phase approach, scoping phase and environmental impact assessment phase. The scoping study is an important phase of the project as it identifies issues and aspects that require further detailed investigation. It determines the scope of the following phases of the project. The environmental impact assessment will draw on information contained within the scoping report and aims to assess the potential impacts on the biophysical and the socioeconomic environment within the study areas. Scoping and EIA process is shown in Figure 11.3-1.

The final EIA report on FGD at Medupi TPS was submitted to DEA on 23 May 2018, and DEA has granted the Environmental Authorization (EA) for the Medupi FGD Project in September 2018 (Amendment of EA on October 2018).

As for the construction of water pipeline, which will connect the off-take point on the MCWAP Phase 2 and the Medupi FGD Plant via the existing raw water reservoir in the Medupi TPS site, the basic assessment process (BA) in line with the regulation will be required. The project proponent, Eskom, expects that the BA process will be concluded on or before December 2019, as of December 2018.

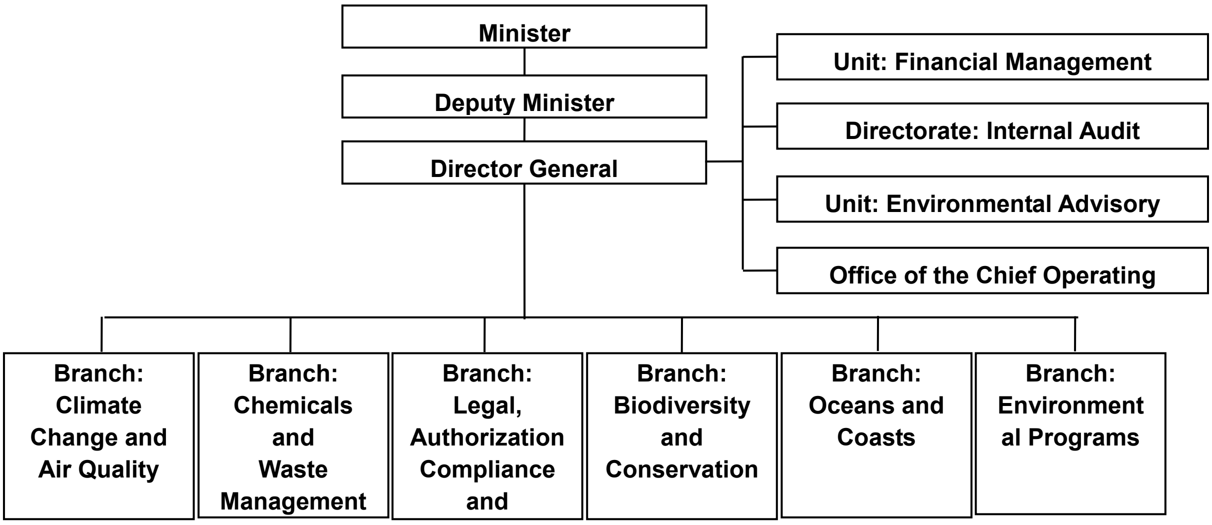


Source: Based on NEMA (No.107 of 1998): Environmental Impact Assessment Regulations (2014), prepared by the JICA Study Team

Figure 11.3-1 Scoping and EIA Process in South Africa

(3) Relevant Organization for EIA in South Africa

The organization structure of the Department of Environmental Affairs (DEA) in South Africa is shown in Figure 11.3-2. The Legal, Authorization, Compliance and Enforcement Branch under DEA will authorize the EIA.



Source: Based on the website information, prepared by the JICA Study Team
https://www.environment.gov.za/aboutus/structure

Figure 11.3-2 Organization Structure Chart of DEA in South Africa

(4) Categorization of the Project in accordance with the JICA Environmental Guidelines

Category A defined by the JICA Guidelines for Environmental and Social Considerations, April 2010 (hereinafter, “JICA Environmental Guidelines”) generally includes i) projects in sensitive sectors, ii) projects that have characteristics that are liable to cause adverse environmental impact, and iii) projects located in or around environmental sensitive areas. Moreover, a project causing large-scale involuntary resettlement is classified under Category A. Projects are classified as Category B if potential adverse impacts on the environment and society are less adverse than those in Category A.

Based on the above guidelines, the FGD project is classified as Category B by JICA because the project is not considered as a large-scale project, is not located in an environmental sensitive area, and has no sensitive characteristics under the JICA Environmental Guidelines, so the project is unlikely to cause significant adverse impacts to the environment.

(5) Gap Analysis between South African Environmental Regulation and JICA Environmental Guidelines

The result of gap analysis between the South Africa’s Environmental Regulations and JICA Environmental Guidelines is shown in the following table.

There is no reference to the following items, which are described in the JICA Environmental Guidelines, in South African Environmental Regulation;

- Language on the process of information disclosure;
- Availability of accessing the EIA report;
- Disclosure of the monitoring result;
- Working conditions;
- Land acquisition and involuntary resettlement; and
- Indigenous peoples

However, the past and ongoing EIA-related performance and practices of Eskom conform to the requirement of the JICA Environmental Guidelines although it is not clearly specified in South African environmental regulations. It was confirmed and will be expected in the proposed project that Eskom secures the necessary measures and meets the requirement of the JICA Environmental Guidelines with regard to the process of public engagement such as language on the process of information disclosure, availability of accessing the EIA report and dissemination of monitoring result. The land acquisition and involuntary resettlement are not expected in the proposed project. There are no concerns on indigenous peoples. The working conditions are not specified in the scope of EIA according to the South African regulation. But the adequate measures are undertaken according to applicable regulations such as Occupational Health and Safety Act and it should be confirmed in the proposed project.

Table 11.3-3 Gap Analysis of South African Environmental Regulations and JICA Environmental Guidelines about EIA

No.	JICA Guidelines for Environmental and Social Considerations (April 2010)	South Africa NEMA (107/1998)	Gap between South African Environmental Regulations and JICA Environmental Guidelines	Measures to Filling Gap in this Project
Basic Matter				
1	Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan. (Appendix 1, 1.1)	The potential consequences for or impacts on the environment of listed activities or specified activities must be considered, investigated, assessed and reported on to the competent authority or the Minister responsible for mineral resources, as the case may be, except in respect of those activities that may commence without having to obtain an environmental authorization in terms of this Act. Every applicant must comply with the requirements prescribed in terms of this Act in relation to (a) steps to be taken before submitting an application, where applicable, (b) any prescribed report; (c) any procedure relating to public consultation and information gathering, (d) any environmental management program, (e) the submission of an application for an environmental authorization and any other relevant	There is no gap.	The project policy on environmental and social impact assessment is based on the national regulations and JICA Environmental Guidelines.

No.	JICA Guidelines for Environmental and Social Considerations (April 2010)	South Africa NEMA (107/1998)	Gap between South African Environmental Regulations and JICA Environmental Guidelines	Measures to Filling Gap in this Project
		information; and (f) the undertaking of any specialist report, where applicable. [NEMA: Sec 24(1), (1A)] Integrated environmental management is to identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage, the risks and consequences and alternatives and options for mitigation of activities, with a view to minimizing negative impacts, maximizing benefits, and promoting compliance with the principles of environmental management. [NEMA: Sec 23(2)]		
Information Disclosure				
2	EIA reports (which may be referred to differently in different systems) must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them (Appendix 2 EIA Reports for Category A Projects)	Where a person who desires but is unable to access written comments as contemplated in sub-regulation (1) due to the following: (a) lack of skills to read or write; (b) disability; or (c) any other disadvantage; Reasonable alternative methods of recording comments must be provided for. [NEMA: EIAR2014 (mended 2017), Sec44(2)] The participation of all interested and affected parties in environmental governance must be promoted, and all people must have the opportunity to develop the understanding, skills and capacity necessary for achieving equitable and effective participation, and participation by vulnerable and disadvantaged persons must be ensured. [NEMA: Sec 4(4)(f)]	There is no reference to language in laws and regulations.	Since English is a widely understandable language in the site, all documents related to environmental issues are disseminated in English.
3	EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted (Appendix 2 EIA Reports for Category A Projects)	Chapter 2 and Chapter 6 of NEMA: EIAR2014 (amended 2017) described the time frame and methodology of public participation, respectively to obtain Environmental Authorization.	There is no reference to availability of accessing the EIA report, but previous EIA report for Eskom projects are disclosed in the company website of Eskom. Project stakeholders can access to the all environmental reports any time. Reports are to be made available to the public, by placing such reports in easily accessible public venues, such as public libraries, police stations and municipal offices.	All documents related to EIA report for FGD Project are disclosed on the project Eskom's website.

No.	JICA Guidelines for Environmental and Social Considerations (April 2010)	South Africa NEMA (107/1998)	Gap between South African Environmental Regulations and JICA Environmental Guidelines	Measures to Filling Gap in this Project
Public Consultation				
4	Projects must be adequately coordinated so that they are accepted in a manner that is socially appropriate to the country and locality in which they are planned. For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of project plans. (Appendix 1, 5.1)	(1) The applicant must ensure that the comments of interested and affected parties are recorded in reports and plans and that such written comments, including responses to such comments and records of meetings, are attached to the reports and plans that are submitted to the competent authority in terms of these regulations. (3) Potential or registered interested and affected parties, including the competent authority, may be provided with an opportunity to comment on reports and plans contemplated in sub-regulation (1) prior to submission of an application but must be provided with an opportunity to comment on such reports once an application has been submitted to the competent authority. [NEMA: EIAR2014 (mended 2017), Sec44(1)(3)]	There is no gap.	Public meetings were conducted at two stages in line with the national regulation. Public meeting for draft scoping report for Medupi FGD project was conducted in November 2014. And public meeting for draft EIA report for Medupi FGD project was conducted in March 2018.
5	In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Records of such consultations must be prepared. (Appendix 2 EIA Reports for Category A Projects)	The applicant must ensure that the comments of interested and affected parties are recorded in reports and plans and that such written comments, including responses to such comments and records of meetings, are attached to the reports and plans that are submitted to the competent authority in terms of these Regulations. [NEMA: EIAR2014 (mended 2017), Sec44]	There is no gap.	Minutes of the meetings of all stakeholder meetings are prepared. Comment and response reports are also prepared for each public participation.
6	Consultations with relevant stakeholders, such as local residents, should take place if necessary, throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared. (Appendix 2 EIA Reports for Category A Projects)	The following section provides guidance as to when public participation must be undertaken - • Before the submission of an application for Environmental Assessment (EA), but the relevant Competent Authority (CA) and potential and registered interested and affected parties must, irrespective of whether or not any public participation (PP) took place prior to the submission of the application. • Additional PP may be required where significant changes have been made or significant new information has been added to the basic assessment report (BAR), scoping and environmental impact report (S & EIR), environmental management program (EMPr) or where applicable, a closure plan, which change or information was not contained in the reports or plans consulted on during the initial Public Participation Process (PPP), for a period of at least 30 days. [Public Participation Guideline in terms of NEMA, 1998 EIAR, DEA, 2017]	There is no gap.	Public meetings were conducted at two stages, i.e., scoping phase and draft EIA phase, in line with the national regulation.
Environmental and Social Items to be Assessed				
7	The impacts to be assessed with regard to environmental and social considerations include impacts on human	Sustainable development requires the consideration of all relevant factors including the following: ecosystems, biological diversity, landscapes and sites	There is no reference to working condition, land acquisition and in involuntary resettlement	Eskom's activities and considerations for

No.	JICA Guidelines for Environmental and Social Considerations (April 2010)	South Africa NEMA (107/1998)	Gap between South African Environmental Regulations and JICA Environmental Guidelines	Measures to Filling Gap in this Project
	health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and the indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. (Appendix 1 Environmental and Social Considerations Required for Intended Projects, 3. Scope of Impacts to be Assessed, 1)	that constitute the nation's cultural heritage, use and exploitation of non-renewable/ renewable natural resources, people's environmental rights, unfairly discriminate against any person, particularly vulnerable and disadvantaged persons, equitable access to environmental resources, benefits and services to meet basic human needs, human well-being, environmental health and safety consequences, social, economic, right of workers, human health dangers, actual or potential conflicts, global and international responsibilities, vital role of women and youth, sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands. [NEMA 2(4)]	in EIA regulations.	working safety and health conditions shall be clarified in this report. Occupational Health and Safety Act No. 83 of 1993, OSHSAS 18001, and the accompanying Construction Regulations are applied for the working health and safety condition. South African laws relating to resettlement and land acquisition are to be solved in accordance with Interim Protection of Informal Land Rights (Act 31 of 1996), The Constitution 108 of 1996, Restitution of Land Rights Act 22 of 1994, Expropriation Act (Act 63 of 1975), and Extension of Security of Tenure Act (1997) Not applicable for Medupi FGD Project, since there is no land acquisition and no resettlement due to the implementation of the project.
8	In addition to the direct and immediate impacts of the projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle	If a proponent or applicant intends undertaking more than one activity as part of the same development within the area of jurisdiction of a competent authority, a single application must be submitted for such development and the assessment of impacts, including cumulative impacts, where applicable, and consideration of the application, undertaken in terms of these regulations, will include an assessment of all such activities forming part of the development.	There is no gap.	Air quality concentrations during operation of the project are predicted including cumulative concentrations due to existing Matimba TPS emissions.

No.	JICA Guidelines for Environmental and Social Considerations (April 2010)	South Africa NEMA (107/1998)	Gap between South African Environmental Regulations and JICA Environmental Guidelines	Measures to Filling Gap in this Project
	should be considered throughout the life cycle of the project. (Appendix 1 Environmental and Social Considerations Required for Intended Projects, 3. Scope of Impacts to be Assessed, 2)	If one or more proponents intend undertaking interrelated activities at the same or different locations within the area of jurisdiction of a competent authority, the competent authority may, in writing, agree that the proponent or proponents submit a single application in respect of all of those activities and to conduct a consolidated assessment process but the potential environmental impacts of each activity, including its cumulative impacts, must be considered in terms of the location where the activity is to be undertaken. [NEMA: EIAR2014 (mended 2017), Sec11(3)(4)] An assessment of each identified potentially significant impact and risk, including— (i) cumulative impacts, (ii) the nature, significance and consequences of the impact and risk, (iii) the extent and duration of the impact and risk, (iv) the probability of the impact and risk occurring, (v) the degree to which the impact and risk can be reversed, (vi) the degree to which the impact and risk may cause irreplaceable loss of resources; and (vii) the degree to which the impact and risk can be mitigated; [NEMA: EIAR2014 (mended 2017), Appendix3, Sec3(1)(j)]		Medupi TPS Project is considered as an indivisible project from FGD Project. Therefore, the status of environmental and social considerations is confirmed from the point of view of JICA Environmental Guidelines thorough reviewing the existing environmental documents and interviewing with Eskom Environmental Team experts.
Monitoring and Grievance Mechanism				
9	Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. (Appendix 1 Environmental and Social Considerations Required for Intended Projects, 9. Monitoring, 3)	There is no reference to public review, discussion and examination of the results of monitoring process in laws and regulations. However, DEA can issue Record of Decision for EIA report attached with specific conditions. In terms of specific conditions for Medupi TPP, Environmental Monitoring Committee (EMC) which includes representative local community members was required. EMC must monitor and audit project compliance to relevant regulations and environmental documents, have a meeting and report periodically.	There is no reference to public review, discussion and examination of the results of monitoring process in laws and regulations.	EMC for Medupi TPS has been established and is executing its task continuously in line with the Record of Decision.
10	When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems. (Appendix 1 Environmental and Social Considerations Required for Intended Projects, 9. Monitoring, 4)		ditto	ditto
Ecosystem and Biota				
11	Projects must not involve	Sustainable development requires the	There is no gap.	The project policy

No.	JICA Guidelines for Environmental and Social Considerations (April 2010)	South Africa NEMA (107/1998)	Gap between South African Environmental Regulations and JICA Environmental Guidelines	Measures to Filling Gap in this Project
	significant conversion or significant degradation of critical natural habitats and critical forests. (Appendix 1 Environmental and Social Considerations Required for Intended Projects, 6. Ecosystem and Biota, 1)	consideration of all relevant factors including the following: (i) That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimized and remedied [NEMA 2(4)(a)(i)] South Africa has two other laws for natural conversation, which are the Protected Areas Act 57 of 2004 and the Biodiversity Act 10 of 2004		on environmental and social impact assessment is based on the national regulations and JICA Environmental Guidelines.
Indigenous Peoples				
12	Any adverse impacts that a project may have on indigenous peoples are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures must be taken to minimize impacts and to compensate indigenous peoples for their losses. (Appendix 1, 8.1)	There is no reference to indigenous people in laws and regulations.	There is no reference to indigenous people in EIA Regulations.	Not applicable for Medupi FGD Project, since there are no indigenous people.

Source: Prepared by JICA Study Team

11.3.3. National Environmental Management Waste Act

All waste management activities are regulated by the National Environmental Management Waste Act, 2008 (Act No. 59 of 2008) (NEM:WA) and the regulations thereunder. In order to regulate waste management activities and to ensure that they do not adversely impact on human health and environment, the NEM: WA (2008) introduced the licensing of waste management activities. All waste management activities, which are listed in Government Notice 921 (2013) in terms of the NEM: WA (2008) require licensing from the competent authority before these activities may proceed. There are three categories under the NEM: WA in which waste is classified and the handling of that waste is defined. The categories also define which process should be followed in order to obtain a waste permit for the handling of waste in each category. A waste management license (WML) is also regarded as an environmental authorization. As such, the process to follow to obtain a WML is regulated by the EIA Regulations of 2014. One development proposal can require multiple environmental authorizations (e.g., EIA and WML). In such cases, separate application forms, in the format required by the competent authorities for the listed activities, must be submitted to the relevant competent authorities. The process for such applications will run concurrently, and the result will be separate environmental authorizations, issued simultaneously.

For Category "A" activities, a person who wishes to commence, undertake, or conduct an activity listed under this Category, must conduct a basic assessment (BA) process set out in EIA Regulations (2014) as part of the waste licence application process.

For Category "B" activities, a person who wishes to commence, undertake, or conduct an activity listed under this Category, must conduct a scoping and environmental assessment reporting process as part of the waste licence application process.

For Category "C" activities, a person who wishes to commence, undertake, or conduct an activity listed under this Category, must comply with the National Norms and Standards for the Storage of Waste (GN 926 of 2013)

Each of the project activities, as well as the corresponding waste management activity, is provided in Table 11.3-4.

Table 11.3-4 Description of Applicable Waste Management Activities listed in the GN R718 (2008)

Activity Number	Description of Listed Activity
Government Notice No.718 NEMA 2008 as amended on 2013: Category B	
7	The disposal of any quantity of hazardous waste to land.
10	The construction of a facility for waste management activity listed in Category B of this schedule (not in isolation to associated waste management activity).
Government Notice No.718 NEMA 2008 as amended on 2013: Category C	
2	The storage of hazardous waste at a facility that has a capacity to store in excess of 80 m^3 of hazardous waste at any one time, excluding the storage of hazardous waste in lagoons or temporary storage of such wastes.

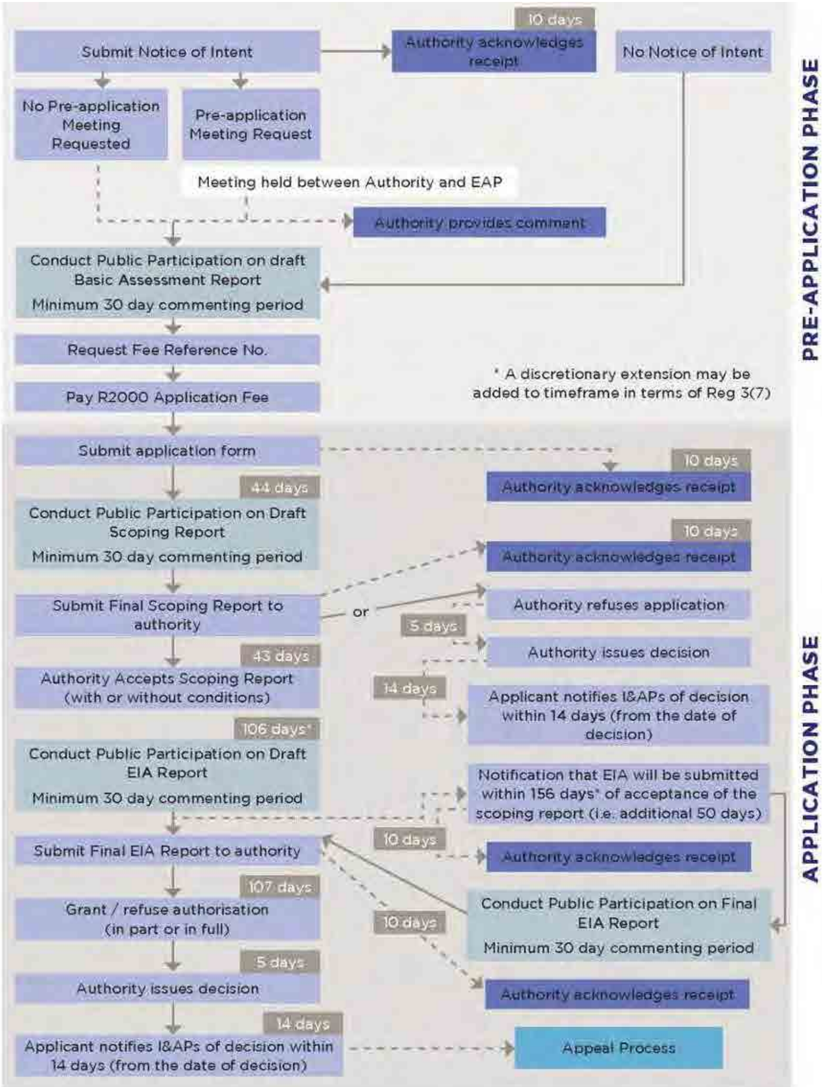
Source: Government Notice No.718 NEMA 2008 as amended GNR921 on 2013

The procedure and requirements for waste management license application is summarized in Table 11.3-5 and Figure 11.3-3.

Table 11.3-5 Processing of Waste Management License Application

Process	Step	Steps in Processing of Waste Management License Applications
Pre-application Process	1-1	Submit a notice of intent to apply for a WML to the LA (Licensing Authority)
	1-2	Set up a consulting meeting with the LA
	1-3	Submit a pre-application basic assessment report or pre-application scoping report for comment to the LA
	1-4	Conduct pre-application public participation process ("PPP") for a period not shorter than 30 days
Public Participation Process	2-1	Advertisement must be placed in at least two local newspapers or an official Gazette and at least in one provincial newspaper
	2-2	Any reports must be made available for public comment for a minimum of 30 days.
Basic Assessment Process (Category A)	3-1	Conduct basic assessment process as described in Regulation 19 of the EIA Regulations, 2014
	3-2	Once the LA has reached a decision, the LA has to inform the applicant of the decision in writing within five days
Scoping and Environmental Impact Reporting Process (Category B)	4-1	Conduct basic assessment process
	4-2	Once the LA authority has reached a decision, the LA has to inform the applicant of the decision in writing within five days,
	4-3	The applicant must notify all I&APs of the outcome of the application, reasons for the decision as well as the date of the decision within 14 days.

Source: National Environmental Management Waste Act, 2008 (Act No. 59 of 2008)



Source: Waste Management License Guideline 2017, Western Cape Government

Figure 11.3-3 Scoping and EIR Process Flow for Waste Management License Application

11.3.4. National Water Act

The activities associated with the proposed Medupi FGD retrofit project triggered some of the water uses that are defined in Section 21 of the National Water Act, 1998 (Act No. 36 of 1998) (NWA). Accordingly, these water uses may not be undertaken without being granted a water use license from the DWS. In accordance with Sections 40 and 41 of the NWA (1998), a water use license application process will be carried out. In terms of the NWA (1998), the following water uses would be triggered during the project, therefore, would require a water use license.

Table 11.3-6 Water Use Activities Listed in Section 21 of National Water Act, 1998 (Act No. 36 of 1998)

Activity Number	Description of Listed Activity
Section 21 of National Water Act, 1998 (Act No. 36 of 1998)	
a	Taking water from a water resource
g	Disposing of waste in a manner which may impact on a water resource.
h	Disposal of water that has been heated within a power generation process.

Source: National Water Act, 1998 (Act No. 36 of 1998)

The procedure and requirements for water use license application are summarized in Table 11.3-7

Table 11.3-7 Timeframes for Receiving and Steps in Processing of Water Use License Application

Step	Steps in Processing of Water Use License Applications	Maximum Days Allocated	Cumulative Days	Responsible
0	Pre-application enquiry	0	0	Applicant / Responsible authority
1	Application submitted	1	1	Applicant
2	Responsible authority acknowledges receipt of the application	10	11	Responsible authority
3	Applicant confirm arrangement for site inspection with an allocated case officer	5	16	Applicant
4	Site inspection to confirm water uses, determine information requirements and the need for public participation	20	36	Responsible authority / Applicant
5	Confirm requirements for water use license application technical report based on site visit and meeting	5	41	Responsible authority
6	Compilation, consultation and submission of water use license application technical report by applicant	105	146	Applicant
7	Reject/accept water use license application technical report	10	156	Responsible authority
8	Assessment	139	295	Responsible authority / Applicant
9	Decision and communication to applicant	5	300	Responsible authority

Source: Water Use License Application and Appeals Regulation, 2017 (Act No. 36 of 1998)

11.4. Alternative Analysis

(1) No-project Scenario

No-project means that it is intended to continue the operation of the power station without the FGD retrofit. This option would result in the Medupi TPS operating in contravention of the conditions of its Atmospheric Emission License (AEL); and under these circumstances, to remain compliant to legislation, the Medupi TPS would need to shut down its operations. This would have a catastrophic impact on the South African economy and the stability of electricity supply to southern Africa. Therefore, a no-go option is unrealistic scenario, and the FGD retrofit project of Medupi TPS is essential for the improvement of air quality and continuous supply of electricity.

(2) Alternative Analysis for Technology to be Used

The alternative analysis was conducted for technology to be applied for desulphuration, namely; Wet FGD and FGD - Circulating Fluidized Bed (CFB). As a result, it was concluded that the installation of Wet FGD (WFGD) facilities is considered as the feasible technology after the evaluation of suggested alternatives in the following table. The optional locations for installation were not considered since the FGD is supposed to be installed to the existing Medupi TPS and the available layout is limited.

Table 11.4-1 Alternative Analysis for Technology Used

Item	Wet FGD	Dry FGD-CFB
Summary of Technology	This technology has a long history of application to fossil fueled power plants in units of all sizes and remains the predominant process utilized today.	A lime, water and fly ash-laden flue gas are mixed in a reactor to remove the sulphur dioxides from the boiler flue gas stream. CFB: Circulated Fluidized Bed
Technical and Operation	- WFGD technology has a long history of application to fossil fired generating facilities in units of all sizes. - WHGD has been used extensively around the world. - SO2 Removal Efficiency >98%	- There are DFGD technologies where a group of small flash dry modules are clustered together for parallel operation. - DFGD systems have been used for low sulphur fuels. - SO_2 Removal Efficiency > 90-95%
Cost	- Initial Cost: USD 982-1,122 million - Operational Cost (annual): USD 87.3 million	- Initial Cost: USD 1.483-1,623 mil. - Operational Cost (annual):USD 109.1 mil - There is a disadvantage of cost benefit. It is estimated that DFGD technology will result in a higher capital cost for implementation due to modifications required for existing ductwork design and the additional new fabric filter system. - The estimated operating expense for cost of DFGD is higher than the WFGD system, mostly due to the significantly higher cost of the lime reagent.
Environmental and Social Advantage	- It has a high removal efficiency on high sulphur coals and only requires a single absorber vessel per boiler. - It has a potential to contribute to the boarder socio-economic development of Lephalale and its surrounding areas due to WFGD flexibility of using lower quality limestone.	- There is no wastewater stream discharged by this process.
Disadvantage	- Generally, the wastewater generated from this technology will require further treatment process. - The amount of water used in this system is larger than the one from dry FGD-CFB technology.	- Fly ash generated in the process will require a disposal to landfill.
Evaluation	The installation of WFGD is considered as the feasible technology.	The use of DFGD is not economically feasible.

Source: Summarized by the JICA Study Teambased on the final environmental impact report for the proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

11.5. Scope of Impacts to be Assessed

(1) Procedure of Scoping for EIA

In order to assess the likely significant environmental and social impacts, conceivable environmental and social impacts by the project implementation were identified based on project description and overall environmental and social conditions in and around the project site. The impacts of pollution, natural environment, and social environment were classified as A to D in accordance with the following criteria, assuming no specific measures toward the impacts are taken:

A: Significant Negative Impact — A+: Significant Positive Impact
B: Some Negative Impact — B+: Some Positive Impact
C: Impacts are not clear, need more investigation
D: No impacts or impacts are negligible, no further study required

(2) Results of Scoping

The result of scoping for environmental and social impact assessment is shown in Table 11.5-1. These impacts were evaluated in each of the three stages separately, namely: pre-construction stage (PCS), construction stage (CS), and operation stage (OS).

FGD retrofit activities will occur predominantly within an impacted footprint. Due to the recent clearing of the site for the power station, there is very little natural environment remaining that could be impacted upon by the FGD Retrofit Project. It is anticipated that the FGD retrofit will not generate significant additional impacts.

Table 11.5-1 Results of Scoping for ESIA
(Pre-Construction Stage (PCS), Construction Stage (CS), and Operation Stage (OS))

	JICA Guideline	Impact Rating		Description
No	Item	PCS/ CS	OS	
Pollution				
1	Air Quality	B-	A+/ C	[CS] Some negative impacts on air quality are expected due to the operation of heavy equipment/vehicles incidental to construction activities. Dust will also be generated by excavation work for the water pipeline trench. [OS] There is a possibility of exhausted gases generated from the Thermal Power Station, although current emission gas concentration will be improved by this project.
2	Water Quality	B-	B-	[CS] There is a risk of temporary water pollution due to excavation, cutting, clearing the site, and wastewater discharge from the sanitation activities of construction workers. [OS] There is a possibility that wastes may generate a potentially significant impact to groundwater quality and surface water quality at disposal sites, if improperly managed. The wastewater from FGD will be treated and the clean water will be re-used in the plant. There is no factor to polluted surface water due to discharge from FGD.
3	Soil Contamination	D	D	It is not expected that the project will cause soil contamination due to common operation of heavy equipment/vehicles.
4	Solid Waste	B-	B-	[CS] There is a possibility that the construction works will generate solid waste in the construction stage. [OS]FGD technology will generate gypsum, sludge, and salts.
5	Noise and Vibration	B-	B-	[CS] Some negative impacts of noise are expected due to operation of heavy equipment/vehicles incidental to construction activities. The impact of vibration is not anticipated because there are no receptors in the surrounding area. [OS] Noise will be generated from operation house (e.g., electric generator). The impact of

No	JICA Guideline Item	Impact Rating PCS/CS	Impact Rating OS	Description
				vibration is not anticipated because there are no receptors in the surrounding area.
6	Ground Subsidence	D	D	It is not expected that the project will cause ground subsidence due to sufficient piling designed to avoid ground subsidence.
7	Offensive Odor	D	D	There is no factor to generate offensive odor.
8	Bottom Sediment	D	D	There is no factor to cause negative impact on the bottom sediment.
Natural Environment				
9	Protected Area	D	D	The FGD project site is planned in the existing Medupi Thermal Power Station. There is no protected area in and around the project site.
10	Ecosystem	C	C	The impact is negligible because the FGD plant is designed inside the existing Medupi TPS site. There is no sensitive and valuable flora, fauna, and biodiversity inside. Although the railroad yard site is within the Medupi TPS footprint, the part of the area has not been changed yet.
11	Hydrological Situation	D	D	The project uses surface water only and thus, no impact on groundwater and hydrological condition is expected in and around the project area.
12	Topography and Geographical Features	D	D	Construction of FGD facility will not change the topographical condition.
13	Soil Erosion	C	C	The impact is negligible because the FGD plant is designed inside the existing Medupi TPS site. Although the railroad yard site is within the Medupi TPS footprint, the part of area has not been changed yet. Soil erosion may occur in the construction and operation stage.
Social Environment				
14	Involuntary Resettlement	D	D	There is no possibility of involuntary resettlement due to the implementation of the project since the FGD project is planned in the existing Medupi TPS site. The water pipeline is planned in the existing Medupi TPS site or in the public land (road and railway). Therefore, there is no involuntary resettlement and no land acquisition.
15	Poor, Indigenous People and Ethnic Minority	D	D	No poor, indigenous people and ethnic minority groups live in and around the project site.
16	Local Economy such as Employment and Livelihood	B+	B+	[CS/OS] Employment opportunity might be created due to the project implementation.
17	Land Use	D	D	There is no factor to cause negative impact on land use since FGD structure is designed inside the existing Medupi TPS site.
18	Water Usage or Water Rights	D	C	[CS]There is no negative impact on water usage or water rights. [OS] FGD technology increases the amount of water use.
19	Social Institutions	D	D	Physical community division is not expected due to project implementation.
20	Existing Social Infrastructure and Services	C	C	The impact is negligible because FGD structure is designed inside the existing Medupi TPS site. The increase in traffic volume is anticipated during the construction stage and operation stage. The water pipeline will be planned to cross the existing public infrastructures (road and railway).
21	Misdistribution of Benefit and Damage	D	D	Misdistribution of benefit and damage is not expected because the project is a public service.
22	Local Conflicts of Interest	D	D	Local conflicts of interest due to project implementation are not expected.
23	Cultural Heritage	D	D	No cultural heritage is located in/near the project site.
24	Landscape	D	D	The impact is negligible because FGD structure is designed inside the existing Medupi TPS site.
25	Gender	D	D	There is no possibility of negative impact on gender due to the implementation of the project since the construction and installation of infrastructure for the FGD retrofit will take place within the already developed Medupi TPS.

	JICA Guideline	Impact Rating		Description
No	Item	PCS/ CS	OS	
26	Children’s Right	D	D	There is no possibility of negative impact on children’s right due to the implementation of the project since the construction and installation of infrastructure for the FGD retrofit will take place within the already developed Medupi TPS.
27	Infectious Diseases such as HIV/AIDS	B-	A+	[CS] There is a possibility to increase the risks of infectious diseases due to the influx of construction workers into the project site. [OS] It is expected that sanitation conditions in the city will improve more than the current emission condition due to the FGD project.
28	Working Conditions	B-	B-	[CS/OS] Impact on the working conditions of workers is expected.
Others				
29	Accidents	B-	B-	[CS] There is a risk of accidents during construction works and transportation of heavy vehicles. [OS] Improper handling of facilities may cause accidents during the operation phase.
30	Global Warming	D	C	[CS] The impact is negligible because construction activities are temporarily. [OS] Although it is expected that quantity of greenhouse gas emission during the operation of Medupi TPS will not significant change from current situation due to the FGD project, Carbon dioxide emissions is increased due to the use of electricity for operation of FGD.

Source: JICA Study Team

Note: Project Stage: PC: Pre-Construction; C: Construction; O: Operation

Legend of Rating: A-: Significant Negative Impact A+: Significant Positive Impact
B-: Some Negative Impact B+: Some Positive Impact
C: Impacts are not clear, need more investigation
D: No impacts or impacts are negligible, no further study required

(3) Terms of Reference for the Preparation of EIA

According to the scoping results as described above and the environmental baseline and social conditions collected for the project area, the following tasks need to be carried out for the preparation of environmental social impact assessment of the project:

- Review the latest project description about major factors, which is affecting environmental conditions,
- Review the draft EIA report which is under preparation, as of end of September 2017,
- Review the monitoring report during construction and operation of Medupi TPS, and
- Review the result of site inspection.

Table 11.5-2 TOR for Preparation of EIA

	Environmental Items	Survey Item	Survey Method
1	Air Quality	i) Current air quality condition ii) Identification of project activities that will impact on air quality during operation ii) Current and/or proposed mitigation measures	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) and Appendix -Review the monitoring report during construction and operation of Medupi TPS
2	Water Quality	i) Current groundwater quality condition ii) Current and/or proposed mitigation measures	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) and Appendix -Review the monitoring report during construction and operation of Medupi TPS
4	Solid Waste	i) Disposal material flow of the project ii) Waste management plan iii) Current and/or proposed mitigation measures	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) and Appendix -Review the monitoring report during construction and operation of Medupi TPS
5	Noise	i) Current noise condition ii) Surrounding noise receptors condition ii) Current and/or proposed mitigation measures	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) and Appendix -Review the monitoring report during construction and operation of Medupi TPS
10	Ecosystem	i) Current situation of vegetation and floral communities ii) Current situation of faunal commutes iii) Current situation of watercourses, wetland and ephemeral systems iv) Proposed mitigation measures	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) and Appendix
13	Soil Erosion	i) Soil condition ii) Proposed mitigation measures	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) and Appendix
18	Water Usage or Water Rights	i) Latest water use plan	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) and Appendix - Review the documents regarding Mokoro and Crocodile (West) Water Argumentation Project (MCWAP) - Review the water source and water use plan in the wide area including project area
20	Existing Social Infrastructure and Services (Road traffic and Road and Railway)	i) Traffic volume of closest intersection at present and in the future ii) Latest water pipeline plan	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) and Appendix -Interview with the staff of Medupi FGD Project
27	Infectious Diseases such as HIV/AIDS	i) Current status of infectious diseases ii) Current and/or proposed mitigation measures	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) -Interview with the staff of Medupi TPS
28	Working Conditions	i) Regulation regarding to worker's safety health and environment ii) Current and/or proposed mitigation measures	-Review the Final EIA Report on Medupi FGD Retrofit Project (May 2018) -Interview with the staff of Medupi TPS
29	Accidents	i) Current accidents monitoring ii) Current and/or proposed mitigation measures	-Interview with the staff of Medupi TPS
30	Global Warming	i) Electric use for FGD	-Interview with the staff of Medupi TPS

Source: JICA Study Team

11.6. Study Result of Environmental and Social Considerations

The EIA study examined and assessed the possible impacts resulting from the proposed activities on the environment, human health, and other social surroundings, associated with the construction and operation of the FGD system within the Medupi TPS footprint and the railway yard and siding, including limestone and gypsum handling facilities, diesel storage facilities, and new access roads. This section describes the study result for specific items that were evaluated as A^- (significant negative impact), B^- (some negative impact) or C (Impacts are not clear, need more investigation) in the scoping study.

11.6.1. Air Quality

(1) Study result

1) Current air quality condition and NAAQ

The main findings of air quality monitoring data in 2013 and 2014 reviewed and provided for EIA study are summarized as follows:

- SO_2 concentrations infrequently exceeded the short-term (hourly) National Ambient Air Quality (NAAQ) limits at the monitoring stations located in Marapong and Lephalale. However, the frequency of exceedance does not exceed the NAAQS limits and it is within compliance with NAAQS.
- Currently, the Matimba Power Station is likely to be the main contributing source to the ambient SO_2 ground level concentrations in the study area due to the magnitude of its emissions. Other sources which may not contribute significantly due to their low release level include: spontaneous combustion of coal discards associated with mining operations, clamp firing emissions during brickmaking at Hanglip and potentially household fuel burning within Marapong.
- NO_2 concentrations infrequently exceeded short-term NAAQ limits (but are in compliance with NAAQS) at the monitoring stations located at Marapong and Lephalale. Low level sources of NOx in the region include combustion within coal discard dumps, brick firing operations and possibly also household fuel burning and infrequent veld burning.
- Measured PM10 concentrations exceed the daily NAAQS at Marapong for the period 2014 but are lower at Lephalale (where levels comply with daily NAAQS). On the other hand, PM10 concentrations exceed the NAAQS at Marapong for the period 2013 and 2014. PM2.5 concentrations at Marapong are within the NAAQS applicable till 2029 but exceed the more stringent NAAQS applicable in 2030.

(2) Prediction Result

1) Air quality in the construction stage

In consideration, the FGD plant will be designed inside the existing developed Medupi TPS, earthwork and activities of heavy vehicles are limited. The impacts from the construction activities were not assessed further as their impacts would be localized and of a temporary nature. The impacts from the railway siding and handling operations as well as vehicle entrainment from the new access road would contribute to the particulate matter. The diesel storage facility would contribute to volatile organic compounds. Impacts from these activities, however, will also be localized and will not exceed the National Ambient Air Quality Standards offsite. Meanwhile, the water pipeline, which is planned to connect the off-take point on the MCWAP Phase 2 and the Medupi FGD plant via the existing raw water reservoir in the Medupi TPS site, is expected to be approximately 5.3 km length and designed underground basically. The trench width is expected to be approximately 1800 mm for single pipe or 3600 mm for double pipes, and the total trench depth is expected to be 2000 mm to 2500 mm. Therefore, dust will be generated by excavation work for the water pipeline trench.

2) Air quality simulation at operation stage

Impacts on air quality by the operation of Medupi TPS with/without FGD were assessed by calculation of the air concentrations using a suitable atmospheric dispersion model based on the baseline air quality monitoring data and quantification of air emissions. The assessment of the significance of the impact was made through the comparison of simulated air concentrations with local NAAQSs. The summary of air quality simulation is shown in Table 11.6-1 below.

Table 11.6-1 Summary of Air Quality Simulation

Item		Contents
Simulation Model		Dispersion Model - USEPA&s CALMET Meteorological Model and CALPUFF Dispersion Model - Wind erosion model for quantification of fugitive emissions from ash dumps - In-house wind erosion model called ADDAS (Burger & Held, 1997; Burger, 2010)
Model Area		- Modeling domain: 50 km (east-west) x 50 km (north-south)
Meteorological Input Data		- Surface and upper air profiles for the period of 2011-2013
Prediction Scenario	Scenario 1	2014 Baseline: under operation of Matimba Power Station - Emission from the Matimba Power Station Stacks
	Scenario 2	2020 Baseline: under operation of Matimba Power Station and Medupi Power Station without FGD - Emission from the Matimba Power Station Stacks - Emission from the Medupi Power Station Stacks (all six units without FGD)
	Scenario 3	Proposed project operations under operation of Matimba Power Station and Medupi Power Station with FGD - Emission from the Matimba Power Station Stacks - Emission from the Medupi Power Station Stacks (all six units with FGD) - Fugitive dusts from the proposed ash dump under unmitigated operation (no controls in place)

Source: Summarized by JICA Study Team based on Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

The simulation result for each scenario is shown in Table 11.6-2 and the results of SO_2 distribution on-hour basis and 24 hours basis by mathematical model simulation are shown in Figure 11.6-1 and Figure 11.6-2, respectively.

Simulated impacts from the Matimba Power Station and the Medupi Power Station without FGD (2020 baseline) was in non-compliance with SO_2 NAAQS on a regional scale resulting in a moderate significance of impact. However, the area of non-compliance of SO_2 concentrations reduces significantly for proposed Project operations scenario and reduces the significance to the lower impact as no exceedances of the NAAQS are simulated at the closest sensitive receptors in the study area.

No exceedances of the NAAQS for NO_2, PM10 and PM2.5 were simulated at sensitive receptors due to proposed project operations, resulting in low significance of impact. Although the available monitoring data shows that the PM10 concentrations are non-compliant with the daily NAAQS at Marapong, the simulated impacts due to proposed project operations do not contribute significantly to current ambient particulate concentrations.

Table 11.6-2 Simulated Air Quality at the Closest Sensitive Receptors With/Without FGD at Medupi TPS

Pollutant and NAAQ	Scenario	Receptor (Predicted Point)	Frequency of Exceedance of Hourly NAAQ Limit		Frequency of Exceedance of Daily NAAQ Limit		Annual Average Concentration (μg/m³)		Within NAAQ
			Exceedance	NAAQ Limit	Exceedance	NAAQ Limit	Prediction	NAAQ	O.K./N.G.
SO2 1 hour: 350 μg/m³ 24hours:125 μg/m³ 1year:50 μg/m³	Senario1: 2014 Baseline	Settlement (NW of Matimba Power Station)	31	88	1	4	5.6	50	O.K.
		Marapong	22	88	2	4	4.3	50	O.K.
		Lephalale	24	88	1	4	4.2	50	O.K.
	Senario2: 2020 Baseline	Settlement (NW of Matimba Power Station)	89	88	6	4	11.8	50	N.G.
		Marapong	67	88	4	4	9.4	50	O.K.
		Lephalale	55	88	1	4	8.7	50	O.K.
	Senario3: Proposed Project Operations	Settlement (NW of Matimba Power Station)	34	88	2	4	8.0	50	O.K.
		Marapong	22	88	2	4	5.8	50	O.K.
		Lephalale	25	88	1	4	5.6	50	O.K.
NO2 1 hour: 200 μg/m³ 1year:40 μg/m³	Senario1: 2014 Baseline	Settlement (NW of Matimba Power Station)	3	88	NA	NA	1.0	40	O.K.
		Marapong	4	88	NA	NA	0.7	40	O.K.
		Lephalale	1	88	NA	NA	0.7	40	O.K.
	Senario2: 2020 Baseline	Settlement (NW of Matimba Power Station)	9	88	NA	NA	1.9	40	O.K.
		Marapong	4	88	NA	NA	1.5	40	O.K.
		Lephalale	1	88	NA	NA	1.4	40	O.K.
	Senario3: Proposed Project Operations	Settlement (NW of Matimba Power Station)	27	88	NA	NA	3.4	40	O.K.
		Marapong	14	88	NA	NA	2.6	40	O.K.
		Lephalale	5	88	NA	NA	2.0	40	O.K.
PM10 24 hours: 70 μg/m³ 1year:40 μg/m³	Senario1: 2014 Baseline	Settlement (NW of Matimba Power Station)	NA	NA	0	4	0.4	40	O.K.
		Marapong	NA	NA	0	4	0.3	40	O.K.
		Lephalale	NA	NA	0	4	0.3	40	O.K.
	Senario2: 2020 Baseline	Settlement (NW of Matimba Power Station)	NA	NA	0	4	0.7	40	O.K.
		Marapong	NA	NA	0	4	0.6	40	O.K.
		Lephalale	NA	NA	0	4	0.6	40	O.K.
	Senario3: Proposed Project Operations	Settlement (NW of Matimba Power Station)	NA	NA	0	4	0.7	40	O.K.
		Marapong	NA	NA	0	4	0.6	40	O.K.
		Lephalale	NA	NA	0	4	0.6	40	O.K.
PM2.5 24 hours: 40 μg/m³ 1year:20 μg/m³	Senario1: 2014 Baseline	Settlement (NW of Matimba Power Station)	NA	NA	0	4	0.4	20	O.K.
		Marapong	NA	NA	0	4	0.3	20	O.K.
		Lephalale	NA	NA	0	4	0.3	20	O.K.
	Senario2: 2020 Baseline	Settlement (NW of Matimba Power Station)	NA	NA	0	4	0.7	20	O.K.
		Marapong	NA	NA	0	4	0.6	20	O.K.
		Lephalale	NA	NA	0	4	0.6	20	O.K.
	Senario3: Proposed Project Operations	Settlement (NW of Matimba Power Station)	NA	NA	0	4	0.7	20	O.K.
		Marapong	NA	NA	0	4	0.6	20	O.K.
		Lephalale	NA	NA	0	4	0.6	20	O.K.

Source: Airshed Planning Professionals (Pty) Ltd, Air Quality Specialist Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Dec. 2016)

<table>
<tr><th>Senario</th><th>1 hour (NEQS:350μg/m3)</th></tr>
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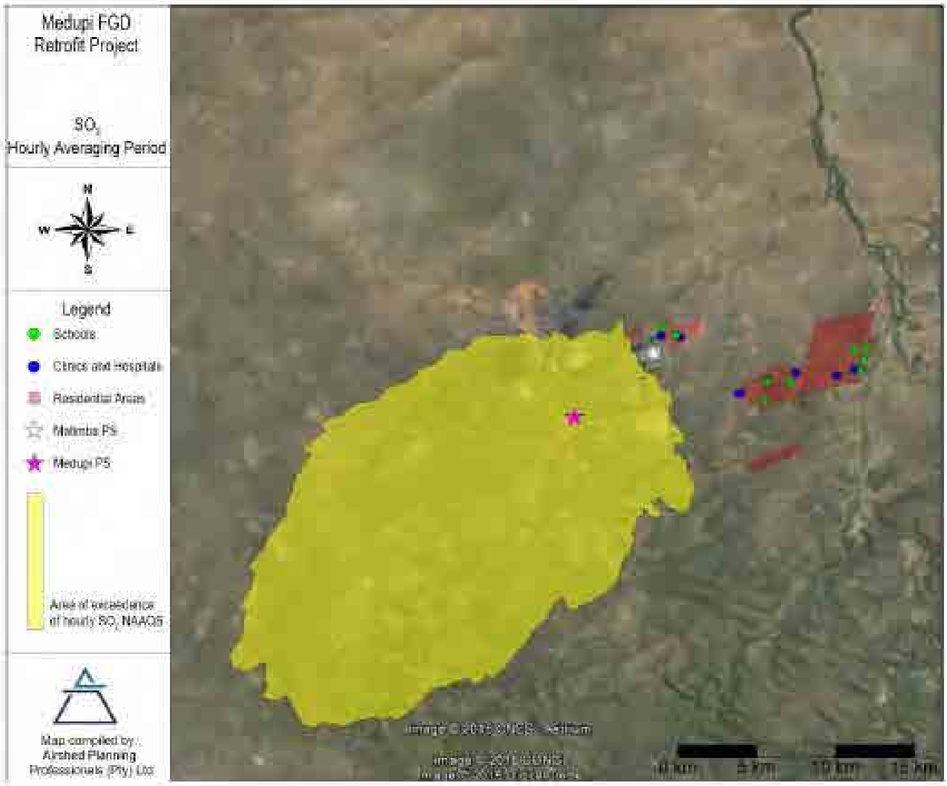
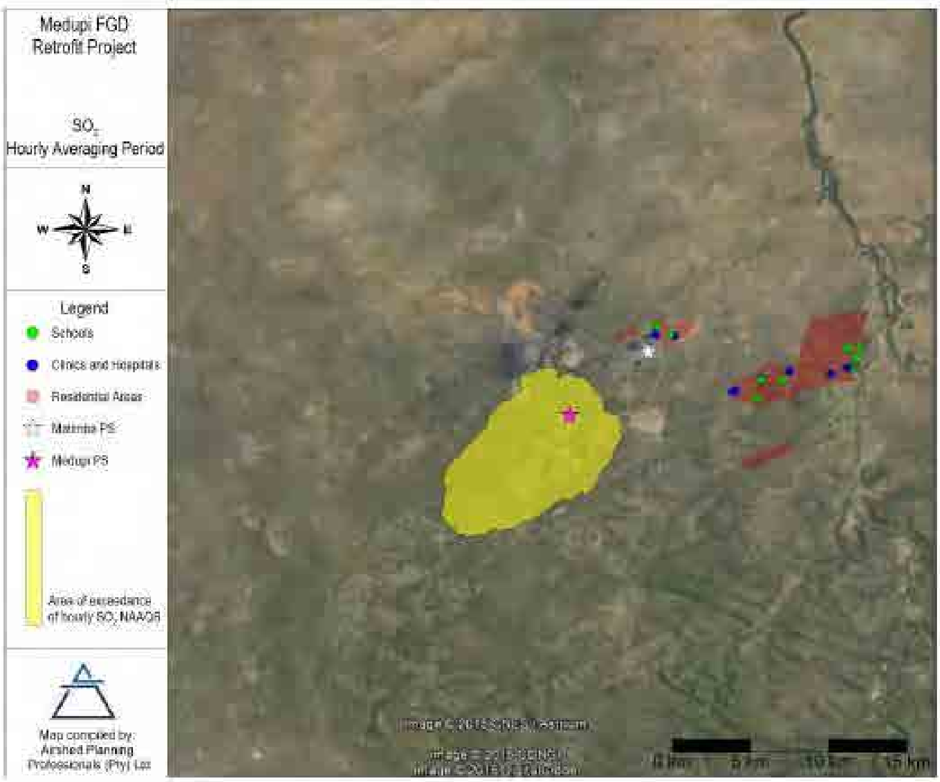
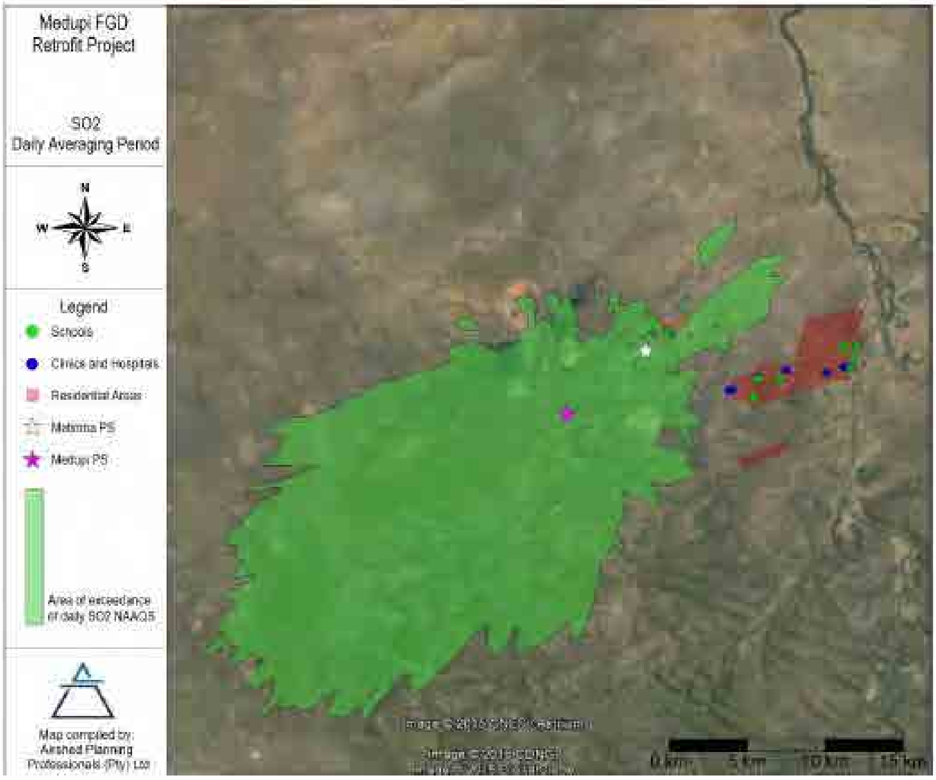
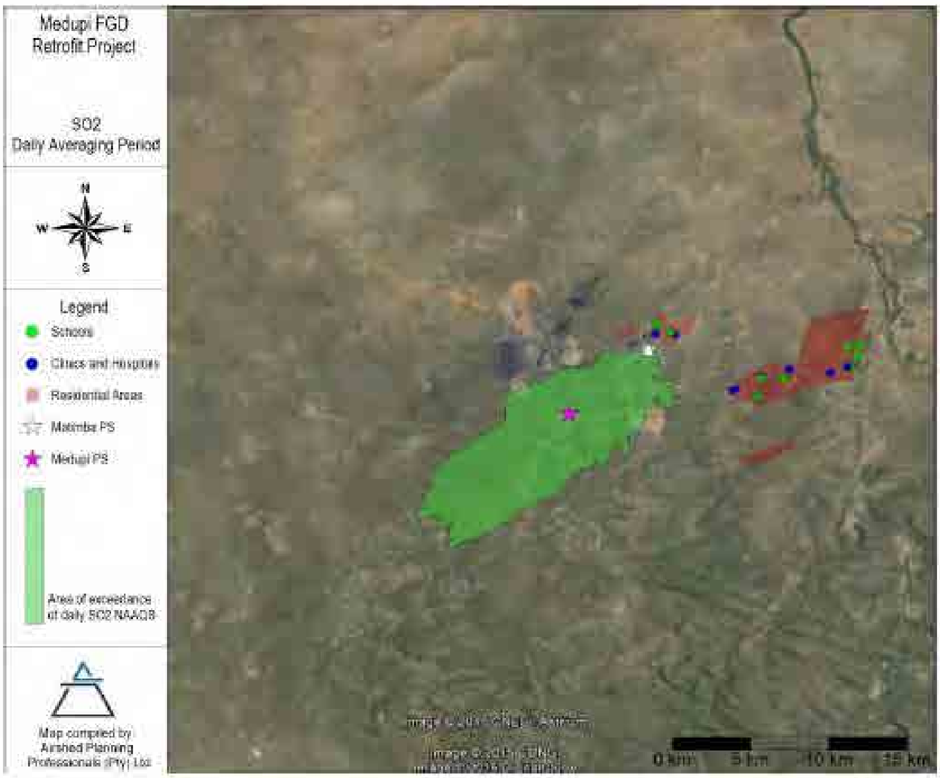
Without FGD
2020</td><td>
</td></tr>
<tr><td>Medupi TPS
With FGD
2020</td><td>
</td></tr>
</table>

Source: Airshed Planning Professionals (Pty) Ltd, Air Quality Specialist Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Dec. 2016)

Figure 11.6-1 Area of Exceedance of SO2 NAAQS With/Without FGD at Medupi TPS (1 hour)

Senario	1 hour (NEQS:350μg/m3)
Medupi TPS Without FGD 2020	
Medupi TPS With FGD 2020	

Source: Airshed Planning Professionals (Pty) Ltd, Air Quality Specialist Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Dec. 2016)

Figure 11.6-2 Area of Exceedance of SO2 NAAQS With/Without FGD at Medupi TPS (24 hours)

11.6.2. Water Quality

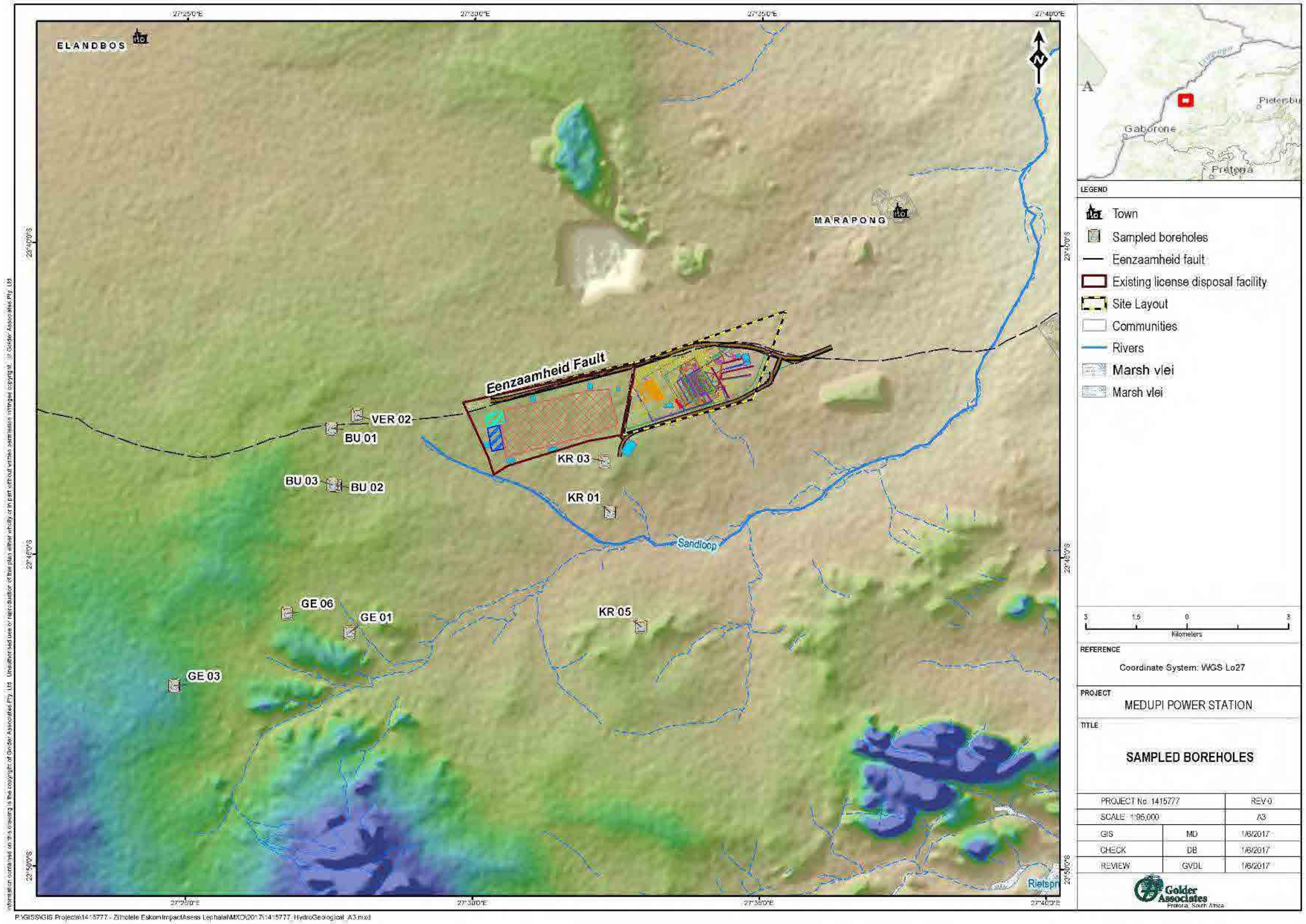
(1) Study result

1) Current groundwater quality condition

The groundwater quality data is obtained from the groundwater survey (10 points) conducted in the surrounding area of Medupi TPS in September 2015 and the regular groundwater monitoring (19 points) by Eskom in Medupi TPS area in 2016. The results are summarized as below.

Groundwater quality in the surrounding area (September 2015)

- The monitoring results are summarized in Figure 11.6-3, Table 11.6-3, and Table 11.6-4.
- The samples for the following parameters exceeded the South African National Standards (SANS) 241 (2011) maximum allowable standard; EC (2), TDS (2), Na (2), Cl (3), N (2), Al (3), F (4), Fe (5), and Mn (1), where the numbers in brackets indicate the number of boreholes in which these constituents exceeded.
- Two boreholes, i.e., BU02 and BU03 located on the west side of Medupi TPS, showed elevated nitrate values (Class II in the Department of Water Affairs and Forestry (DWAF) Guidelines; 16 mg/l and Class IV; 66 mg/l, respectively). This water quality poses chronic health risks and represents poor and unacceptable water quality. The elevated nitrate concentrations are probably related to point- source pollution caused by animal farming and stockades.
- Classified by DWAF guidelines, the background groundwater quality of the existing licensed disposal facility is marginal (Class 2) to poor (Class 3 - 4) water quality.



Source: Hydrogeological Impact Assessment for Medupi FGD Retrofit Project, February 2018

Figure 11.6-3 Groundwater Monitoring Points around Medupi TPS (Year 2015)

Table 11.6-3 Groundwater Analytical Results around Medupi TPS (Year 2015) (1)

Borehole Number	Physical Determinants			Chemical Determinants				
	pH	EC (mS/m)	TDS (mg/l)	MALK (mg/l)	Ca (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)
KR05	7.3	31	180	160	14.57	2.601	<2	52.47
BU03	7.3	288	1896	292	186.4	22.59	95.25	237.8
KR01	5.7	15.7	116	8	6.462	6.399	3.619	11.21
KR03	5.4	27.4	198	8	11.26	6.992	5.197	23.29
BU02	7.5	204	1320	288	135.4	16.99	64.56	194.8
VER02	7.4	112	652	356	77.3	15.34	34.14	108.1
BU01	7.5	178	1058	368	81.3	18.44	54.05	194.4
GE03	7.8	124	670	276	23.38	6.421	16.57	200.1
GE01	7.1	12.2	84	48	3.492	2.483	1.525	16.91
GE06	7	39.6	248	208	31.94	2.945	26.2	11.87
SANS241: 2011 Max. Allowable Limit	9.7	<170	1200	-	-	-	-	200
Class 0 Max. Allowable Limit	9.5	<70	<450	-	<80	<25	<70	<100
Class 1 Max. Allowable Limit	10	150	1000	-	150	50	100	200
Class 2 Max. Allowable Limit	10.5	370	2400	-	300	100	200	400
Class 3 Max. Allowable Limit	11	520	3400	-	>300	500	400	1000
Class 4 Max. Allowable Limit	>11	>520	>3400	-		>500	>400	>1000
South African Water Quality Guidelines (SAWQG), Volume 5 – Agricultural Use – Livestock Watering Target Range	-	154	1000	-	1000	-	500	2000
Minimum	5.4	12.2	84	8	3.492	2.483	<2	11.2
Maximum	7.8	288	1896	368	186.4	22.59	95.250	237.8
Average	7	103.19	642.2	201.2	57.1504	10.1201	30.311	105.1

Note1 : Department of Water Affairs and Forestry: DWAF Guidelines 1998 Water Category : Class0: Ideal water quality, Class1: Good water quality, Class2: Marginal water quality, water suitable for short-term use only, Class3: Poor water quality, and Class 4: Unacceptable water quality

Note2: Red highlighted figure means the result exceeds limits of upper level of SANS241:2011

Source: Hydrogeological Impact Assessment for Medupi FGD Retrofit Project, February 2018

Table 11.6-4 Groundwater Analytical Results around Medupi TPS (Year 2015) (2)

Borehole Number	Chemical Determinants							Water Quality Class
	Cl (mg/l)	NO3 as N (mg/l)	SO4 (mg/l)	Al (mg/l)	F (mg/l)	Fe (mg/l)	Mn (mg/l)	
KR05	9	<0.2	8	0.715	0.3	2.143	0.044	III
BU03	664	66	62	0.1	2.2	0.108	<0.025	IV
KR01	25	<0.2	24	0.576	0.9	7.056	0.068	I
KR03	36	2	51	2.207	2.7	0.566	0.138	III
BU02	518	16	36	0.255	2.2	6.59	0.775	III
VER02	167	0.5	40	<0.100	1.3	3.614	0.324	III
BU01	336	<0.2	71	0.103	2.3	1	0.09	II
GE03	280	<0.2	41	<0.100	0.7	0.042	0.122	II
GE01	18	<0.2	<5	0.13	<0.2	4.817	0.131	III
GE06	17	0.3	<5	<0.100	<0.2	0.03	0.065	0
SANS241: 2011 Max. Allowable Limit	300	11	500	0.3	1.5	0.3	0.5	
Class 0 Max. Allowable Limit	<100	<6	<200	-	<0.7	<0.01	<0.1	0
Class 1 Max. Allowable Limit	200	10	400	-	0.7-1.0	0.01-0.2	0.1-0.4	I
Class 2 Max. Allowable Limit	600	20	600	-	1.0-1.5	0.2-2.0	1.0-4.0	II
Class 3 Max. Allowable Limit	1200	40	1000	-	1.5-3.5	2.0-10.0	4.0-10.0	III
Class 4 Max. Allowable Limit	>1200	>40	>1000	-	>3.5	>10.0	>10.0	IV
South African Water Quality Guidelines (SAWQG), Volume 5 – Agricultural Use – Livestock Watering Target Range	1500	1000	100	5	2	10	10	
Minimum	9	<0.2	<5	<0.100	<0.2	0.030	<0.025	
Maximum	664	66.0	71	2.207	2.7	7.056	0.775	
Average	207	8.6	34	0.439	1.3	2.597	0.178	

Note1 : Department of Water Affairs and Forestry: DWAF Guidelines 1998 Water Category : Class0: Ideal water quality, Class1: Good water quality, Class2: Marginal water quality, water suitable for short-term use only, Class3: Poor water quality, and Class 4: Unacceptable water quality

Note2: Red highlighted figure means the result exceeds limits of upper level of SANS241:2011

Source: Hydrogeological Impact Assessment for Medupi FGD Retrofit Project, February 2018

Groundwater quality in this project area (November 2016)

- The monitoring location and results are shown in Figure 11.2-5, Table 11.2-4, and Table 11.2-5, respectively.
- The water quality of the existing boreholes is largely poor in quality with DWAF classes ranging from ideal (Class 0) to unacceptable (Class 4) water quality.

2) Surface water quality

These nonperennial streams in the area, represented by the Sandloop River were found to be seasonal and only likely to flow after rainfall events. The general drainage of the area is in the easterly direction towards the Mokolo River. Due to lack of flow, water quality sampling points were dry and no water samples were collected in the site survey of surface water impact assessment. The water quality data in the surrounding area was obtained from the Wetland Assessment (Natural Scientific Services, 2015) and utilized for water quality analysis. The only concerns were noted for ammonia (0.10 – 2.80 mg/L) which is likely caused by livestock activities in the upper stream area.

With regard to the surface water quality management, the existing water management system (EWMS) at Medupi TPS should be noted with the two major functions as summarized below.

- A dirty water management system to ensure that polluted water from the power station and its associated infrastructure, including the existing ash disposal facility (ADF), as well as sediment-laden runoff from disturbed areas is separated from clean area runoff and it is collected in pollution control dams (PCD); and
- A clean water management system to divert water undisturbed by the power station's operations around the disturbed project footprint.

(2) Prediction and result

1) Groundwater quality

The qualitative assessments were undertaken for each aspect/activity of the project components and stage as summarized in the table below. There would be some negative impacts during the construction and operation of FGD system and associated infrastructures.

Table 11.6-5 Impact Assessment of Groundwater Quality by FGD Project

Activity/Project Stage			Positive Impacts	Negative Impacts
Trucking of Type 1 waste to a hazardous disposal facility	OS	Removal of hazardous waste from existing licensed waste disposal facility	Removal of contamination source	None
		Transportation of hazardous waste to a licensed hazardous waste disposal site	Removal and transportation of hazardous waste	None
		Spillage during transportation of hazardous waste	None	Contamination of groundwater, impacting on existing users in the vicinity of spillage
		Disposal of hazardous waste	Disposal of hazardous waste	None
Installation of FGD system	CS	Construction of FGD	None	Moderate impact by temporary water pollution due to inappropriate construction works
	OS	Operation of FGD	There is no discharge water from FGD system, since Closed Cycle Cooling Water System will be adopted.	None
Installation of railway yard, limestone and gypsum handling facilities including diesel storage facilities and associated infrastructure between the Medupi TPS and existing ADF	CS	Construction of railway yard, limestone and gypsum handling facilities	None	There is a possibility of moderate impact by temporary water pollution due to inappropriate construction works
	OS	Operation of railway yard, limestone and gypsum handling facilities and associated infrastructure	None	Moderate impact if any accidental spillages happen during transportation of hazardous waste.
Installation of the water pipeline from MCWAP phase2 to FGD plant in the Medupi TPS site	CS	Excavation activities for the installation of the water pipe	None	There is a possibility of moderate impact by temporary water pollution due to inappropriate construction works

Source: Summarized by JICA Study Team based on the Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

2) Surface water quality

The construction work of FGD system, railway yard, and associated infrastructure including the water pipeline would cause some minor pollution impacts on the natural surface water quality, but quite limited due to the existing storm water management system (SWMS). Cumulatively, there is no expectation for further impact to the environment because the proposed project area is located apart from the natural surface water stream or river.

In addition, the trucking of salts and sludge from Medupi to the licensed hazardous waste site will not pose a serious threat to water resources in the study area and region.

11.6.3. Solid Waste

(1) Study result

1) Key waste stream of the Project operation

According to the waste assessment report (Jones & Wagener (Pty) Ltd, January 2015), the FGD plant and the FGD WWTP operation will generate three waste streams, namely: FGD gypsum, FGD WWTP sludge, and FGD WWTP crystallizer solids.

- FGD gypsum: Medupi will be retrofitted with a wet limestone forced oxidation FGD system, in which limestone ($CaCO_3$, sorbent) reacts with gaseous SO_2 to form non-toxic gypsum crystals ($CaSO_4 \bullet 2H_2O$, byproduct). In the case of the Medupi Power Station two limestone qualities are considered for usage, namely: 85% limestone and 96% limestone.

$$CaCO_{3\,(aq)} + SO_{2\,(g)} \rightarrow CaSO_{3\,(aq)} + CO_2$$

$$CaSO_{3\,(aq)} + \tfrac{1}{2}\,O_{2\,(g)} \rightarrow CaSO_4.2H2O_{(s)} \text{ (gypsum)}$$

- FGD wastewater treatment plant (WWTP) sludge and FGD WWTP crystallizer solids：sludge and salt are produced as byproduct from WWTP

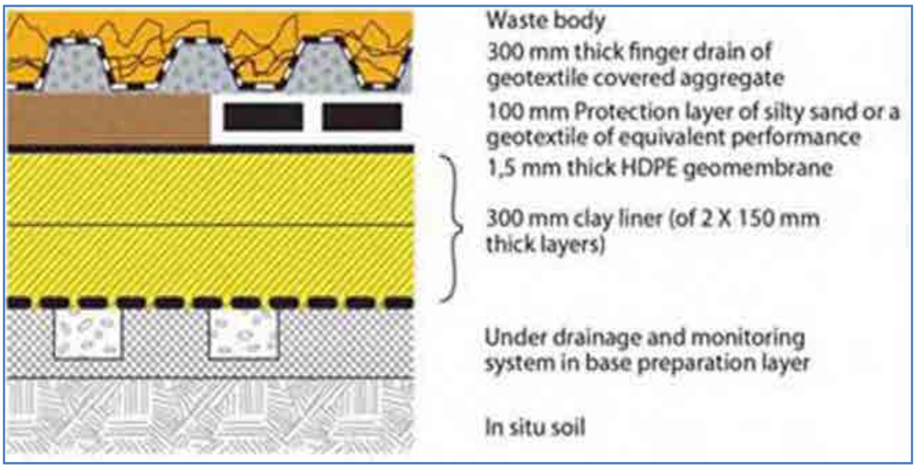
2) Waste management plan

The current waste management license (WML) was issued for ADF of Medupi TPS in 2015. The amendment application for disposal of FGD was submitted to DEA in March 2018. The application mentioned the proposed change of the specific type of waste from “ash only” to “ash and gypsum”.

The Integrated Water and Waste Management Plan (IWWMP) attached with the Integrated Water Use License Application (IWULA) for the FGD project was submitted in June 2018. The application of IWWMP described the waste (ash and gypsum) disposal facility and the management method of by-products generated by wastewater treatment from FGD as follows:

Waste Management Facility (Ash and gypsum)

According to the waste classification as per the NEM:WA National Norms and Standards for Disposal of Waste to Landfill, which determines the barrier (liner) system required for the waste disposal facility, the FGD gypsum would classify as a Type 3 waste and would be disposed of on a Class C liner (see figure below). FGD gypsum will be conveyed to a connection point with the existing overland ash conveyor system that delivers ash to the disposal facility. The disposal facility located on 1,000 ha is prepared adjacent to the west of Medupi TPS facilities, and operation of facility has already been started for ash from Medupi TPS. Assuming an ash deposition rate of 791,452.50 m^3, i.e., including gypsum deposition,



the total storage value comes to193,315,105 m^3, which converts to a total life of 19.2 years.

Source: "Norms and Standards for the Assessment of Waste for Landfill Disposal" (National Norms and Standards) promulgated in the form of Government Notice Regulations (GNR) 635 (DEA, 2013a)

Figure 11.6-4 Class C Landfill Barrier System

FGD WWTP Sludge and Salt

Chemical sludge and salts produced as by-products of the WWTP will be temporarily stored in appropriately designed storage facilities next to the WWTP. The storage facilities will have a 7-day storage capacity in line with the Norms and Standards for the Storage of Waste (GN926 of 29 November 2013). The footprint of the impermeable concrete surface bed where the waste will be handled and stored is 2,370 m^2. This is assuming that the waste is stored at a height of 0.6 m. The perimeter of the facility will have 2 m high reinforced concrete walls. An estimate of the waste quantities of FGD WWTP sludge 85% and 95%, limestone is 2.7 or 5.0 m^3/h, respectively. The transportation of salts and sludge via trucks from the temporary waste storage facility to licensed landfill site categorized as Class A to be contracted by Eskom.

(2) Prediction result

1) Impacts in the construction stage

It is predicted that the construction work of FGD system and other associated facilities such as railway yard and limestone and gypsum handling facilities will generate some amount of waste. However, the waste will be classified, reduced, recycled or treated in accordance with the applicable regulations and Medupi TPS waste management system. Thus, it is considered that the waste issue will not cause any significant environmental impact.

2) Impacts in the operation stage

It is predicted that the construction work of FGD system and other associated facilities such as railway yard and limestone and gypsum handling facilities will generate some amount of waste. The excavation work for water pipeline trench will generate solid waste. However, the waste will be classified, reduced, recycled or treated in accordance with the applicable regulations and Medupi TPS waste management system. Thus, it is considered that the waste issue will not cause any significant environmental impact.

11.6.4. Noise

(1) Study result

1) Noise condition and the receiving environment

The baseline noise survey was conducted and Noise Sensitive Receptors (NSR) were identified prior to the impact prediction. The main findings are summarized as below.

- Several individual residential dwellings are located within a few kilometers from the Medupi TPS. There are also residential areas to the north and northeast of the Matimba Power Station.
- Baseline noise levels are affected by road traffic, mining activities, birds and insects. Noise levels in the vicinity of the Medupi TPS are currently comparable to levels typically found in suburban districts. Representative day-time and night-time baseline noise levels are 48.3 dBA and 43.7 dBA, respectively.

(2) Prediction result

1) Noise level during operation of FGD facilities

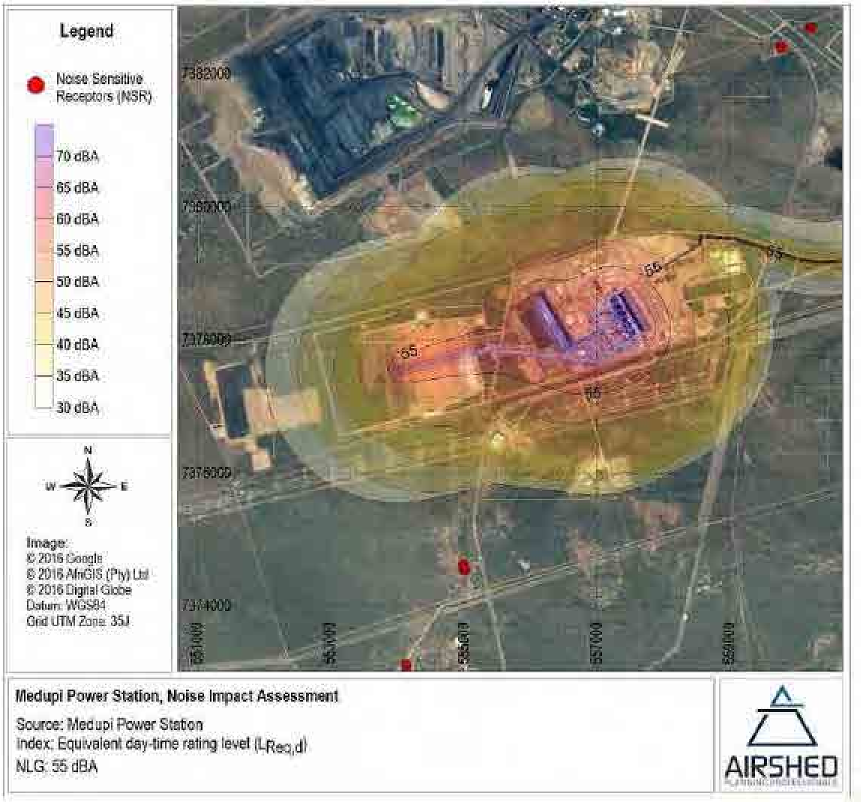
The noise level to be generated during the operational stage was calculated by an environmental noise prediction model with the conditions shown in Table 11.6-6. The results for the day-time and night-time simulation are presented in isopleth form in Figure 11.6-5 and Figure 11.6-6. The simulated noise levels were assessed against the International Finance Corporation (IFC) guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night) since these levels are applicable to nearby Noise Sensitive Receptors (NSRs) and are in-line with South African National Standards (SANS) 10103 guidelines for urban districts (55 dBA during the day and 45 dBA during the night). The IFC's 3 dBA increase criterion was used to determine the potential for noise impact. The results showed that the noise generated by the project operation will not exceed the selected noise guidelines at NSR surrounding the Medupi Power Station with an increase above the baseline of less than 3 dBA at all of the identified NSR. The operational phase will result in noise levels that do not exceed the selected impact criteria at the nearest NSR. "Little" to no reaction from individuals within this impacted area may be expected.

Table 11.6-6 Conditions of Noise Propagation Modelling

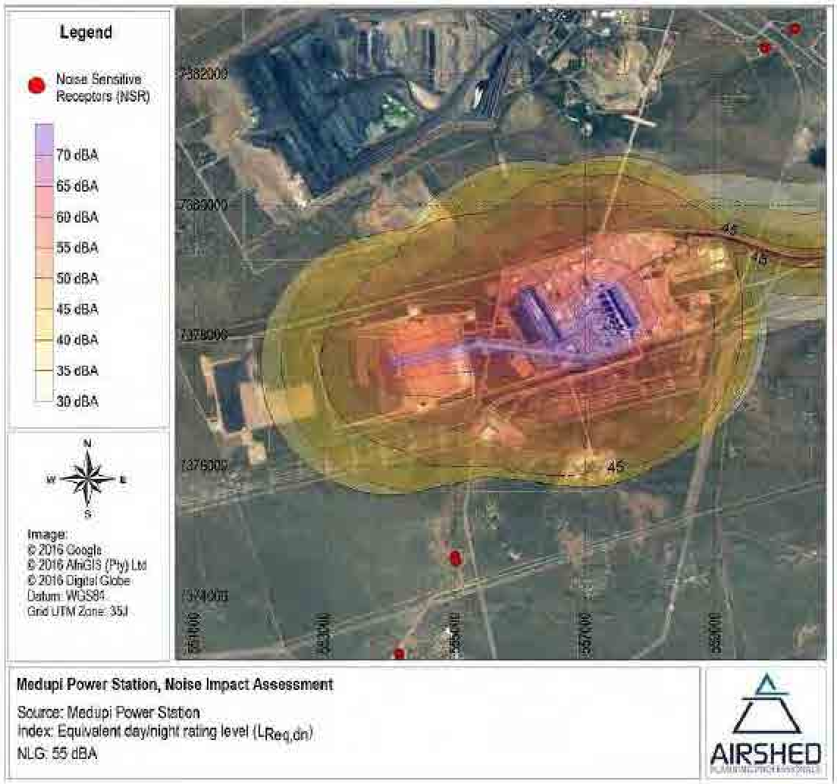
Item	Description
Baseline data	Noise survey data measured at three locations around the Medupi TPS in September 2015
Modelling area	10 km east-west by 10 km north-south
Noise source included in simulation	Main steam boilers, steam turbine-generator units, ball mills, ash stacker, coal and ash conveyors, conveyor transfer stations, general industrial noise (i.e., small pumps, conveyors, motors, coal handling etc.) and access road to transport the salts and sludge offsite.
Noise prediction model	Cadna A in accordance with ISO 9613 (Attenuation of sound during propagation outdoors)

Source: Summarized by JICA Study Team based on Noise Specialist Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Airshed Planning Professionals (Pty) Ltd, February 2018)

Day Time



Night Time



Source: Noise Specialist Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Airshed Planning Professionals (Pty) Ltd, February 2018)

Figure 11.6-5 Simulated Equivalent Continuous Rating Level for Project Activities (Leq, d/n)

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<td>Day Time</td>
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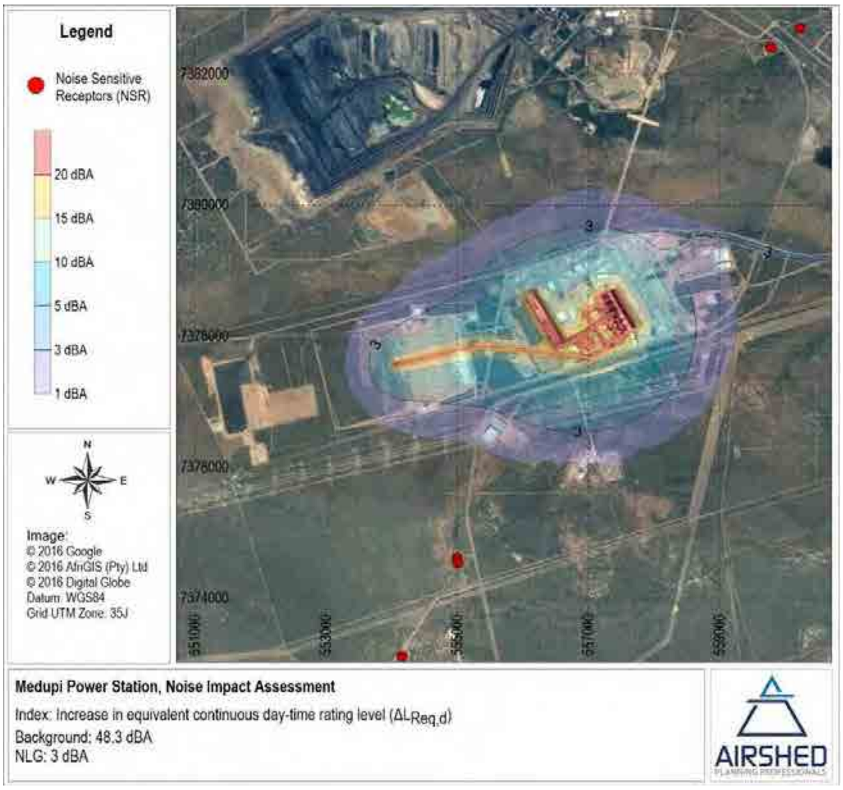

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<td>Night Time</td>
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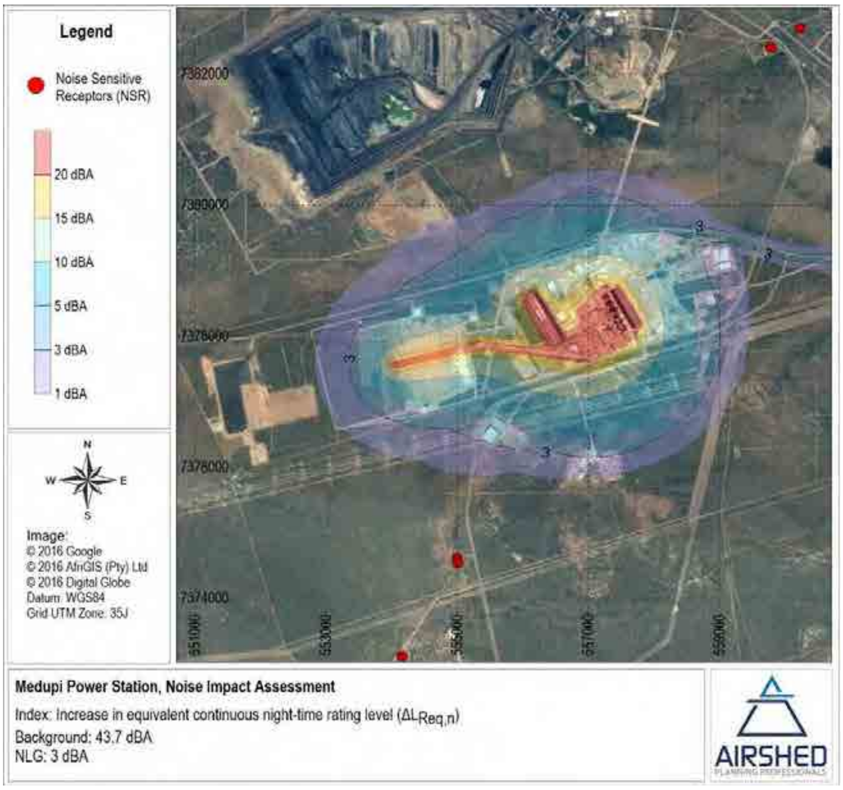

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Source: Noise Specialist Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Airshed Planning Professionals (Pty) Ltd, February 2018)

Figure 11.6-6 Simulated Equivalent Continuous Rating Level for Project Activities (ΔLeq, d/n)

11.6.5. Ecosystem

(1) Survey Result

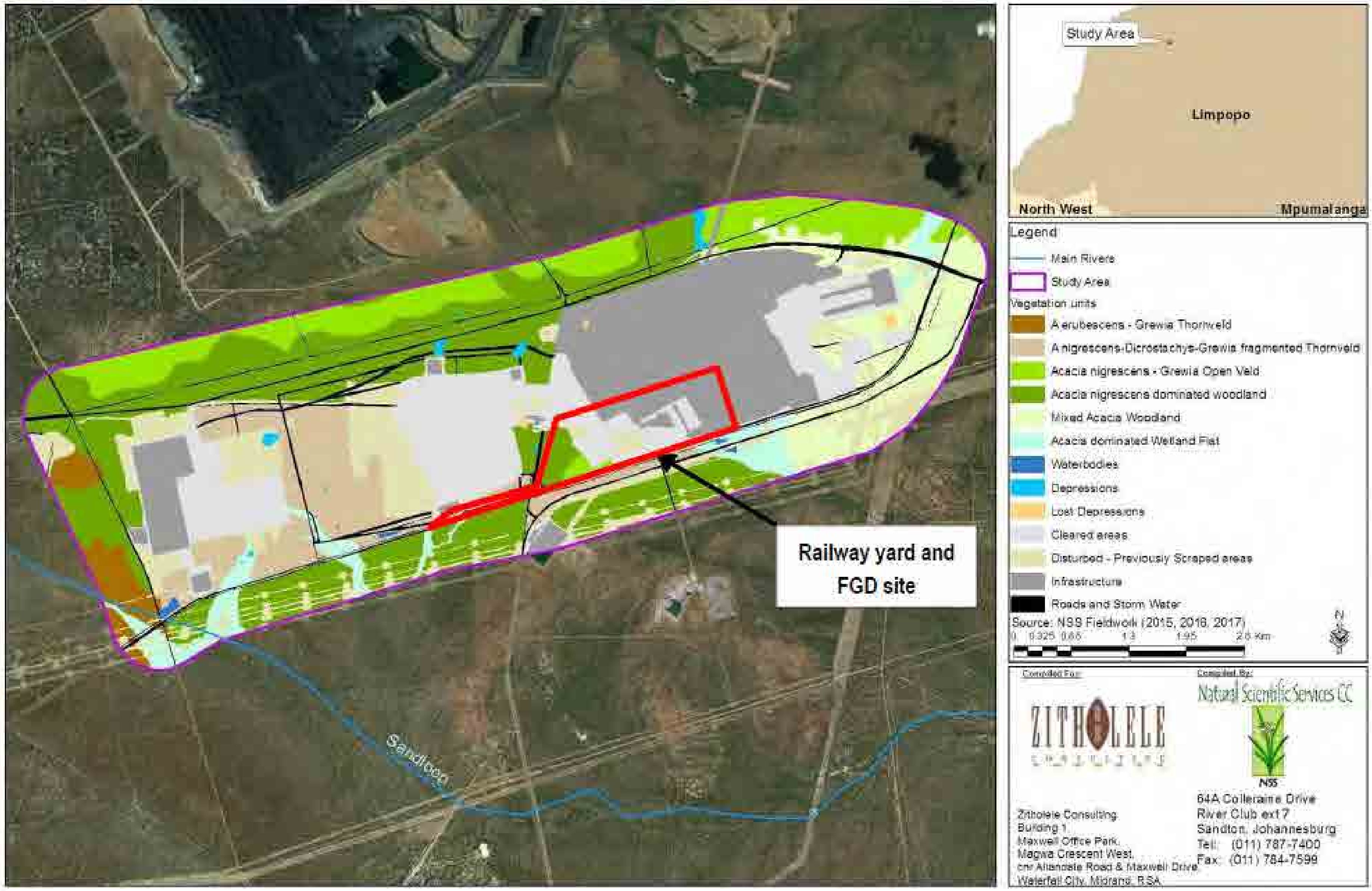
The study area investigated by the specialist (Natural Scientific Services) largely cover undisturbed areas within the existing Medupi TPS footprint is located, as well as a buffer area of 500 m outside the Medupi TPS property boundary. However, in this EIA only wetland resources and possible impacts within the proposed railway yard site or FGD infrastructure footprint within the MPS footprint, or within 500 m of these sites were considered.

1) Vegetation and Floral Communities

Figure 11.6-7 explains the vegetation units for the study area. The typical vegetation consists of short open woodland. In disturbed areas thickets of *Acacia erubescens*, *Acacia mellifera* and *Dichrostachys cinerea* are almost impenetrable. Vegetation communities identified within the study site are mainly Acacia dominated woodlands with associated wetlands and included: *Acacia nigrescens* Grewia Open Veld, and disturbed Acacia mixed woodland (). No wetlands, water bodies, depressions or washes are present within the railway yard FGD infrastructure footprint.

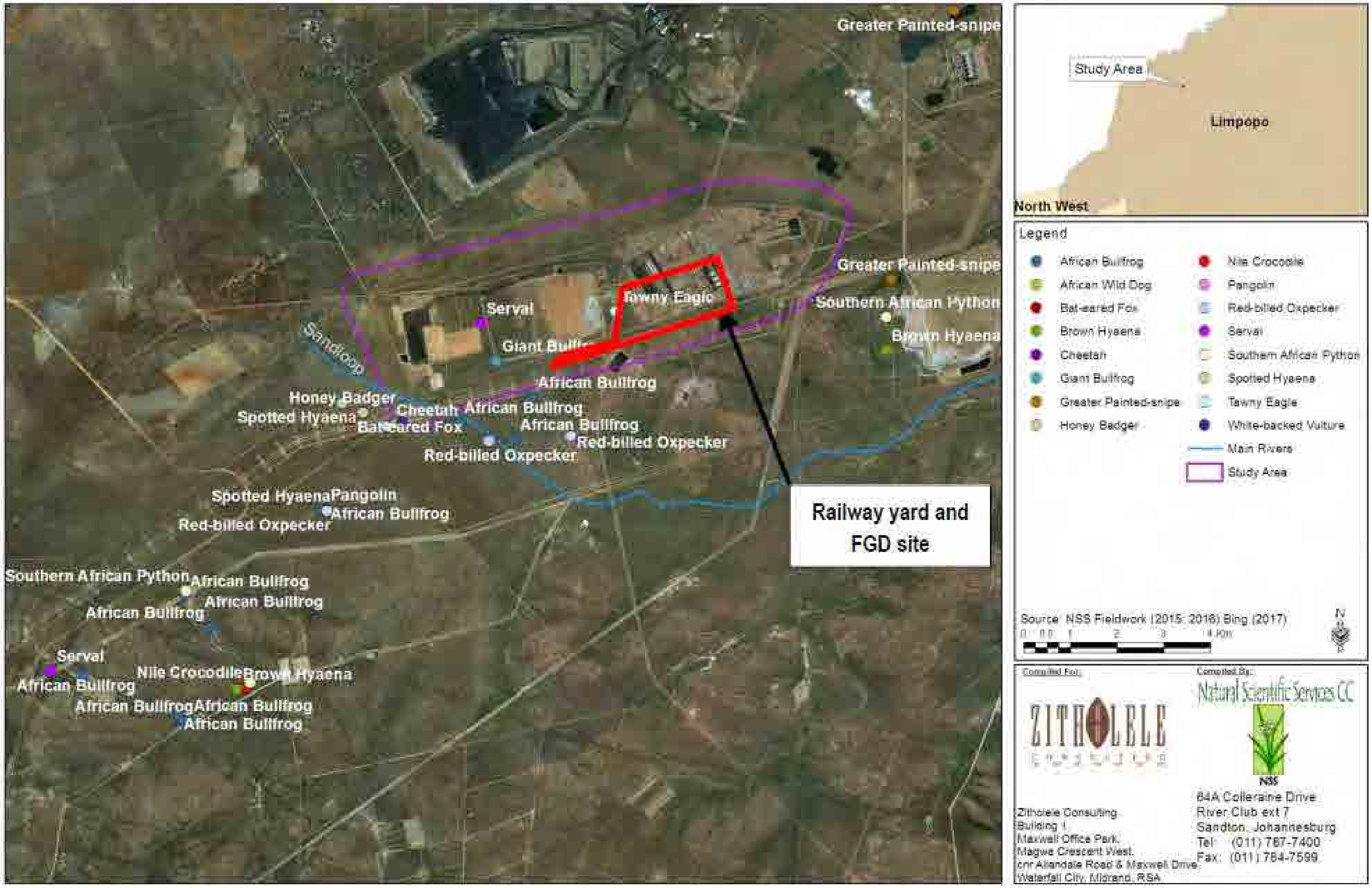
2) Faunal Commutes

Field survey and secondary data survey by NSS in and around the FGD study area yielded 43 mammals, 158 birds, 20 reptiles, 16 frogs, nine butterflies, two dragonfly and one scorpion species. Of all of these species, only the endangered Tawny Eagle was noted or recorded within the study site boundaries. Notable faunal observations in and around the FGD study area included Serval (Near Threatened, abbreviated as NT), Brown Hyaena (NT), Whitebacked Vulture (Endangered, abbreviated as EN), Tawny Eagle (Vulnerable, abbreviated as VU) and Red-billed Oxpecker (NT), African Bullfrog (Protected Species, abbreviated as PS) and Giant Bullfrog (NT). Figure 11.6-8 explains the distribution map of conservation important fauna in and around Medupi TPS. Identification situation and the number of habitats of all species mentioned above were not clarified because all secondary data does not include the detailed information.



Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

Figure 11.6-7 Vegetation Units for the study area (from Abell et. al. 2018)



Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

Figure 11.6-8 Localities of Conservation Important Fauna Surveyed in and around Medupi TPS (from Abell et. al. 2018)

3) Watercourses, Wetland and Ephemeral Systems

The Sandloop has a present ecological state (PES) of moderately modified (Category C) where the loss and change of natural habitats and biota have occurred but the basic ecosystem functions are still predominately unchanged. The Ecological Importance (EI) and Ecological Sensitivity (ES) are reported as moderate and low, respectively.

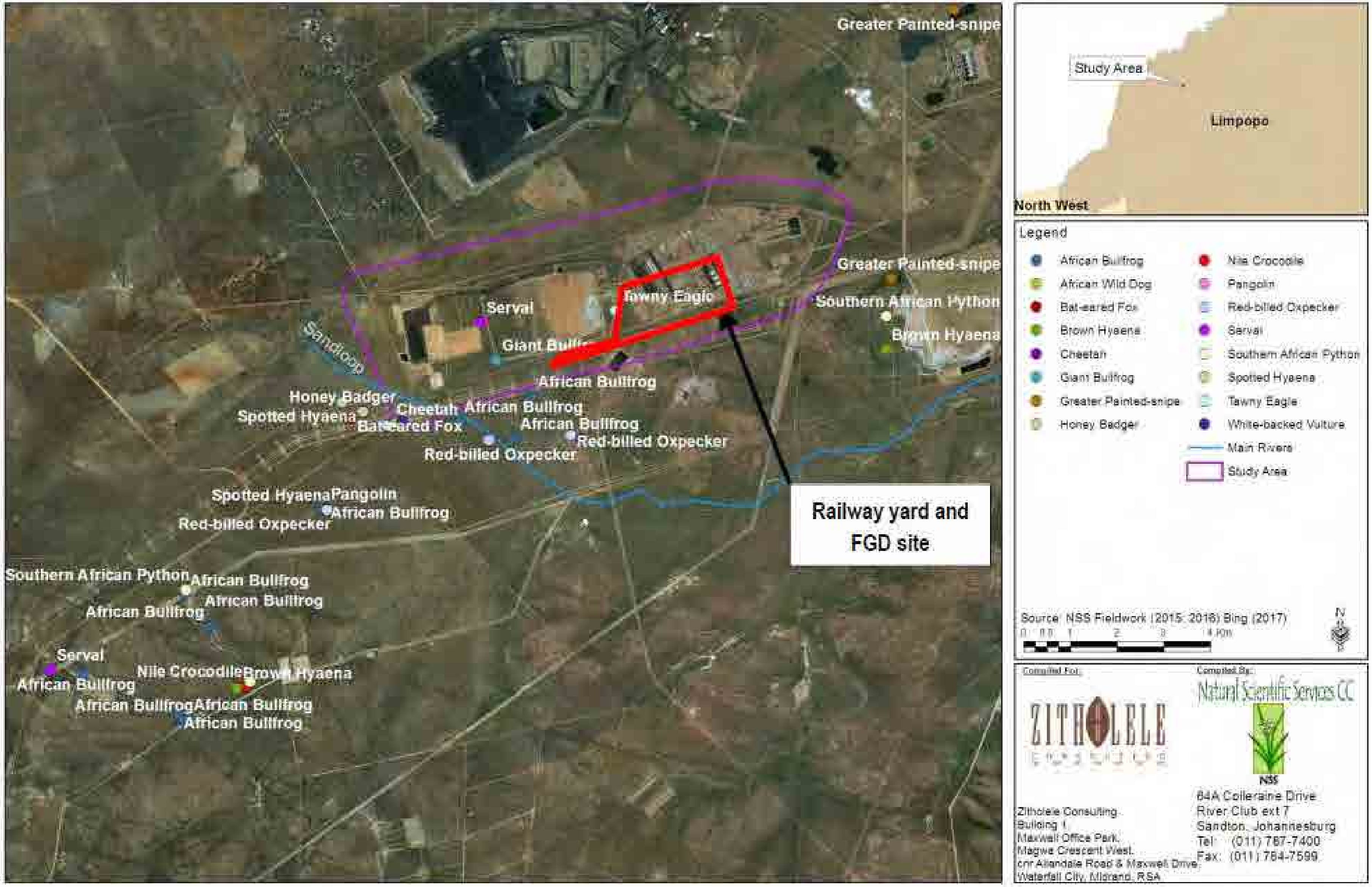
Four hydro-geomorphic (HGM) wetland units were identified surrounding the Medupi TPS, which include two south–east and one north–east draining washes (Semi Ephemeral/Wash (SEW) 1 – 3), and multiple inward-draining depressions (D1).

No wetland units were however identified within the study area, although SEW 2 is located just southeast of the study site outside the Medupi TPS property boundary. (Figure 11.6-9)

The railway yard and FGD infrastructure study site, including associated structures and infrastructure, furthermore do not impact directly on the Sandloop tributary.

The upper reaches of this system diagonally bisect the south western corner of the Medupi TPS ADF site and is classified as a Freshwater Ecosystem Priority Area (FEPA) in recognition of its reference site suitability as an upper foothill ephemeral system that is still in a largely natural state. The depressions identified within the greater study area surrounding the Medupi TPS are small in extent and ephemeral in nature.

NSS utilized the WET Eco Services tool to obtain an understanding on what ecosystem services the four hydro-geomorphic (HGM) units identified around the study area would provide. With all four units, the main service is Biodiversity Maintenance. This is evident during high rainfall events when these areas become inundated and provide breeding and foraging habitat for an array of species.



Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

Figure 11.6-9 Extent of Wetlands Identified Surrounding the Medupi TPS

(2) Prediction Result

1) Impacts in the construction stage

During assessment of the biodiversity and potential wetlands within the proposed FGD footprint, railway yard and associated infrastructure supporting these systems including the water pipeline, it was concluded that no direct impact occurred on wetlands within this footprint area. The closest wetland to the proposed infrastructure is situated outside the MPS just south of the proposed FGD infrastructure site. Impact on this wetland (referred to as SEW 2 in Figure 11.6-9) would be expected to be minor since the FGD infrastructure is situated within the footprint of the existing MPS.

A number of impacts relating to the potential loss of vegetation units and species, potential increasing of alien species, habitat and fauna mortality during the construction phase were identified and assessed.

Another prominent impact feature that was identified during the construction phase is the loss of catchment area contributing to stormwater runoff due to the need to separate and contain contaminated “dirty” water. Associated with this is an expected increase in flood peaks and pollution through contaminated runoff.

2) Impacts in the operation stage

Impacts identified relating to the operational phase of the Medupi TPS FGD and railway yard are largely a continuation of the impacts that emerged during the construction phase. Loss of catchment area for small wetland on the south side of Medupi TPS and decreased water inputs remain after construction, while vehicle traffic within the Medupi TPS footprint remains a threat to the fauna present on the Medupi TPS footprint.

11.6.6. Soil Erosion

(1) Survey Result

The fine to medium grained nature of the topsoil, the relatively low clay contents (<12%), and the generally low organic carbon render the majority of the topsoil highly sensitive to erosion. This is only tempered by the relative flatness of the topography for all but in few areas, with a resultant moderate to low erosion index for most of the site if not well protected. Once the cover is disturbed or removed, the potential for erosion is increased.

(2) Prediction Result

Most part of the project area has been already cleared and developed for construction of Medupi TPS. This project will require some additional soil excavation and removal for construction of related infrastructures. The underground water pipeline is expected to be approximately 5.3 km length, the trench width is expected to be approximately 1800 mm for single pipe or 3600 mm for double pipes, and the total trench depth is expected to be 2000 mm to 2500 mm. Therefore, the pipeline trench will be excavated. The removal of vegetative cover and/or topsoil would cause a soil erosion by wind and water although this area has little precipitation.

11.6.7. Water Usage or Water Rights

(1) Study result

1) Water requirement for FGD

Water demand-supply plan in Medupi TPS is shown in Table 11.6-7. Medupi TPS requires a total volume of 13.4 million cubic meters per annum (m^3/year) of raw water to operate the power station including the FGD units which will be retrofitted. Currently, the power station has a total water allocation of 10.9 million m^3/year, which is sourced from Mokolo Dam via Phase 1 of the Mokoro and Crocodile (West) Water Argumentation Project (MCWAP). This allocation of 10.9 million m^3/year will be enough to operate the Medupi TPS as well as 3 (three) x FGD units. The water shortfall of 2.5 million m^3/year will be sourced via Phase 2A of the MCWAP from the Crocodile River once implemented by the Department of Water and Sanitation (DWS), and will cater for, among other requirements, the three remaining x FGD units. Water supply agreements are to be concluded and signed with the DWS by the middle of 2018 for the supply of water to both Medupi and Matimba power stations which will be aligned to Water Use License (WUL). This project plan minimizes the water usage for the operation of FGD by applying the closed-type water circulating system.

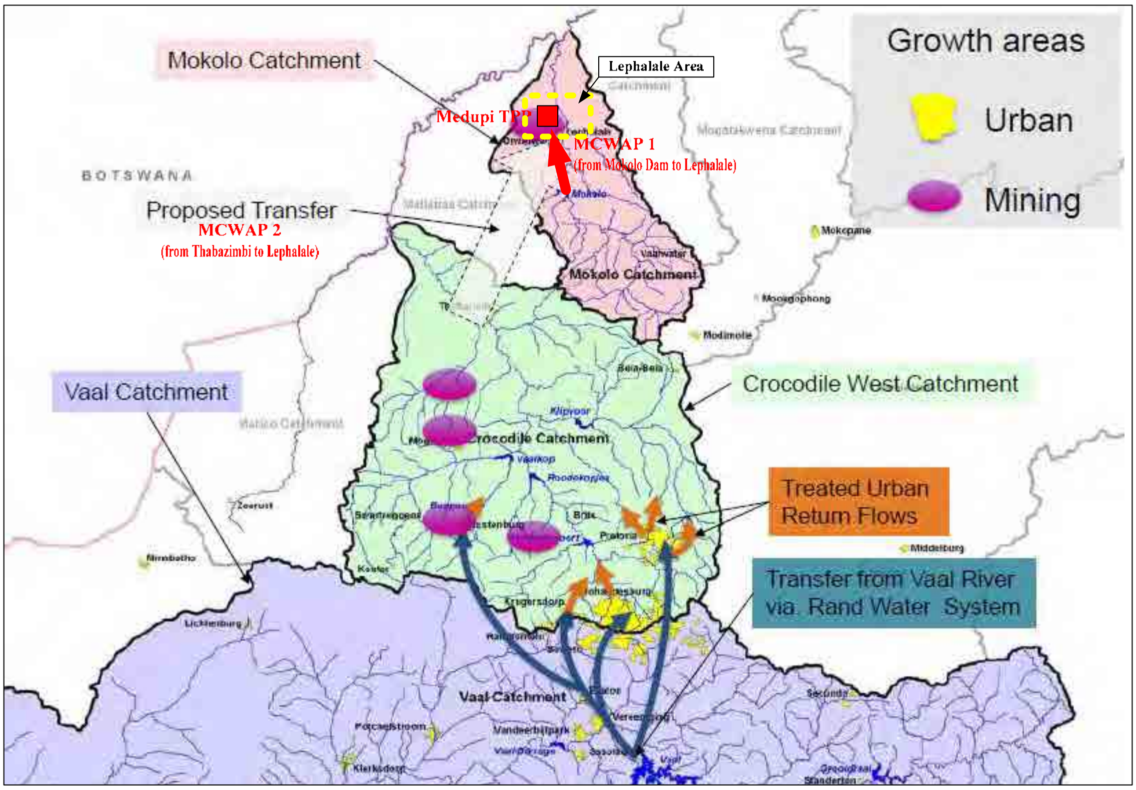
Table 11.6-7 Water Demand-Supply Plan in Medupi TPS

	Items	Amount of Water (million m^3/year)	
Demand Plan	Required water amount for Medupi TPS (6 units)	6.0	13.4
	Required water amount for Medupi FGD (6 units)	7.4	
Supply Plan	Current water capacity（supplied by MCWAP1）	10.9	13.4
	Additional water (will be supplied by MCWAP2) (1)+(2)-(3)	2.5	

Source：Original data was obtained from DWS and Eskom

2) Water balance in the Lephalale area

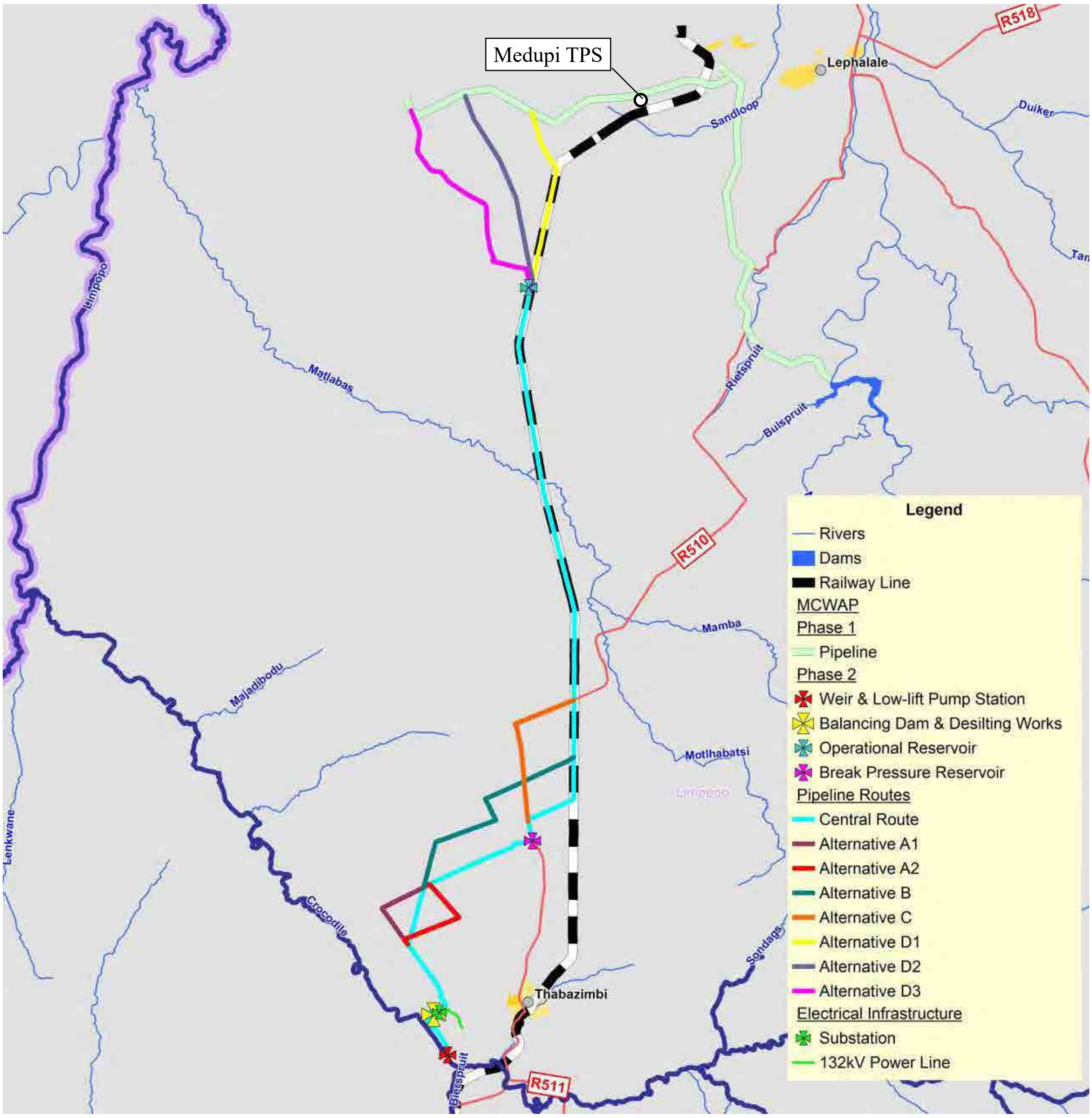
The balance of water supply and demand in the Lephalale area is analyzed in Section 8.1, which concluded that the future water demand in this area is expected to increase significantly. The Mokoro and Crocodile (West) Water Argumentation Project (MCWAP) Phase 2 is addressing the water needs of the Lephalale area. Water users are not only thermal power stations but also urban domestic users, industrial users, irrigation users, and rural area farm users. Lephalale area, Mokolo Dam catchment area, the Crocodile River catchment area, Vaal catchment, and MCWAP1 (existing) and MCWAP2 (planned) are shown in Figure 11.6-10 and Figure 11.6-11. DWS has already started the water supply project, known as the land water system, which transports water from the Vaal River catchment to the Crocodile River catchment area. Used water as domestic non-commercial water in the Vaal River catchment area is treated at wastewater facilities, and transported to and use in the Crocodile River catchment area. In consideration of increasing of water consumption due to increase in future population in Johannesburg and Pretoria, DWS has plans to extend the existing wastewater facilities or develop new facilities. Additional water supply to Medupi FGD by DWS is 2.5 million m^3/year, which is estimated to be approximately 3.3% against the total capacity of MCWAP2 water supply (75.86 million m^3/year).



Source: Presentation Material of Water Resources Assessments, DWS, 30 Nov.2017

Figure 11.6-10 DWS Water Supply Plan

As a result of water balance analysis between the amount of water supply from MCWAP2 sourced by Crocodile River in consideration of land water system and the amount of water use in the downstream area during dry season, it was confirmed that there will be no shortage of water supply for MCWAP2 and no impact on the water use in Crocodile River catchment area (Section “8.1 Water Resources” of this report).



Source: Proposed Mokolo and Crocodile River (West) Water Augmentation Project (Phase 2a) (MCWAP-2a): Water Transfer Infrastructure, Final EIA report, November 2018, DWS

Figure 11.6-11 Location Map of MCWAP Phases 1 and 2 (Tabazimbi-Lephalale)

(2) Prediction Result

The application of FGD will require additional amount of water supply. However, the water supply infrastructure will be developed based on the future water demand prediction in the Lephalale area initiated by DWS. The Integrated Water Use License Application for the project has been just prepared, as of June 2018 and is to be submitted to DWS. The project proponent will secure necessary water supply sharing with the other water requirements under the MCWAP scheme. The balance between water demand and supply will be well managed among related water users and stakeholders and it is not expected to cause water conflicts in the region.

11.6.8. Existing Social Infrastructure and Services (Road Traffic, Road and Railway)

(1) Survey Result

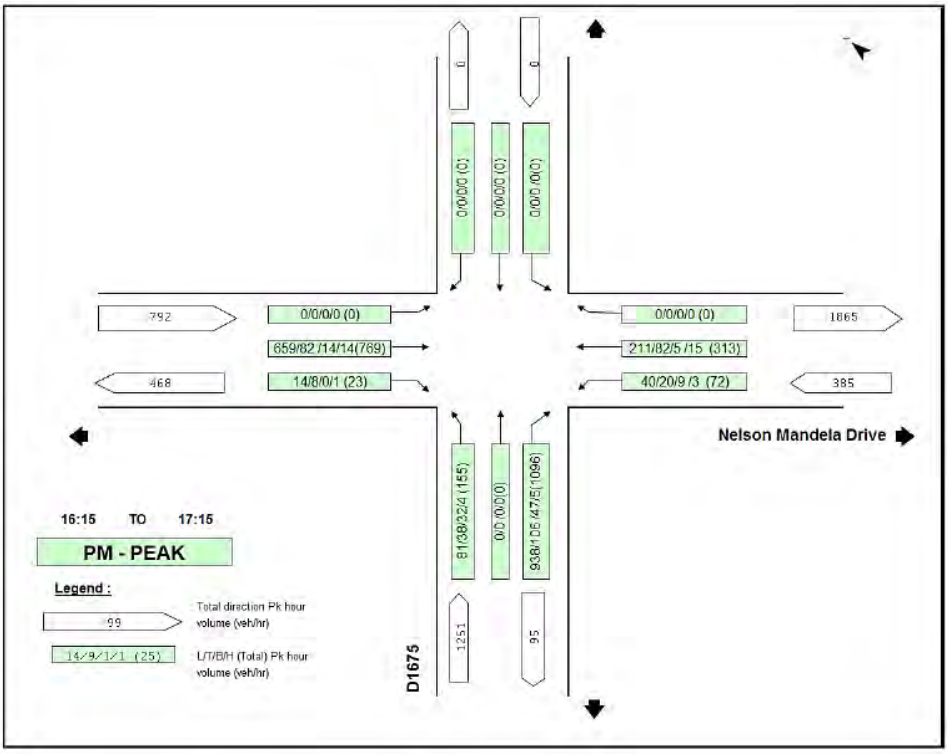
1) Road Traffic around Medupi TPS

The existing road networks around the Medupi TPS are shown in Figure 11.6-12. Nelson Mandela Drive and the Afguns Road provide access to Medupi Power Station, following onto the D1675 and then through Entrance Gates 1, 2 or 4. Afguns Road provides access to farms in the area and connects with the R510 further south.

Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

Figure 11.6-12 Road Network at MPS

Traffic counts for the 24-hour period were undertaken at six locations at the junctions along internal roads and outside the Medupi TPS. The results from a traffic count undertaken at the main access point from Nelson Mandela Drive are shown in Figure 11.6-13. The peak hour was identified as 16:00 to 17:00.



Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

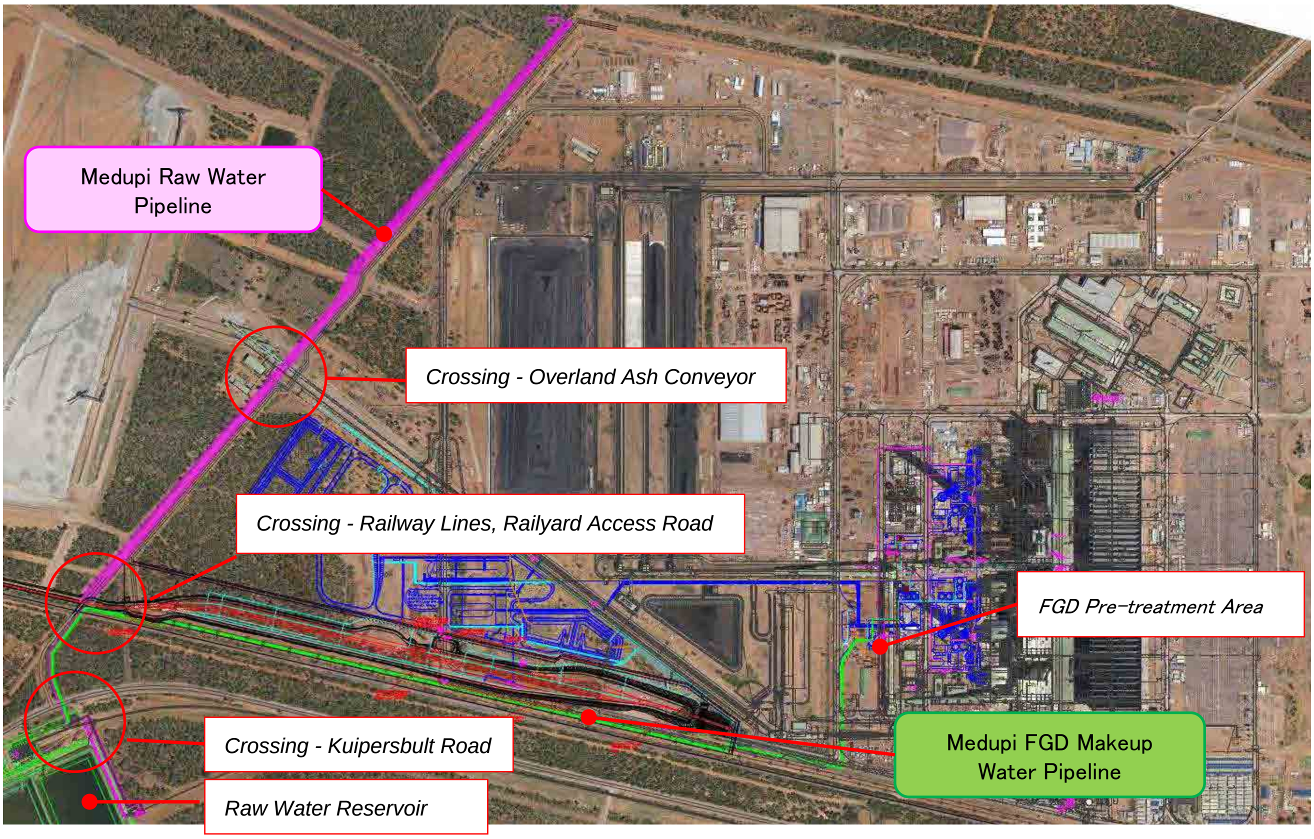
Figure 11.6-13 PM Peak Hour Traffic Volumes – Nelson Mandela Drive/D1675

The Level of Service (LOS) ratings have been used to evaluate the existing and future traffic situation. LOS tries to answer how good the present traffic situation is at a particular intersection. Thus, it gives a qualitative measure of traffic in terms of delays experienced. It is represented by six levels ranging from level A to level F. Level A represents minimal delays where the driver has the freedom to drive with free flow speed while level F represents uncomfortable conditions accompanied by long delays on Nelson Mandela Drive/D1675 and D1675/Afguns Road intersections currently operate at a LOS F for the northbound movement during the PM peak hour, and a LOS A for the west and eastbound movement.

2) Water Pipeline Plan

The water pipelines consist of the Medupi Raw Water Supply Pipeline and the Medupi FGD Makeup Water Supply Pipeline, as shown in the following figure. The Medupi Raw Water Supply Pipeline will connect the identified off-take point on the MCWAP Phase 2 Pipeline at the north side of Medupi TPS and the existing raw water reservoir. The water pipeline will run underground in a south-westerly direction, and cross under the access road to the rail yard, the railway line, and the Kuipersbult Road. The total length of Medupi Raw Water Supply Pipeline is approximately 2,550 m (pink line in the figure). The Medupi FGD Makeup Water Supply Pipeline will connect the existing raw water reservoir and the FGD plant. The water pipeline runs underground to the northward, and crosses under the

Kuipersbult Road, and turns east after crossing under the railway line. The total length of Medupi FGD Makeup Water Supply Pipeline is approximately 2,780 m (green line in the figure). The water pipeline is designed underground basically and shall cross under the Kuipersbult Road/Railway. The crossing will require an approval from relevant authorities. The trench width is expected to be approximately 1800 mm for single pipe or 3600 mm for double pipes, and the total trench depth is expected to be from 2000 mm to 2500 mm. Therefore, dust will be generated by excavation work for the water pipeline trench.



Source: Advisory Technical Report -Medupi FGD Makeup Water Supply and Medupi Raw Water Supply Report, August 2018, Eskom

Figure 11.6-14 Overall Water Pipeline Route Layout

(2) Prediction Result

1) Road Traffic around Medupi TPS

The construction phase of the FGD plant and the waste disposal sites will include the following transport and traffic activities:

- Transport of staff, materials and equipment to site.
- Transport of abnormal load to site.
- Management of existing traffic around the site during construction.

In the operation phase, the input materials to the FGD process are soda ash, lime, or limestone. The limestone will be either brought in by rail to the plant via rail siding from where it is collected, handled and stockpiled until used in FGD system or it could be transported to the plant with conventional bulk side-tipper trucks. The soda ash will also be transported to the FGD plant with conventional bulk powder trucks. Waste from the FGD process includes gypsum (which will be dewatered) and wastewater. The wastewater will be treated and cleaned for re-use in the plant. By-products of the wastewater treatment process (salts and sludge) will be disposed at the existing licensed hazardous waste facility, after storage at a temporary storage facility in the vicinity of the wastewater treatment plant. The gypsum together with the ash will be disposed of at the existing Medupi Ash Disposal Facility, which will be designed with appropriate barrier system, given that ash and gypsum are both classified as the same waste type.

Eskom is still in the process of developing their heavy haul/lift plans and thus accurate prediction is not available, as of now. However, the traffic impact would be increased because existing intersection is already operating at a LOS F at Nelson Mandela Drive/D1675 in the PM peak hour. The project proponent will discuss with relevant authorities to mitigate traffic issue.

2) Water Pipeline Plan

The water pipeline is designed underground basically and will cross under the public existing infrastructures (public road and railway). The approval from relevant authorities must be obtained prior to construction, if any. These will be the technical condition in the contract of the detailed design contractor. Therefore, the impact due to the conflict of the pipeline crossings will be avoided.

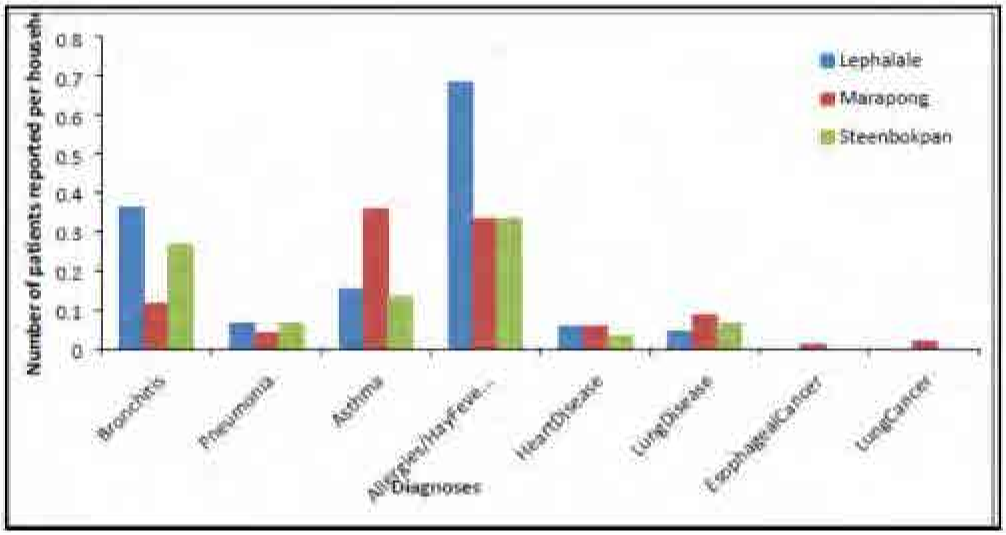
11.6.9. Infectious Diseases such as HIV/AIDS

(1) Survey Result

1) Community health and wellness related to Air Pollution

The World Health Organization (WHO) in 2012 reported that one in eight deaths in the world is due to air pollution. The pollution is either ambient (outdoor) or indoor. WHO further concluded that 88% of premature deaths in middle- and low-income countries whose economy is coal based to ambient pollution. South Africa is one of such countries whose economy is coal-based economy.

In Lephalale, coal is the main source of pollution throughout its life cycle: from extraction, combustion through to disposal. It contributes to pollution of both ambient and domestic air through a wide range of pollutants such as PM (particulates/dust), SO_2, NO_2, O_3 (Ozone) (Itzkin, 2015, as cited in (Tomose, et al., 2018)). Liquid fossil fuel burnt/used by cars contributes to carbon monoxide (CO), while other known general pollutants include lead and volatile organic compounds. A study undertaken by Itzkin (2015) provides a good insight into amount of pollution experienced by the people in the Waterberg as the result of the combustion of coal. Figure 11.6 12 presents a correlation between illnesses generally associated with the combustion of coal and illnesses diagnosed in residents of Lephalale, Marapong and Steenbokpan in the Lephalale LM (Tomose, et al., 2018).



Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018)

Figure 11.6-15 Diagnoses of Those Who Went to Seek Medical Assistance for Lephalale, Marapong and Steenbokpan Represented as Average Number per Household (from Itzkin, 2015 as cited by Tomose, et al., 2018)

2) HIV/AIDS

Although not directly linked to emissions, deaths from HIV/AIDS related illness such as pneumonia, tuberculosis and many more may be accelerated due to high levels of exposure to harmful gases such as SO_2 and PM which both contribute to lung disease. HIV prevalence in Lephalale is almost double that of the province and the district and AIDS infections are almost 20% higher.

Eskom has identified HIV/AIDS as one of the risks to maintain the sustainability of its own business and managed the impact of HIV/AIDS. The goals of the HIV/AIDS workplaces program are: to have zero tolerance to new HIV infections, mother to child transmissions and zero tolerance to stigma and discrimination. The company has developed integrated response strategies, which are education and awareness, prevention; check of employees' HIV status, treatment, care, and support. Free condoms are provided to all employees. The monthly medical health services are provided by Eskom and contractors in conjunction with governmental health services. Eskom meets the human resources sustainability index standard, which requires 50% of the staff to have undergone voluntary counseling and testing (VCT).

(2) Prediction Result

1) Community health and wellness related to air pollution

In the operation phase of FGD, the FGD technology will result to reduction in SO_2 levels in the atmosphere, resulting in improved ambient air quality and improved human health and quality of life due to implementing FGD (positive impact).

2) HIV/AIDS

The construction activity will engage a certain amount of labors from outside. Such influx of labors is likely to trigger social vices including commercial sex, drug and alcohol abuse, juvenile delinquency, etc. It could potentially lead to escalation of sexually transmitted diseases including HIV/AIDS, among others. However, necessary countermeasures have been prepared and are supposed to be applied to the proposed project.

11.6.10. Working Conditions

(1) Survey Result

1) Legal requirement

In South Africa, the management of occupational health and safety is stipulated in the following law and regulations:

- Occupational Health and Safety Act,1993
- OHSAS 18001:2007 System Safety Management Process
- Construction Regulations, 2014

In addition, Eskom has established independent requirement and program as follows:

- Eskom Safety, Health and Environmental Requirements
- Safety, Health and Environmental (SHE) program to be implemented by contractors

Since Eskom has already established and applied comprehensive SHE programs and implementation system in the Medupi TPS Project, the existing framework and implementation are reviewed as follows and considered to be applied to this proposed project.

2) Framework of Safety, Health and Environmental (SHE) management for contractors

The working conditions of contractors and suppliers are secured by the Safety, Health and Environmental (SHE) specifications. These specifications are provided to potential contractors during the tender phase and these specifications form part of the technical criteria which are used in selecting successful bidders. These specifications are also included in the conditions of the signed contract for implementation by the contractor. Detailed health and safety program are drawn up for the project by contractors and approved by Eskom prior to construction commencement and continuously revised in line with any change in the risk profile based on any revision issued by the Eskom team.

In addition, the project has a Site Labor Agreement that is to be signed by leaders of various unions and governs all labors related to issues from sourcing of personnel, skills development, payment, conditions of work, grievance mechanisms, dispute resolution processes, and dis-employment process.

The Department of Labor conducts annual audits to check the compliance of the proposed project and contractors while the assurance audits/assessments shall be conducted by Eskom's Industrial Relations personnel.

3) Practical proceeding for safety and health program

All personnel working on site are subject to medical examinations and a full Eskom induction prior to being allowed to enter the site. Each contractor will then also have their own induction program focusing on risks specific in his/her scope of work. These are the annual requirements. Over and above these implementations, each contractor also conducts legal liability training with his/her own employees as well as working at heights training. Toolbox talks are also done every morning covering specific monthly topics as well as to discuss any particular risks. In addition, lessons learned from previous safety incidents are also shared and discussed each morning prior to work.

4) Labor's camp

The labor camps and accommodation are already built for the construction of the Medupi TPS (see the below picture for one of such camps). The same camps are planned to be utilized for the execution of the proposed project.

5) SHE training program

Various training programs have been developed for each target trainee personnel or teams working for Medupi TPS Project. The training matrix for each principle contractor on site specifies SHE courses that are composed of SHE induction and trainings for OHSAS 18002, first aid program, evacuation warden, Occupational Health and Safety Act 85 of 1993 OHS Act, working at heights, fundamentals of firefighting, construction regulations, Eskom Lifesaving Rules and Behavior Safety Awareness.

Monthly traffic safety drive is done together with local authorities and traffic police. Regular health interventions are provided including training and awareness and the provision of voluntary testing days for diseases like tuberculosis and HIV/AIDS.

6) Safeguards for local community

Any violence with residents does not fall within the ambit of Eskom or contractors and is managed through the South African Police Service. Regular joint meetings are however held to ensure threats are identified and mitigation measures are put in place prior to any erupting violence. The Medupi TPS Project does have many mechanisms including the Environmental Monitoring Committee (EMC) and Project Information Offices in town as well as surrounding communities where residents are able to raise grievances with procedures in place to address any complaints.

(2) Prediction Result

The construction work for FGD project will bring out the additional needs of safety and health management for workers and communities. However, the comprehensive programs and implementation structure for SHE management have been already available and supposed to be applied to the proposed project. Therefore, it is predicted that the occupational health and safety risks will decrease as much as possible due to the periodical implementation of health and safety management program including the education and training to workers.

11.6.11. Accidents

(1) Survey Result

Accidents during the construction operation could result in significant impact not only to the on-site workers but also to the surrounding environment and residents in local communities. Eskom has prevention measures and promptly respond to accidents or incidents in place as described in the previous section: “11.6.10 Working condition”. The existing measures are summarized as follows and are considered to be applied to this proposed project.

All Personal Protective Equipment (PPE) required to be used by contractors is supplied by Eskom. As a minimum, all personnel are issued with overhauls, safety boots, reflective vest, safety glasses, earplugs and a hard hat.

In addition, the Medupi project has an Emergency Plan to deal with all types of incidents covering Health, Safety, Environmental and Security requirements and has all the requisite infrastructure, equipment and specialized personnel. This plan includes-

- Pre-emergency planning,
- Emergency medical and first-aid treatment,
- Methods or procedures for alerting on-site employees,
- Safe distances and places of refuge,
- Training and Awareness

The team at the power station regularly conducted emergency drills based on the Medupi Emergency Preparedness Plan. There is a full-time emergency team on site with necessary medical facilities and paramedics operated 24/7 supplied by Eskom. A Service Level Agreement is in place with Eskom Generation to assist during emergency as well as an agreement in place with local authorities to assist. There is also a fully equipped hospital in town. Security services are also provided for including an evacuation plan with alarms/speakers all around the site.

(2) Prediction Result

The construction and operation of FGD project could raise the risks of hazards at the facilities or environmental accidents especially in case of improper handling of the facilities. However, the risk of accident will be controlled by the Medupi Emergency Preparedness Plan.

11.6.12. Global Warming

(1) Survey Result

According to the operation plan of Medupi TPS, there is no difference between the emission volume of CO_2 due to the operation Medupi TPS "with FGD" and "without FGD". greenhouse gas (GHG) production of electricity and the estimated consumption of coal in Medupi TPS are fixed.

(2) Prediction Result

The quantity of GHG emission during the operation of FGD will not increase. Because the electricity for FGD operation will be from Medupi TPS and the total amount of electricity generation by TPS will not change (not increase).

11.7. Impact Assessment

The results of environmental and social impact assessment are summarized in the following table based on the EIA study results.

Table 11.7-1 Result of Environmental and Social Impact Assessment

No	Item	Scoping Result		Assessment Result		Basis/ Reason for the Survey Result
		PCS/ CS	OS	PCS/ CS	OS	
Pollution						
1	Air Quality	B-	A+/ C	B-	A+	[CS] The construction work for the FGD facilities is not likely to cause the negative impact on the ambient air quality because the impact at the construction site is localized and will not deteriorate the ambient air quality offsite the residential area. Meanwhile, dust will be generated by excavation work for the water pipeline trench. The appropriate management of emission gas due to the construction activities is required in consideration of current excesses of daily ambient air limits. [OS] An area of non-compliance of cumulative SO_2 concentrations will decrease significantly after FGD installation. There will be no exceedances of NAAQS at sensitive receptors. The ambient air quality will be improved through reduction of SO_2 due to the operation of FGD system.
2	Water Quality	B-	B-	B-	B-	[CS] - Moderate negative impact on groundwater quality is anticipated related to construction work of FGD system, railway yard and associated infrastructure - Pollution of natural surface water quality is anticipated but quite limited due to the existing Storm Water Management System (SWMS). [OS] - Contamination of groundwater is predicted if any accidental spillages happen during transportation of hazardous waste - The wastewater from FGD will be treated and the clean water will be re-used in the plant. There is no factor to polluted surface water due to discharge from FGD.
3	Soil Contamination	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
4	Solid Waste	B-	B-	B-	B-	[CS] The construction works will generate solid wastes and cause a moderate impact. However, it will be appropriately managed by the

No	Item	Scoping Result		Assessment Result		Basis/ Reason for the Survey Result
		PCS/ CS	OS	PCS/ CS	OS	
						Medupi TPS Waste Management System. [OS] FGD technology will generate gypsum, sludge, and salts as by-products and require the disposal site. However, these wastes will be managed in accordance with the applicable regulation with obtaining the Waste Management License.
5	Noise and Vibration	B-	B-	D	D	[CS] FGD facilities will be set in the existing Medupi TPS. The impact of noise and vibration is temporarily and is not anticipated because there are no receptors in the surrounding area. [OS] As a result of quantification of noise emissions and simulation of noise levels, it was calculated that the noise levels at human receptors will not exceed the NSRs. The impact of vibration is not anticipated because there are no receptors in the surrounding area.
6	Ground Subsidence	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
7	Offensive Odor	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
8	Bottom Sediment	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
Natural Environment						
9	Protected Area	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
10	Ecosystem	C	C	B-	B-	[CS] Impact on this wetland (SEW 2) would be expected to be minor since the FGD infrastructure is situated within the footprint of the existing Medupi TPS. A number of impacts relating to the potential loss of vegetation units and species, potential increasing of alien species, habitat and fauna mortality during the construction phase were identified and assessed. Impact to specific endangered species is not predicted. Another prominent impact feature that was identified during the construction phase is the loss of catchment area contributing to stormwater runoff due to the need to separate and contain contaminated “dirty” water. Associated with this is an expected increase in flood peaks and pollution through contaminated runoff. [CS/OS] Impacts identified relating to the operational phase of the Medupi TPS FGD and railway yard is largely a continuation of impacts that emerged during the construction phase. Loss of catchment area and decreased water inputs remain after construction, while vehicle traffic within the Medupi TPS footprint remains a threat to the fauna present on the Medupi TPS footprint.
11	Hydrological Situation	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
12	Topography and Geographical Features	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
13	Soil Erosion	C	C	B-	D	[CS]Although the new development area is partiality, there is a possibility of soil erosion due to the removal of vegetative cover and/or topsoil and excavation work especially along the water pipeline trench during construction. [OS] The topsoil will be protected since the facilities and buildings will be constructed on the area where the vegetative cover and/or topsoil are removed.
Social Environment						
14	Involuntary Resettlement	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessment is conducted.
15	Poor, Indigenous People and	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessment is conducted.

No	Item	Scoping Result		Assessment Result		Basis/ Reason for the Survey Result
		PCS/ CS	OS	PCS/ CS	OS	
	Ethnic Minority					
16	Local Economy such as Employment and Livelihood	B+	B+	B+	B+	It was evaluated as a positive impact in the scoping stage (see Table 11.5-1) and no further assessment is conducted.
17	Land Use	D	D	N/A	N/A	There is no factor to cause negative impact on land use since FGD structure is designed inside the existing Medupi TPS site.
18	Water Usage or Water Rights	D	C	N/A	D	[CS] It was evaluated in the scoping stage (see Table 11.5-1) and no further assessment conducted. Amount of current total water supply to Medupi TPS is 10.9 million m^3/year and is supplied by the MCWAP Phase1 Project. This amount of water is enough for the operation of three FGD facilities. Thus, there is no problem about water use during construction stage. [OS] FGD technology increases the amount of water use. However, the balance between water demand and supply will be well managed among related water users and stakeholders under MCWAP scheme. Additionally, it is impossible for water users to use excessive amount of water which is agreed before. Therefore, the possibility of local conflicts regarding water use is low. As a result of water balance analysis between the amount of water supply from MCWAP2 sourced by Crocodile River in consideration of land water system and the amount of water use in the downstream area during dry season, it was confirmed that there will be no shortage of water supply for MCWAP2 and no impact on the water use in Crocodile River catchment area(Section "8.1 Water Resources" of this report).
19	Social Institutions	D	D	N/A	N/A	Physical community division is not expected due to project implementation.
20	Existing Social Infrastructure and Services	C	C	B-	B-	[CS] Increase in traffic volume is anticipated due to vehicles/trucks transporting materials to and from Medupi for the construction of the FGD. The water pipeline is designed underground basically and will cross under the public existing infrastructures (road and railway). Therefore, the impact due to the conflict of the pipeline crossings will be avoided. [OS] The traffic volume will be increased to transport limestones to Medupi TPS and transport salts and sludge to hazardous waste facilities.
21	Misdistribution of Benefit and Damage	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
22	Local Conflicts of Interest	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
23	Cultural Heritage	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
24	Landscape	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
25	Gender	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
26	Children's Right	D	D	N/A	N/A	It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed.
27	Infectious Diseases such as HIV/AIDS	B-	A+	B-	A+/B-	[CS/OS] There is a possibility to increase the risks of infectious diseases due to influx of construction/operation workers into the project site. [OS] The FGD technology will result to reduction in SO_2 levels in the atmosphere, resulting in improved ambient air quality and improved human health and quality of life due to the implementation of FGD (Positive Impact).
28	Working Conditions	B-	B-	B-	B-	[CS/OS] Occupation health and safety risks will be increased resulting from the construction and operation works. However, the comprehensive

No	Item	Scoping Result		Assessment Result		Basis/ Reason for the Survey Result
		PCS/ CS	OS	PCS/ CS	OS	
						programs and implementation structure for SHE management have been already available and supposed to be applied to the proposed project.
Others						
29	Accidents	B-	B-	B-	B-	[CS/OS] There is a risk of accidents due to improper handling of facilities during construction/operation although the risk of accident is controlled by the Medupi Emergency Preparedness Plan with regular emergency drill to avoid accidents.
30	Global Warming	D	C	N/A	D	[CS] It was evaluated in the scoping stage (see Table 11.5-1) and not further assessed. [OS] The quantity of greenhouse gas emission during the operation of FGD will not increase. Because the electricity for FGD operation will be from Medupi TPS and the total amount of electricity generation by the power station will not change.

Source: The JICA Study Team

Note:

- Project stage: PCS: Pre-construction stage, CS: Construction stage, OS: Operation stage
- Impact:
  - A+/-: Significant positive/negative impact is expected.
  - B+/-: Positive/negative impact is expected to some extent.
  - C: Extent of impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
  - D: No impact is expected.
  - N/A: Impact assessment was not conducted because the items were categorized into D in scoping phase.

11.8. Mitigation Measurements

The report on the Environmental Management Program for the Medupi FGD Retrofit Project (Zitholele Consulting (Pty) Ltd, May 2018) has been prepared in order to secure the appropriate implementation of mitigation measures for possible adverse impacts, and submitted to DEA. The mitigation measures of all the items which are assessed as B- in the impact assessment in Section 11.7 are shown in the table below. Environmental mitigation measurements and environmental monitoring cost including environmental permission for the Medupi FGD project was estimated approximately JPY 18.6 million, which is included into the project cost.

Table 11.8-1 Major Mitigation Measurements

No.	Items (Impacts)	Proposed Mitigation Measures	Implementing Organization	Responsible Organization
Construction phase				
1	Air Quality	- Proper maintenance of all equipment at regular intervals - Periodically water spray - The reduction of surface wind speed (windbreaks and source enclosures)	Contractor	Project proponent
		- Regular water sprinkling on exposed surfaces to reduce dust emission.	Contractor	Project proponent
2	Groundwater Quality	- Implementation of site working procedures (SWP) for construction work to minimize the risk of contamination and prevent the spillage of hazardous waste	Contractor	Project proponent
		- Clean up and recording of any accidental spillages of contaminants	Contractor	Project proponent

No.	Items (Impacts)	Proposed Mitigation Measures	Implementing Organization	Responsible Organization
		- Periodical groundwater monitoring	Contractor or Consultant	Project proponent
4	Solid Waste	- Compliance with requirements of Waste Management License and IWWMP thorough the visual check and management of the disposal /storage yard of hazardous and/or domestic waste, and abnormal points of liner, if any	Contractor	Project proponent
		- Monitoring of waste amount	Contractor or Consultant	Project proponent
10	Ecosystem	- Control of alien species under the Medupi TPS Alien Control Program	Contractor	Project proponent
		- Monitor and relocation of Conservation Important species	Contractor	Project proponent
		- Fencing of construction area to prevent encroachment into surrounding vegetation.	Contractor	Project proponent
		- Reporting of important raptor species nests if found before construction. (Likelihood is very low)	Contractor or Consultant	Project proponent
		- Minimizing catchment loss by the PCD, coal stockpile and other associated infrastructure.	Contractor	Project proponent
		- Maintain existing tortoise road signs and insert new ones where necessary. Continue to enforce speed regulation controls.	Contractor	Project proponent
13	Soil Erosion	- Limiting the area of impact inclusive of the resource (soils) stockpiles and the length of servitudes, access and haulage ways and conveyancing systems.	Contractor	Project proponent
		- Concurrent rehabilitation of all affected sites that are not required for the operation.	Contractor	Project proponent
		- Restriction of vehicle movement over unprotected or sensitive areas to reduce compaction.	Contractor	Project proponent
20	Existing Social Infrastructure and Services (Road Traffic)	- Arrange the traffic control staff at the intersection.	Contractor	Project proponent
27	Infectious Diseases such as HIV/AIDS	- Development of more HIV/AIDS related campaigns by the developer educating its contractors. (workshop, treatment, providing free condoms, periodical health check of employee)	Contractor or Consultant	Project proponent
28	Working Conditions	- Preparation of and Compliance with Safety, Health and Environmental (SHE)Policy	Contractor	Project proponent
29	Accidents	- Preparation of and Compliance with Safety, Health and Environmental (SHE)Policy	Contractor	Project proponent
Operation phase				
2	Groundwater Quality	- Implementation of site working procedures (SWP) for construction work to minimize the risk of contamination and prevent the spillage of hazardous waste	Project proponent or Consultant	Project proponent
		- Clean up and recording of any accidental spillages of contaminants	Project proponent	Project proponent
		- Periodical groundwater monitoring	Project proponent or Consultant	Project proponent
4	Solid Waste	- Compliance with requirements of Waste Management License and IWWMP thorough the visual check and management of the disposal	Project proponent	Project proponent

No.	Items (Impacts)	Proposed Mitigation Measures	Implementing Organization	Responsible Organization
		/storage yard of hazardous and/or domestic waste, and abnormal points of liner, if any		
		- Monitoring of waste amount	Project proponent or Consultant	Project proponent
10	Ecosystem	- Control of alien species under the MPS Alien Control Program	Project proponent	Project proponent
		- Monitor Conservation Important species	Project proponent or Consultant	Project proponent
		- Maintain existing tortoise road signs and insert new ones where necessary. Continue to enforce speed regulation controls.	Project proponent	Project proponent
20	Existing Social Infrastructure and Services	- Designation of traffic route of vehicles/trucks for transporting limestone to Medupi TPS and transporting salts and sludge from Medupi TPS to disposal site to minimize the impact to other road users	Project proponent or Consultant	Project proponent
27	Infectious Diseases such as HIV/AIDS	- Development of more HIV/AIDS related campaigns by the developer educating its contractors.	Project proponent	Project proponent
28	Working Conditions	- Preparation of and Compliance with Safety, Health and Environmental (SHE)Policy	Project proponent	Project proponent
29	Accidents	- Preparation of and Compliance with Safety, Health and Environmental (SHE)Policy	Project proponent	Project proponent

*: Mitigation measures are included construction/operation general activities, and cost is included in the construction/operation cost.

Source: Original data was obtained from the final environmental impact report for the proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project (Zitholete Consulting, May 2018) and Report on the Environmental Management Program for the Medupi FGD Retrofit Project (Zitholele Consulting (Pty) Ltd, May 2018)

11.9. Monitoring Plan

The items for which any mitigation measures will be taken are supposed to be monitored to examine the effectiveness of the mitigation measure. The monitoring plan is shown in the table below to clarify monitoring items, frequency, monitoring points, responsible agency, reporting system, etc., in each project stage.

In addition, the environmental air quality will be continuously monitored at existing monitoring stations since it is mandated by the condition of Atmospheric Emissions License (AEL).

The result of water balance analysis between the amount of water supply and the amount of water use in the downstream area during dry season explained that there will be no shortage of water supply for MCWAP2, and no impact on water use in Crocodile River catchment area. Because the estimated water supply and demand scenario of MCWAP2 might be changed in the future, it is necessary to make an agreement by the project proponent to conduct the periodical monitoring of the amount of water inflow and water supply in this water network.

It is recommended that the monitoring format is unified from the aspect of the information sharing and effectiveness for both of the project proponent and donors.

Table 11.9-1 Monitoring Plan

No.	Item	Sub-item	Survey Point	Frequency of Monitoring and Reporting	Responsible Agency/Person	Supervising Agency/Person
General Items Related to All Stages						
All	Compliance	Compliance with EMP, authorization and licenses	Not particularly specified	Monthly	SCM, CM, EM, EA, EO	Project proponent (PD)
Construction Stage						
1	Air Quality	PM, NOx, SO_2 Note: Requirement by AEL	Around Medupi TPS Monitoring Station	Everyday	Contractor	EO, EA, EM (project proponent)
2	Groundwater Quality	Parameters are shown under the table *	Existing monitoring boreholes, and newly-drilled monitoring boreholes in the area surrounding the existing licensed disposal facility	Monthly for existing boreholes By-annually for Newly-drilled monitoring boreholes	Contractor	EO, EA, EM (project proponent)
4	Solid Waste	Waste generated on site (kg and L)	At waste generation source or collection point	Monthly	Contractor	EO, EA, EM (project proponent)
10	Ecosystem	As specified in the existing monitoring protocol of the Medupi TPS	Construction area and sensitive area	Ad per existing monitoring protocol of the MPS.	Contractor	EO, EA, HO, PD (project proponent)
13	Soil Erosion	Reporting of the protection of topsoil	Construction area	Monthly	Contractor	EM, EO, EA, Specialist
27	Infectious Diseases such as HIV/AIDS	Record of HIV/AIDS workplaces program and medical health services	Construction site	Monthly	Contractor /EMC	CM, EM, PD (project proponent)
28	Working Conditions	Record of SHE trainings program	Construction site	Monthly	Contractor /EMC	CM, EM, PD (project proponent)
29	Accidents	Preparation and implementation of Medupi Emergency Preparedness Plan, record of accidents	Construction site	Monthly	Contractor /EMC	CM, EM, PD (project proponent)
Operation Stage						
1	Air Quality	PM, NOx, SO_2 Note: Requirement by AEL	Around Medupi TPS Monitoring Station	everyday	EO, EA, HO (project proponent)	EO, EA, EM (project proponent)
2	Groundwater Quality	Parameters are shown under the table *	Existing monitoring boreholes	Monthly	EO, EA, HO (project proponent)	EO, EA, EM (project proponent)
4	Solid Waste	Amount of each classified waste material (ton or m^3)	At waste generation source or collection point	Monthly	EO, EA, HO (project proponent)	EO, EA, EM (project proponent)
10	Ecosystem	As specified in	Medupi TPS site	Ad per existing	EO, EA, HO, PD	EO, EA, HO, PD

No.	Item	Sub-item	Survey Point	Frequency of Monitoring and Reporting	Responsible Agency/Person	Supervising Agency/Person
		the existing monitoring protocol of the Medupi TPS		monitoring protocol of the MPS.	(project proponent)	(project proponent)
20	Existing Social Infrastructure and Services	Check the traffic route and problems	Main intersections	Monthly	EO, EA, HO, PD (project proponent)	CM, EM, PD (project proponent)
27	Infectious Diseases such as HIV/AIDS	Record of HIV/AIDS workplaces program and medical health services	Medupi TPS site	Monthly	EO, EA, HO, PD (project proponent)	CM, EM, PD (project proponent)
28	Working Conditions	Record of SHE trainings program	Medupi TPS site	Monthly	EO, EA, HO, PD (project proponent)	CM, EM, PD (project proponent)
29	Accidents	Preparation and implementation of Medupi Emergency Preparedness Plan, record of accidents	Medupi TPS site	Monthly	EO, EA, HO, PD (project proponent)	CM, EM, PD (project proponent)

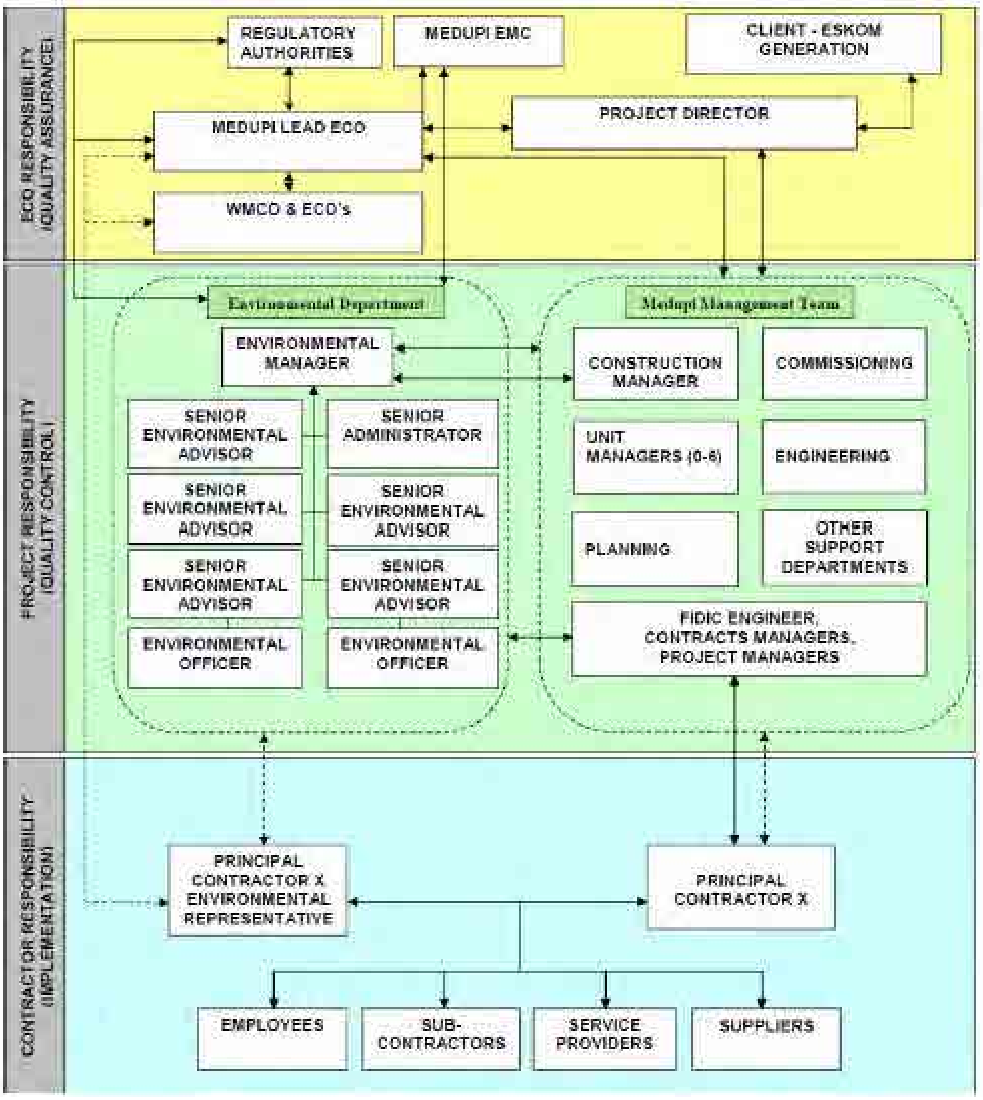
*Groundwater quality monitoring parameters: Groundwater level and quality (pH, EC, cadmium, magnesium, sodium, potassium, p-Alk & m-Alk, chloride, sulphate, nitrate, fluoride, aluminum, iron, manganese, chromium 3 & 6, copper, cobalt, COD

Note; PSM: Station Manager, GM: General Manager, PD: Project Director, SCM: Senior Construction Manager, CM: Contracts Manager, EM: Environmental Manager, EA: Environmental Advisor, EO: Environmental Officer, ECO: Environmental Control Officer, C: Contractor including sub-contractors, EMC: Environmental Monitoring Committee, HO: Eskom Head Office

Source: Original data was obtained from the Environmental Performance Monitoring and Measurement Procedure (Eskom, Oct 2015) and Interview with Eskom

11.10. Implementation Structure

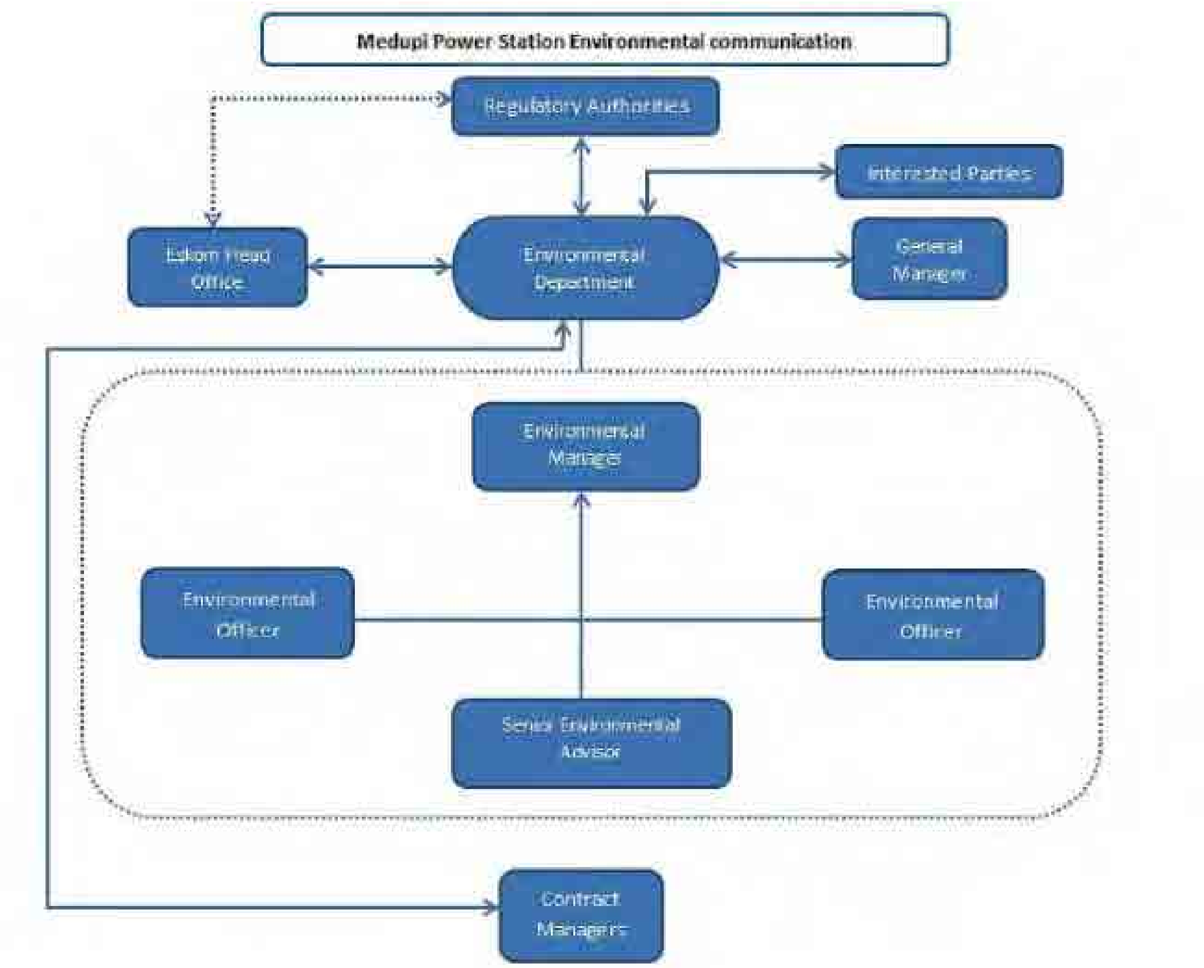
The implementation of the Environmental Management Plan and Environmental Monitoring Plan will conform to the current Environmental Communications Procedure of Medupi TPS. The current Environmental Communication Framework for the Medupi TPS during the construction stage is shown in Figure 11.10-1, while the one during the operational stage is shown in Figure 11.10-2. The grievance mechanism will also follow the current procedure. A Complaints Register is maintained on site where the register shall contain contact details of complainants, the nature of the complaint, details on the complaint itself, as well as the date and time that the complaint was made and resolved.



ECO: Environmental Control Officer, EMC: Environmental Monitoring Committee, WMCO: Waste Management Control Officer

Source: IWULA and IWWMP for the proposed Medupi Power Station FGD Retrofit Project and associated (Zitholele Consulting (Pty) Ltd, June 2018)

Figure 11.10-1 Environmental Communications Framework at the Medupi Power Station During Construction Stage



ECO: Environmental Control Officer, EMC: Environmental Monitoring Committee, WMCO: Waste Management Control Officer

Source: IWULA and IWWMP for the proposed Medupi Power Station FGD Retrofit Project and associated (Zitholele Consulting (Pty) Ltd, June 2018)

Figure 11.10-2 Environmental Communications Framework at the Medupi Power Station During Operation Stage

11.11. Stakeholder Meeting

11.11.1. Public Participation

Public participation is an essential and legislative requirement for environmental authorization. The principles that demand communication with society at large are best embodied in the principles of the National Environmental Management Act (Act 107 of 1998, Chapter 1), South Africa's overarching environmental law.

The public participation process for the proposed Medupi Power Station FGD Technology Retrofit has been designed to satisfy the requirements laid down in the above legislation and guidelines. This section of the report highlights the key elements of the Public Participation Process (PPP) during the Scoping and EIA phases.

Detailed contents about PPP including the stakeholder meeting minutes are described in the Final

EIA Report on Medupi FGD Retrofit Project (May 2018) and its Appendix F-6 “PPP-Presentations-and-Minutes”.

(1) Identification of Interested and Affected Parties

The identification of key stakeholders and interested and/or affected parties (I&APs) was done in collaboration with Eskom, the Medupi Environmental Monitoring Committee, the local municipalities, organs of state, and other organizations in the study area.

(2) Notification to Stakeholder and Residents

Notifications for the opportunity to participate or comments/reviews in the EIA are as follows:

- Site notices (in English) were placed at the Medupi Power Stations at the public entrance road;
- Distribution of a letter of invitation to become involved, addressed to I&APs and organizations, accompanied by a Background Information Document (BID) containing details of the proposed project, and a registration sheet were done in June 2014 by e-mail, fax, and post;
- The BID was also distributed in the study area specifically at residential houses, bus stops, etc.;
- The announcement of the EIA process was announced in the Mogol Post, the Lephalale Express and the Northern News; and
- EIA process notices (A3 paper sized notices) were placed at conspicuous and prominently public places, inviting stakeholders to participate in the EIA process.

11.11.2. Scoping Phase

The first phase of an EIA is the Scoping Phase, which is conducted to gain an understanding of the potential environmental issues that are relevant to the project and to determine where further information is required, in the form of specialist studies/investigations.

The Scoping Report and Plan of Study for the EIA are submitted to the Department of Environmental Affairs (DEA) for review and approval of the proposed approach to the detailed investigation required in the next phase. Key activities involved in the Scoping Phase are as follows:

- Meetings with authorities to agree on process and study requirements;
- Initial public and landowner notification;
- Distribution of a Draft Scoping Report (DSR), including Comments and Responses Report (CRR) for public comment;
- Convening a stakeholder meeting for the Scoping Phase;
- Distribution of the Final Scoping Report (FSR) for comments;
- Submission of the FSR, including the Plan of Study for the EIA to the DEA; and

- Approval of the FSR and supporting documents by DEA, at which time the project moves into the Impact Assessment Phase.

(1) Public Comment and Review of the DSR

Outline of the public comment and review of the DSR is shown in the table below.

Table 11.11-1 Outline of the Public Disclosure of the DSR

<table>
<tr><th colspan="2">Item</th><th colspan="2">Contents</th></tr>
<tr><td rowspan="2">Public Disclosure</td><td>Venue</td><td colspan="2">・ Lephalale Local Municipality
・ Marapong Community Library
・ Agri Lephalale/Farmers Association</td></tr>
<tr><td>Website</td><td colspan="2">http://www.zitholele.co.za/eia-for-medupi-fgd</td></tr>
<tr><td colspan="2">Disclosure Period</td><td colspan="2">from 27 October 2014 to 09 January 2015</td></tr>
<tr><td colspan="2">Public Review Period</td><td colspan="2">from 20 November 2014 to 09 January 2015</td></tr>
<tr><td colspan="2">The ways to request comment on the DSR</td><td colspan="2">・ Completing the comment sheet enclosed (Appendix A)
・ Writing a letter, or producing additional written submissions
・ Sending an e-mail or phoning the public participation office
・ Attending any one of the public meetings</td></tr>
<tr><td colspan="2">Main Comments and Responses</td><td>[Main Comments]
1) A water minimization study, to identify and assess all possible water minimization design improvements, be included as a specialist study.

2) SO_2 emissions would be reduced by an estimated 30% over the next 12 years. This will have a significantly positive impact on the air quality in the region.

3) What will be used as baseline for the waste classification of the gypsum and other waste products associated with the FGD technology, and is there a similar unit functioning of which one can use the same information?</td><td>[Responses]
1 As part of basic design process Eskom considered all of the water minimization options as part of the life cycle assessment.

2) To clarify, relative SO_2 emissions for the entire Eskom coal-fired fleet will reduce by 30% by 2030. This will be a reduction in total Eskom emissions, but will not have a direct impact on the air quality in the Lephalale Region.

3) A chemical make-up will be used for the waste classification of the three waste streams and once Kusile Power Station is in operation the information will be verified through testing of the wastes produced by the Kusile FGD operation.</td></tr>
</table>

Note *: Website mentioned above was written on the notice letters at that time, and was owned by EIA consultants. At this moment Environmental documents are disclosed on the website of Eskom as follows; http://www.eskom.co.za/OurCompany/SustainableDevelopment/EnvironmentalImpactAssessments/medupi/Pages/default.aspx

Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project, Eskom, 2018

(2) Public Meeting of the DSR

Outline of the public meetings of the DSR is shown in the table below.

Table 11.11-2 Outline of the Public Meeting of the DSR

<table>
<tr><th>Item</th><th colspan="2">Contents</th></tr>
<tr><td>Date / Time</td><td colspan="2"><u>Key Stakeholder Workshop</u>
5 November 2014 / 14:00 – 16:00
<u>Public meetings</u>
5 November 2014 / 18:00 – 20:00</td></tr>
<tr><td>Venue</td><td colspan="2">Mogol Golf Club</td></tr>
<tr><td>Participants</td><td colspan="2"><u>Key Stakeholder Workshop</u>
31 people (Male: 21, Female: 10)
<u>Public meetings</u>
27 people (Male: 15, Female: 12)</td></tr>
<tr><td rowspan="4">Main Comments and Responses</td><td colspan="2">Key Stakeholder Workshop</td></tr>
<tr><td>[Main Comments]
1) Why was a dry FGD system not considered in such a water-poor area? Why was the decision made to go for a wet system if it is going to require a considerable amount of water, which the area does not have?

2) As the FGD units and the pollution filters will only be installed after the power station has been running for six years while the surrounding area will be subjected to pollution, what is the anticipated effect on the pollution levels, especially in Marapong which is going to be exposed mostly to pollution?

3) What will be used as baseline for the waste classification of the gypsum and other waste products associated with the FGD technology, and is there a similar unit functioning of which one can use the same information?</td><td>[Responses]
1) The reason why the WFGD was selected is because there are only two options which are viable for the removal of emissions to the degree required for Medupi Power Station. Eskom needs to comply with the minimum emission standards as well as the requirements stipulated by the World Bank. The two commercially viable technologies are WFGD and semi-dry specifically Circulating Fluidized Bed (CFB). Both technologies were assessed and a techno-economical study was done.

2) During the ROD only very low ambient conditions to be adhered to were specified. After the release of the maximum emission standards in 2010 the decision was made to retrofit Medupi Power Station with a WFGD. Until such time as the FGD system is designed and built the power station will operate without it while still adhering to the Minimum Emission Standard.

3) A chemical make-up will be used for the waste classification of the three waste streams and once Kusile Power Station is in operation the information will be verified through testing of the wastes produced by the Kusile FGD operation.</td></tr>
<tr><td colspan="2">Public meetings</td></tr>
<tr><td>1) SANCO’s key concern is whether either of the FGD alternatives, wet and/or dry FGD will reduce the water for other water users, or have a level of impact on the water usage. Lephalale Local Municipality’s water source is very scarce, and if WFGD will be used it will impact on the water usage in the area and will have a cost impact for Eskom.

2) Has a decision been made about which of the two types of FGDs will be used?

3) Will ash be produced and will it be reused?</td><td>1) Medupi Power Station has been designed to accommodate WFGD Retrofit, but is also cooler ready. With the cooler, water usage is drastically reduced. the FGD and Medupi Power Station will use water from Eskom’s water allocation abstraction from the Mokolo-Crocodile Water Augmentation Project.

2) Medupi Power Station was constructed to be FGD ready and based on a techno-economical study, a WFGD system will be utilized. It utilizes limestone as a reagent and gypsum is produced as a by-product.

3) Ash is not a by-product of the FGD technology, only the gypsum, salts, and sludge.</td></tr>
</table>

Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project, Eskom, 2018

(3) Public Comment and Review of the FSR

Outline of the public comment and review of the FSR is shown in the table below.

Table 11.11-3 Outline of the Public Disclosure and Review of the FSR

Item		Contents	
Public Disclosure	Venue	· Lephalale Local Municipality · Marapong Community Library · Agri Lephalale/Farmers Association	
	Website	http://www.zitholele.co.za/eia-for-medupi-fgd	
Disclosure and Public Review Period		from 12 June 2015 to 13 July 2015	
The ways to request comment on the FSR		· Completing the comment sheet enclosed · Writing a letter, or producing additional written submissions · Sending an e-mail or phoning the public participation office	
Main Comments and Responses		[Main Comments] 1) The air pollution control device (abatement equipment) maintenance program must be developed and implemented to ensure that the air pollution control device does not result in substantial emission increase. 2) The new gypsum disposal facility proposed as a feasible disposal alternative in the DSR should be included for evaluation in the impact assessment phase and the disposal of the gypsum in its own compartment in the future as ash disposal facility (ADF) should also be evaluated. 3) The flue gas cooler should be included in the FGD basic design instead of being presented as an alternative in the EIA process.	[Responses] 1) It should be noted that the objective of the FGD is to reduce the level of air pollution generated by the station. The station will continue to utilize the existing maintenance plan to reduce the possible increase in air pollution. 2) These options will be assessed and discussed within the EIA Phase. The conceptual designs of the preferred disposal facilities for FGD waste will be made available within the EIR. However, it must be noted that the EIA is proceeding with the understanding that gypsum will be disposed of with ash at the disposal facility. 3) The cooler, which will reduce the plant's water consumption by around 30%, does not affect the project's costs or pose any technical challenges.

Note *: Website mentioned above was written on the notice letters at that time, and was owned by EIA consultants. At this moment environmental documents are disclosed on the website of Eskom as follows; http://www.eskom.co.za/OurCompany/SustainableDevelopment/EnvironmentalImpactAssessments/medupi/Pages/default.aspx

Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project, Eskom, 2018

11.11.3. EIA Phase

The second phase is the Impact Assessment Phase, which entails undertaking various specialist studies and compiling a draft EIR. As part of the assessment, an Environmental Management Program (EMPr) will be submitted to the Department of Environmental Affairs (DEA) for their approval. By following the EMPr, Eskom and its contractors will ensure compliance to environmental regulations during the planning, construction, and operation phases. Key activities in the Impact Assessment are as follows;

- Specialist studies focused on outcomes of the Scoping Phase and issues raised by stakeholders;
- Progress feedback to stakeholders;
- Compilation of a draft EIR and EMPr indicating the potential positive and negative impacts and measures to enhance positive impacts and to reduce or avoid negative impacts;
- Environmental Impact Statement, highlighting the preferred alternative/s and reasons therefore;
- Distribution of the draft EIR and EMPr, including Issues and Responses Report, to the public for comment;
- A stakeholder meeting in the project area to present a summary of the findings of the EIR for stakeholder comment;
- Distribution of the final EIR and EMPr for comment; and
- Submission of the final EIR and EMPr for DEA decision making.

(1) Public Comment and Review of the Draft Environmental Impact Report (DEIR)

Outline of the public comment and review of the DEIR is shown in the table below.

Table 11.11-4 Outline of the Public Comment and Review of the DEIR

Item		Contents
Public Disclosure	Venue	· Lephalale Local Municipality · Marapong Community Library · Agri Lephalale/Farmers Association
	Website	http://www.zitholele.co.za/eia-for-medupi-fgd http://www.eskom.co.za/OurCompany/SustainableDevelopment/EnvironmentalImpactAssessments/medupi/Pages/default.aspx
Disclosure Period		from 19 February 2018 to 5 April 2018
Public Review Period		from 19 February 2018 to 19 April 2018
The ways to request comment on the DEIR		· Completing the comment sheet enclosed · Writing a letter, or producing additional written submissions · Sending an e-mail or phoning the public participation office · Attending any one of the public meetings

Main Comments and / Responses	[Main Comments] 1) The EA process for the FGD Retrofit Project has been substantially delayed and the current plans are for Medupi only to be fully fitted with FGD by 2026. (with each unit retrofitted 6years after it becomes operational) 2) High-quality lime required for high-quality gypsum production has not been not secured. 3) The impacts on health from operation of the station prior to FGD implementation remains a concern. 4) A flue gas cooler should be incorporated into the base case FGD. Therefore, Eskom's conclusion to reject flue gas cooler technology is not accepted based on the arguments presented by CER.	[Responses] 1) The original RoD for the Medupi Power Station (12/12/20/695) was issued on 21 September 2006, and at the time the no emissions or ambient air quality standards were promulgated. As no promulgated air quality standards existed to guide the selection of SO_2 abatement technology, Eskom opted for the worst-case scenario and designed the Medupi Power Station to be Wet Flue Gas Desulphurization (WFGD) ready. 2) Medupi Power Station FGD was designed to operate with limestone quality that will achieve a 90% minimum SO_2 removal efficiency and is deemed an appropriate sorbent quality. The procurement of suitable limestone is subject to the finalization of commercial contracts with a service provider. 3) The aim of the air quality investigation was to quantify the possible impacts resulting from the proposed activities on the surrounding environment and human health. In order to understand the potential impact, the air quality specialist ran two baseline scenarios considering Matimba and Medupi power stations with all six units operational without FGD. 4) Eskom rejected incorporation of flue gas cooler for the following reasons: ・ The cost of the inclusion of the cooler was not the sole consideration for not implementing the technology. The technical considerations outweigh the cost implications as the pragmatic considerations of the technology for use in the South African context was deemed not to be viable. ・ Other water-saving options such as the retrofitting of the cooler, were also considered through the 2018 TSSR, however, given careful consideration of the technical maintenance issues associated with operation of a gas cooler water rendered its use unfeasible at this stage.

Note *: Website mentioned above was written on the notice letters at that time, and was owned by EIA consultants. At this moment environmental documents are disclosed on the website of Eskom as follows: http://www.eskom.co.za/OurCompany/SustainableDevelopment/EnvironmentalImpactAssessments/medupi/Pages/default.aspx

Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project, Eskom, 2018

(2) Key Stakeholder Workshop and Public Meetings of the DEIR

Outline of the results of key stakeholder workshop and public meetings is shown in the table below.

Table 11.11-5 Outline of the Results of Key Stakeholder Workshop and Public Meetings

Item	Contents
Date / Time	Key Stakeholder Workshop 1st time: 13 March 2018 / 14:00 – 16:00 2nd time: 14 March 2018 / 8:00 – 10:00 Public meetings 1st time: 12 March 2018 / 11:00 – 13:00 2nd time: 12 March 2018 / 15:00 – 17:00

<table>
<tr><th>Item</th><th colspan="2">Contents</th></tr>
<tr><td></td><td colspan="2">3rd time: 13 March 2018 / 18:00 – 20:00</td></tr>
<tr><td>Venue</td><td colspan="2">Key Stakeholder Workshop
1st time: Mogol Golf Club
2nd time: Medupi Power Station Visitor Center
Public meetings
1st time: Community Hall, Lesedi Tshukudu Thusong Center
2nd time: Ditheku Primary School
3rd time: Mogol Golf Culb</td></tr>
<tr><td>Participants</td><td colspan="2">Key Stakeholder Workshop
1st time: 4 people (Male: 11, Female: 3)
2nd time: 9 people (Male: 6, Female: 1, Unknown: 2)
Public Meetings
1st time: 111 people (Male: 63, Female: 33, Unknown: 15)
2nd time: 1 people (Male: 1, Female: 0)
3rd time 18 people (Male: 13, Female: 4, Unknown: 1)</td></tr>
<tr><td rowspan="4">Main Comments and / Responses</td><td colspan="2">Key Stakeholder Workshop</td></tr>
<tr><td>[Main Comments]
1st time:
1) Will there be no temporary waste disposal sites in Lephalale?

2) Are there any plans for using the gypsum in downstream beneficiation to help locals to make use of this opportunity?

2nd time:
1) What will be the timeframe for construction of the FGD?

2) How many storage areas will there be for the gypsum and limestone? Will it be stored separately?

3) What will Eskom do after 20 years if the existing disposal facility is closed?</td><td>[Responses]
1) The EIA deals only with the existing disposal facility. Gypsum will be disposed with ash on the existing facility, while salts and sludge will be temporarily stored on site within the Medupi Power Station footprint, before being trucked to an existing disposal facility.

2) The power station has been designed to allow for future offtake of gypsum. If Eskom comes to a decision to use gypsum then the plant will be ready to implement this future offtake.

1) Eskom has internally relooked how they can accelerate the construction program even by employing more people on the construction teams. It will take about 52 months for construction of each unit, if multiple teams are put in place, Eskom should be able to complete a unit in 36 months instead of 52 months.

2) There is only one limestone storage area within the railway yard and temporary storage area near the gypsum dewatering plant. If the gypsum is suitable for offtake, gypsum will be stored at one storage area within the railway yard. They gypsum and limestone will be stored together, but if gypsum is disposed it.

3) A separate process will be undertaken to find an additional facility for disposal of ash and gypsum after 20 years.</td></tr>
<tr><td colspan="2">Public Meetings</td></tr>
<tr><td>[Main Comments]
1st time:
1) Why is the power station only taking measures now to protect the community from health impacts of gas emissions?

2) Protection of the water resources, particularly the underground systems, must be ensured.</td><td>[Responses]
1) Consultants must remain compliant to legislative requirements of the authorizations and licenses issued to the power station. The Medupi Power Station is therefore implementing the requirements relating to the FGD system in relation to changes in the national.

2) Dirty water dams would be lined as required by legislation, while a water use license application must also be obtained to prevent or minimize pollution into the groundwater. External Environmental Control Officers are furthermore contracted to undertake continuous assessment of the construction activities.</td></tr>
</table>

Item	Contents	
	2nd time 3rd time: 1) Is the Eskom going to use clean water or grey water from the system? 2) What are the characteristics of the ash composition?	No record 1) There are no specifics on the water requirement on the system, even processed water can be used. Currently, there is a plan to get the processed water from Pretoria via the MCWAP Phase 2A scheme. 2) The composition will remain the same except that there will be an addition of calcium sulfide and or calcium sulphate in the mixture.

Source: Final Environmental Impact Report for the Proposed Medupi Flue Gas Desulphurization (FGD) Retrofit Project, Eskom, 2018

11.12. Consideration of Indivisible Project and Associated Project

11.12.1. Medupi Power Station Development Project

In case of satisfied with next three conditions, the associated facilities are defined as the indivisible project and are required to examine their impact carefully in accordance with JICA Environmental Guidelines; i) the associated facilities are not funded as part of the JICA project, ii) the associated facilities would not have been constructed or expanded if the JICA project did not exist, and iii) the JICA project would not be viable without the associated facilities. Therefore, Medupi TPS Project is considered as an indivisible project from FGD project. The status of environmental and social considerations was confirmed from the point of view of JICA Environmental Guidelines through review of the existing environmental documents and interview with Eskom Environmental Team Experts.

The request for inspection on the Medupi TPS was submitted in 2010, therefore the World Bank's Inspection Panel process was reviewed in this section.

(1) Progress of EIA

EIA process on Medupi TPS has been carried out in accordance with South African EIA Regulation and World Bank Safeguard Policy, because the power station project was conducted under Word Bank Loan. Granting of conditional authorization for the Medupi TPS project was issued on 21 September 2006. (See Appendix 11.3) The main activities list is shown in Table 11.12-1.

Table 11.12-1 Medupi TPS EIA Process and Schedule (as of September 2017)

Main Activities	Date
Public Review of the Draft Scoping Report	From 3 October 2005 to 1 November 2005
Final Scoping Study	18 November 2005
Public Review of the Draft Environmental Impact Report	From 23 March 2006 to 28 April 2006
Public Meeting	28 and 29 March 2006
Key Stakeholder Meeting	30 March 2006
Final Environmental Impact Assessment Report and Environmental Management Program	22 May 2006
Addendum to Environmental Impact Assessment Report	June 2006
Environmental authorization	21 September 2006

Source: Original data was obtained from Environmental Impact Assessment Report for the Proposed Establishment of a new Coal-fired Power Station in the Lephalale Area, Limpopo Province, 2006 prepared by Bohlweki Environmental (Pty) Ltd

(2) Confirmation of Environmental and Social Considerations

Medupi TPS is a large-scale project considered as Category A in line with the JICA Environmental Guidelines. The status of environmental and social considerations was confirmed in reference to Appendix 2 of the JICA Environmental Guidelines 2010, which describes the items to be covered in the EIA reports for Category A project, even though EIA of Medupi TPS was finished in 2006 and the JICA Environmental Guidelines is adapted to the project after 2010. Confirmation result of environmental and social consideration status is shown in Table 11.12-2.

Table 11.12-2 Confirmation of Environmental and Social Considerations for Medupi TPS

	Checkpoint in line with JICA Environmental Guidelines	Description in Environmental Documents
The following conditions are met in principle:		
1	When assessment procedures already exist in host countries, and projects are subject to such procedures, project proponents, etc., must officially finish those procedures and obtain the approval of the government of the host country.	The project proponent has already finished EIA procedure officially in line with South African Act, on 21 September 2006
2	EIA reports (which may be referred to differently in different systems) must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them.	EIA report is provided in English which is official language in South Africa.
3	EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted.	All documents regarding to EIA are uploaded at two websites of the project proponent and World Bank. Documents are available at all times for perusal by project stakeholders such as local residents and copying is permitted. Website is shown below.
4	In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Records of such consultations must be prepared.	Records of public consultation meeting are attached in the EIA report.

	Checkpoint in line with JICA Environmental Guidelines	Description in Environmental Documents
5	Consultations with relevant stakeholders, such as local residents, should take place if necessary, throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared.	Public reviews and public meetings were conducted as follows: 1) Draft Scoping Report Public Review: From 3 October 2005 to 1 November 2005 Public Meeting: 28 June 2005 2) Draft EIA Report Public Review: From 23 March 2006 to 28 April 2006 Public Meeting: 28 and 29 March 2006
Environmental Impact Assessment Report An EIA's scope and level of detail should be determined in accordance with the project's potential impacts. The EIA report should include the following items (not necessarily in the order shown):		
6	Executive summary: This concisely discusses significant findings and recommended actions.	Introduction, conclusion and recommendations are mentioned in Chapters 1 and 16 of EIR, respectively.
7	Policy, legal, and administrative framework: This is the framework within which the EIA report is to be carried out.	Policy, legal, and administrative frameworks are mentioned in Chapter 3 of EIR.
8	Project description: This describes the proposed project and its geographic, ecological, social and temporal context, including any off-site investments that may be required (e.g., dedicated pipelines, access roads, power stations, water supply, housing, or raw material and product storage facilities). It also indicates the need for any resettlement or social development plan. It normally includes a map showing the project site and the area affected by the project.	Description of proposed project is mentioned in Chapter 2 of EIR. Background of the project, and necessity of the relating facilities, such as fuel combustion, biller, steam turbines, generator, transmission, conveyor belt and FGD, are described.
9	Baseline data: This assesses the dimensions of the study area and describes relevant physical, biological, and socio-economic conditions, including all changes anticipated to occur before the project commences. Additionally, it takes into account current and proposed development activities within the project area but not directly connected to the project. Data should be relevant to decisions about the project site, design, operation, or mitigation measures, and it is necessary to indicate the accuracy, reliability, and sources of the data.	General description of the study area environment as follows is mentioned in Chapter 5 of EIR. -climate, geology, land type, water resources, ecology and biodiversity, social environment (land use, population, gender, education, employment, housing, services)
10	Environmental impacts: This predicts and assesses the project's likely positive and negative impacts in quantitative terms, to the extent possible. It identifies mitigation measures and any negative environmental impacts that cannot be mitigated, and explores opportunities for environmental enhancement. It identifies and estimates the extent and quality of available data, essential data gaps and uncertainties associated with predictions, and it specifies topics that do not require further attention.	Environmental impact on water resource, ecology, geology, soil, agriculture, air quality, visual, tourism, arch logical, traffic, noise, and social impact assessment are studied in Chapters 6 and 15 of EIR, respectively. The impact assessment is summarized below.
11	Analysis of alternatives: This systematically compares feasible alternatives to the proposed project site, technology, design, and operation including the "without project" situation in terms of the following: the potential environmental impacts; the feasibility of mitigating these impacts; their capital and recurrent costs; their suitability under local conditions; and their institutional, training, and monitoring requirements. For each of the alternatives, it quantifies the environmental impacts to the extent possible, and attaches economic values where feasible. It also states the basis for selecting the particular proposed project design, and offers justification for recommended emission levels and approaches to pollution prevention and abatement.	The scoping process evaluated four alternative sites for the power station and eight alternatives for the ancillary infrastructure, including the 'do-nothing' alternative. In order to evaluate the sites and nominate a preferred site, five (5) rank evaluation was utilized for evaluation of the potential negative impact on the physical and ecological condition, and social environment. The no-project scenario was examined in consideration of the electricity demand in the future.

	Checkpoint in line with JICA Environmental Guidelines	Description in Environmental Documents
12	Environmental Management Plan (EMP): This describes mitigation, monitoring, and institutional measures to be taken during construction and operation in order to eliminate adverse impacts, offset them, or reduce them to acceptable levels.	EMP reports for Medupi TPS during the construction phase and operation phase are prepared in January 2008 (revised on September 2010) and July 2009 (revised on March 2014), respectively. EMP described the relevant law and regulations, contents of the mitigation measurements, responsible persons, monitoring parameters. Environmental mitigation measurements for waste management, hazard management, water usage management, dust management, water leakage protection, biodiversity protection and ash treatment facilities are prepared. Air quality, water quality, and noise level are monitored in line with EMP.
13	Consultation: This includes a record of consultation meetings (date, venue, participants, procedures, opinions of major local stakeholders and responses to them, and other items), including consultations for obtaining the informed views of the affected people, local NGOs, and regulatory agencies.	All minutes of consultation including key stakeholder meeting and focus group meeting are recorded.

Source: JICA Study Team

1) Summary of Environmental Impact Assessment (General)

The major environmental impacts associated with the proposed project as discussed in the EIA include:

- Potential impacts on air quality and human health as a result of emissions from the facility;
- Potential impacts on surface and groundwater resources as a result of the proposed project;
- Potential visual impacts associated with the proposed project and associated impacts on tourism potential;
- Potential noise impacts;
- Potential impacts on heritage sites;
- Potential impacts associated with the transportation of components during construction and fuel during operation;
- Potential impacts on flora, fauna and ecology;
- Potential impacts on soils and agricultural potential; and
- Potential social impacts.

The Medupi PS project area was used as the part of the game-farms. The project proponent, Eskom, prepared the Resettlement Program in compliance with South African legal requirements and purchased the land from land owner for the project site. This resettlement program was reviewed by World Bank in reference to OP 4.12 and found to be satisfactory.

Table 11.12-3 Summary of Environmental Impact Assessment on Medupi TPS Project (Medupi TPS EIA 2006)

No.	Items	Chapter of EIR	Summary of Environmental Impact Assessment
1	Water Resource	Chapter 6	・ Secondary data about faults and water source information, rainfall, groundwater level and water quality conditions, the geological feature structure around the project site and boring data were collected. ・ According to the collected data, surface water resources are limited due to low rainfall, flat gradients, and permeable soil cover. ・ Groundwater has been impacted on by the existing power station and infrastructure; the impact on hydrochemistry is not quantified due to natural pollution. ・ Management of leakage from coal stock yard and/or ash disposal facilities should be completed, and a monitoring program should be established. ・ The preliminary risk assessment indicates that any proposed FGD technology to be incorporated in the power station must aim at reducing the amount of water required and that recycling and treatment be utilized to ensure the impacts of additional clean water use minimal.
2	Flora, Fauna and Ecology	Chapter 7	・ Field survey and secondary data collection on flora, fauna and ecology in and around project area were conducted. Impacts on the rear species recorded in Red Data Book and/or natural plants and wild animals were examined. ・ Impacts of some significance that should be taken into consideration include, destruction of natural habitat; and destruction of protected tree species and associated habitat. ・ The impact on the utilization of the game on the farm by overseas hunting clients, and by sightseeing tourists, will be significantly affected, but falls outside the ambit of this discussion. ・ A new power station 11 km from a game farm will not constitute a significant risk to the health and well-being of any of the game animals on the farm. The construction phase has the potential to cause the loss of animals as outlined.
3	Soils and Agriculture	Chapter 8	・ Soil analysis in the project area (Power Station and Ash Disposal Facility) was conducted. ・ It is recommended that the topsoil (approximately 300-400 mm) be removed and stored prior to construction. In this way, the soil will be available elsewhere at a later date for rehabilitation purposes.
4	Air Quality	Chapter 9	・ See below
5	Visual	Chapter 10	・ The visual impact due to the existing power station structures, chimneys and ADF is examined at short, medium and long-distance area by visual impact index. ・ The vegetation cover of this region is possibly the single most important element in the construction and operation of the proposed coal-fired power station, and should be revered as a critical component in the mitigation and potential negation of the visual impact.
6	Tourism	Chapter 11	・ Interview survey to game farmers was conducted. ・ The proposed power station development will not adversely affect the existing overall tourism industry in the area. ・ Visual/noise impact of power station to be reduced as advised by the visual /noise Impact Specialist and in this report. ・ The existing ecotourism venues in Lephalale should be marketed and that a variety of local tourism accommodation venues are marketed and promoted to business tourists visiting the existing and new power station.
7	Heritage	Chapter 12	・ Field survey in and around the project area was conducted to confirm the current condition and land use. ・ The cemeteries should be avoided from constructing the coal supply conveyor belt. ・ The cemeteries should be avoided. Alternatively, if that is not possible, mitigation measures can be implemented by relocating the graves.

No.	Items	Chapter of EIR	Summary of Environmental Impact Assessment
			・ If archaeological sites are exposed during construction work, it should immediately be reported to a museum, preferably one at which an archaeologist is available, so that an investigation and evaluation of the finds can be made.
8	Transportation	Chapter 13	・ Taking into account of the latest provincial traffic counts survey data, the traffic travel pattern of the peak hour of vehicular traffic at the Matimba Power Station access gate and the current road condition, impacts on traffic condition due to the project were examined. ・ It is recommended that the effect on pavement loading and subsequent advance of any road rehabilitation programme should be mitigated after completion of construction ・ The coal supply transport impact is slight, the extent is localised, the duration is long term. ・ In the event that flue gas desulphurisation is accepted as an appropriate abatement technology, it is recommended that a detailed evaluation be undertaken for the transport of flue gas desulphurisation raw material supply to optimise the placement of infrastructure and minimise the operations costs.
9	Noise	Chapter 14	・ Noise measurement around the project site, collection of the secondary data about land use and noise source information were conducted. ・ The noise mitigating measures should be considered during the construction phase and operation phase. The noise generated from operation of ash transportation conveyor was considered ・ The National Noise Control Regulations and SANS 10103 should be used as the main guidelines for addressing the potential noise impact on this project.
10	Social Environment	Chapter 15	・ There is a possibility of impact on employment creation during construction and operation, influx of job seekers, social problems arising from population influx, change in local infrastructure requirements, effects on local farm owners and residents, safety and daily movement patterns. Many of the negative impacts are anticipated to respond favourably to mitigation measures, whereas some of the positive impacts (e.g., maximization of employment opportunities for members of local communities) can be optimized. Mitigation measures for each impact are proposed

Source：Environmental Impact Assessment Report for the Proposed Establishment of a New Coal-Fired Power Station in the Lephalale Area, Limpopo Province, 2006 prepared by Bohlweki Environmental (Pty) Ltd

2) Impact on Air Quality

Collection of the secondary data and the field survey around the project site are conducted. In the field survey, the baseline level including the impact of existing Matinba TPS was confirmed by measurement on wind direction, wind velocity, and concentration of the air pollutant.

As for the prediction, the mathematical atmospheric dispersion simulation methodology was utilized to predict the SO_2 concentration in several scenarios, such as a number of unit (3 x 800 MW or 6 x 800 MW) and the stack height (220 m or 250 m). In case of SO_2 dispersion simulation, SO_2 control efficiency was compared among 0%, 60 %, 80%, and 90 %. The result of prediction was compared with severest standards among long-term (annual) standard and short-term (1 hour or 24 hours) standard of South Africa, WHO, EC, World Bank, UK, Australia and US-EPA. Prediction of impact of PM included existing and planned ash disposal facilities as emission sources.

Regarding human health risk potential, the risk assessment of UK, which evaluates the hourly concentration of SO_2 was utilized as the evaluation indicator (Low: <660, Moderate: 660-930, High: 930-1400, Very high: >1400 (Unit: μg/m3)). Regarding the potential for vegetation damage, the ambient air quality limits issued by the EC and WHO for protection of ecosystems (Low: <1 300 μg/m³/hour and <20 μg/m³/day, Moderate: < 300 μg/m³/hour or 20 – 30 μg/m³/day, High > 300 μg/m³/hour and >30 μg/m³/day) were compared with the predicted SO_2 concentration at the surrounding farms.

The result of examination above is summarized in Table 11.12-4. To reduce the amount of SO_2 in the exhaust gas, FGD facility was proposed to be installed.

Table 11.12-4 Summary of Impact on Air Quality due to the Implementation of Medupi TPS (Medupi TPS EIA 2006)

Items/Parameters	Result of Prediction and Evaluation on Negative Impact
NO and NO_2	Predicted NO and NO_2 concentrations were predicted to be within local and international air quality limits for all proposed power station configuration scenarios (including cumulative concentrations due to the existing Matimba Power Station emissions).
PM_{10}	Predicted PM_{10} concentrations were within the SA daily and annual standards but exceeded the South Africa National Standard and European Community limit values in the vicinity (within 4 km) of the ash dump.
SO_2	Emissions from the existing Matimba Power Station are predicted to be responsible for exceedances of SA standards particularly downwind of the facility. Given this baseline it is evident that even given 90% control efficiencies on all six units, the maximum predicted hourly concentrations, the spatial extent of non-compliance with the 10-minute limit, daily limits and the frequencies of exceedance at Marapong would be marginally higher than for current operations.
Human Health	Sulphur dioxide concentrations occurring due to existing Matimba Power Station emissions are predicted to be associated with "low" and "moderate" health risks. Significant increments in health risk potentials associated with the proposed power station may therefore be avoided by ensuring a >60% reduction in sulphur dioxide emissions should only three 800 MW be installed. In the event that six units were to be installed - regardless of whether or not these units are to be phased in or not – a control efficiency in excess of 80% would be required for all six units to prevent increments in health risk potentials above baseline conditions.
Vegetation Damage	The potential for vegetation damage and corrosion due to current monitored and predicted ambient sulphur dioxide concentrations is classifiable as "low". Sulphur dioxide abatement with a 60% control efficiency would result in the potential for corrosion and vegetation damages being primarily classified as "low".

Source : Environmental Impact Assessment Report for the Proposed Establishment of a new Coal-Fired Power Station in the Lephalale Area, Limpopo Province, 2006 prepared by Bohlweki Environmental (Pty) Ltd

3) Public Disclosure

The EIA report attached with the minutes of the meeting is publicly disclosed at the following website:

- Eskom HP (accessed in January 2018)
  http://www.eskom.co.za/OurCompany/SustainableDevelopment/EnvironmentalImpactAssessments/Pages/Medupi_Power_Station.aspx
- World Bank HP (accessed in January 2018)
  http://projects.worldbank.org/P116410/eskom-investment-support-project?lang=en&tab=documents&subTab=projectDocuments

(3) Corresponding for Record of Decision for Medupi TPS in Environmental Authorization

Granting of conditional authorization for the Medupi TPS Project mentions the specific conditions. The status of corresponding for the specific condition is shown in Table 11.12-5.

Table 11.12-5 Corresponding for Record of Decision for Medupi TPS in EA

Specific Conditions	Status of Corresponding by Eskom
Air Quality Management	· Air quality monitoring station was set on the south of Medupi TPS. The location is shown in Figure 11.2-1. The monitoring station is equipped for the continuous monitoring of sulphur dioxide (SO_2), oxides of nitrogen (NO, NO_2 and NO_X), ozone (O_3), and fine particulate matter with aerodynamic diameter less than 2.5 µm and less than 10 µm ($PM_{2.5}$, PM_{10}). Temperature, wind speed and wind direction are also monitored. Monitoring report for ambient air quality is submitted as Air Quality Monthly Report to Limpopo Economic Development Environment and Tourism on a monthly basis. · In compliance with the Atmospheric Emission License, the daily amount of coal consumption and the amount of the pollutant in emission gas are monitored and data is submitted as Emission Monthly Report. · The FGD is still planned to be installed.
Environmental Monitoring Committee (EMC) and Environmental Control Officer (ECO)	· The core purpose of the committee is to share information on the EMC and associated activities; share information on project progress related to project environmental issues; offer a platform for the public to raise concerns/objections/recommendations with regard to project environmental issues; and to ensure good communication between the EMC, interested and affected parties (I&APs), stakeholders and the Project. · EMC is composed of Chairperson, Lead Environmental Control Officer, Waste Management Control Officer, Ecologist, Medupi Management Representative, Medupi Environmental Representative, Eskom Stakeholder Representative and Community Representatives. · EMCs conduct periodic site visits and inspections for monitoring and mitigation measures. · Environmental Control Officers (ECO) in Medupi comprised Lead ECO, three assistant ECOs and a Waste Management Control Officer (WMCO), whom are appointed by the EMC in conjunction with Eskom to independently monitor environmental compliance and performance for the duration of the construction phase (including the completion of rehabilitation) as required. The primary role of the Environmental Control Officer is to act as quality assurance regarding all environmental concerns. In this respect, the ECO conducts periodic site inspections, attends regular site meetings, pre-empts problems and suggests mitigation and is available to advise on incidental environmental issues that arise. The ECO conducts compliance assessments on behalf of the EMC, verifying the monitoring reports submitted by the Project Environmental Team and the Principal Contractors environmental officers.

Environmental Management Plan, Monitoring and Auditing	・ In compliance with the EMP prepared during pre-operation, the project proponent submits the monthly Environmental Compliance Report to DEA. ・ Environmental mitigation measurements for waste management, hazard management, water usage management, dust management, water leakage protection, biodiversity protection, ash treatment facilities and coal management, periodically audit and monitoring and record of accidents are reported periodically. ・ Internal Audit: The Project environmental team conducts audits on contractors and focuses specifically on areas such as waste management, incident management, hazardous chemical substance management, non-conformance management, etc. ・ ECO Audit: The ECO is focused on conducting EMP and Environmental Authorization compliance audits on the contractors. These audits are conducted on a quarterly basis. ・ External Audit: The project was visited by a joint supervision mission comprising delegates from the World Bank and African Development Bank. This was part of their bi-annual compliance assessment inspections, which also focused on compliance to environmental and social safeguards and general environmental management on the project.
Water Quality Management	・ To ensure that soil pollution of the resource does not occur during operation, groundwater quality monitoring shown in Figure 11.2-5 is conducted continuously. Monitoring results are reported at EMC meeting.

Source: Medupi Power Station Project Annual EHS Report 2016-17

(4) Conclusion of Environmental and Social Considerations Status

Judging from reviewing work above, the procedure and contents of EIA are satisfied with the requirement of JICA Environmental Guidelines as well as World Bank Safeguard Policy, and as shown in Table 11.12-2 and Table 11.12-3. As for the response to record of decision for EIA report for Medupi TPS, it is confirmed that following up activities are conducted adequately, and reports are compiled periodically as shown in Table 11.12-5.

(5) Overview of the World Bank Inspection Panel Process

The following is an overview of the request for inspection on the Eskom Investment Support Project (EISP) and the Panel's Investigation Report.

On April 6, 2010, the Inspection Panel received a Request for Inspection from NGOs from South Africa, on behalf of representatives of the community members in the Medupi TPS project area. The concerns and likely harm raised in the request are health impacts, impact on water, cultural impacts, livelihood impacts, impacts on economy, upstream impacts, climate change, involuntary resettlement, human rights, cumulative impacts, project alternatives, country systems, legacy of the World Bank involvement, energy access for the poor, and raising concerns with the World Bank. The World Bank has already conducted investigation and responded about all concerns, and the process has been completed.

Table 11.12-6 Overview of the World Bank Inspection Panel Process

Step	Date	Event and /or Response
1	6 April 2010	Inspection Panel received a Request for Inspection
2	7 April 2010	Notice of Registration
3	25 May 2010	Bank Management Response to Request for Inspection Panel Review
4	28 June and 29 July 2010	Eligibility Report and Chairperson Statement
5	21 November 2011	Investigation Report
6	2 March 2012	Management Report and Recommendations
7	26 May 2012	Inspection Panel Investigation Report

Source：The JICA Study Team summarized contents mentioned in the following website (accessed on December 2018)
https://www.inspectionpanel.org/panel-cases/eskom-investment-support-project

Step 1：Request for Inspection
http://ewebapps.worldbank.org/apps/ip/PanelCases/65-Request for Inspection (English).pdf

Step 2：Notice of Registration
http://ewebapps.worldbank.org/apps/ip/PanelCases/65-Notice of Registration (English).pdf

Step 3：Bank Management Response to Request for Inspection Panel Review
http://ewebapps.worldbank.org/apps/ip/PanelCases/65-Management Response (English).pdf

Step 4：Eligibility Report and Chairperson Statement
http://ewebapps.worldbank.org/apps/ip/PanelCases/65-Eligibility Report and Chairperson Statement (English).pdf

Step 5：Investigation Report
http://ewebapps.worldbank.org/apps/ip/PanelCases/65-Investigation Report (English).pdf

Step 6：Management Report and Recommendations
http://ewebapps.worldbank.org/apps/ip/PanelCases/65-Management Report and Recommendations (English).pdf

Step 7：Inspection Panel Investigation Report
https://www.inspectionpanel.org/sites/www.inspectionpanel.org/files/ip/PanelCases/65-Inspection%20Panel%20Overview%20of%20Investigation%20Report%20%28English%29.pdf

11.12.2. Water Supply Project （MCWAP2）

The Mokoro and Crocodile (West) Water Argumentation Project Phase 2 (MCWAP2) is addressing the water needs of the Lephalale area. Additional water supply to Medupi FGD by DWS is 2.5 million m^3/year, which is estimated to be approximately 3.3% against the total capacity of MCWAP2 water supply (75.86 million m^3/year). Water users are not only thermal power stations but also urban domestic users, industrial users, irrigation users, and rural area farm users. Therefore, MCWAP 2 is not considered as an indivisible project from the FGD project.

As for the EIA progress on MCWAP 2, the final scoping reports were accepted by DEA. The draft EIA was submitted to DEA in September 2018. The Final EIA report was submitted to the DEA in November 2018 and DEA granted the (Environmental Authorization (EA) at the end of March 2019. The process to review the appeals to the EA in compliance with the regulation will take place, as of April 2019.

Regarding to the construction of the water pipeline from the off-take point on the MCWAP Phase 2 to the Medupi FGD plant (length is approximately 5.3 km) presented in Figure 11.6-14, Eskom will be the project proponent. Eskom expects that the BA process for the water pipeline will be concluded on or before December 2019, as of December 2018.

Chapter 12 Implementation Plan

12.1. Project Package

The proposed packaging is shown in Table 12.1-1. Originally, Eskom has their project packaging idea that consists of seven separately packages, i.e. absorber work, limestone slurry and gypsum dewatering, and five other works. However, JICA Study Team proposed the unification of absorber work, limestone slurry preparation work, and gypsum dewatering work. Also, the further separation of Engineering & Procurement and Construction (Erection) was recommended. The reason for the combination of absorber work, limestone slurry preparation work, and gypsum dewatering work is to secure the performance guarantee of the FFGD. These three systems should be unified to a single package. On the other hand, the reason for the separation of the EPC (Erection) is so that international bidders with a lot of experience can participate in the bid where they can be free from the construction risk in case the "Construction" element is excluded from the scope of the contract. If they are separated, international bidders will release the construction risk with a characteristic legal framework. Through this Eskom can secure the local contents of a construction package.

Table 12.1-1 Proposed Packaging

	Package	Contracting Arrangement
CP-1	Supply of Equipment Absorber, Limestone Slurry Preparation, and Gypsum Dewatering	EPS
CP-2	Civil Work and Installation for CP-1	C
CP-3	Distributed Control System	EPC
CP-4	Power Supply System	EPC
CP-5	Waste Water Treatment Plant	EPC
CP-6	Rail and Materials Handling Systems for Limestone Supply and Gypsum Disposal	EPC
CP-7	Civil Work for CP-6	C
CP-8	Site Service	Service providing
CP-9	MCWAP connection	EPC

EPS: Engineering, Procurement and Supply
EPC: Engineering, Procurement and Construction
C: Construction (Civil Work and/or Installation)

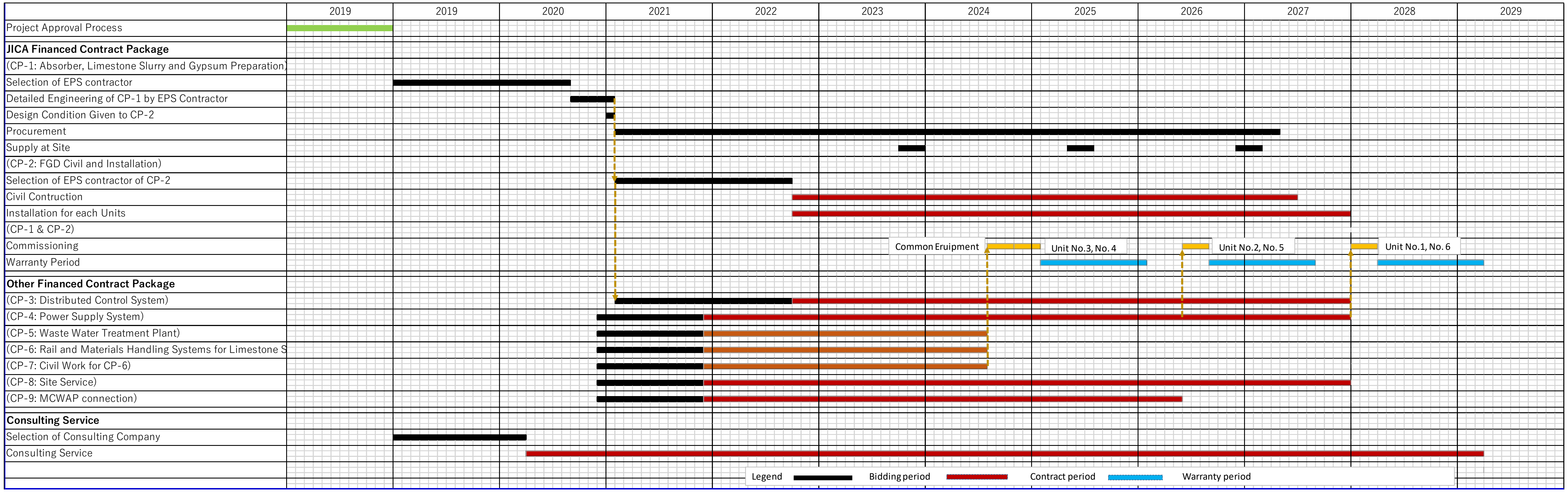
12.2. Scope of the JICA Loan

The scope of the JICA loan covers the construction cost for CP-1 and CP-2 as indicated in Table 12.1-1 and the consulting service fee. Project Implementation Plan

12.3. Project Implementation Schedule

The planned implementation schedule of construction is shown in Table 12.4 1. The total duration of the project is estimated for 84 months from the preparation stage of the JICA Loan Agreement (LA) to the completion of the commissioning tests on-site. In the construction of the FGD, it should be noted that the existing units of Medupi TPS are in operation. One month of work is required to connect the new FGD duct to the existing duct. Therefore, there is a need to adjust the operation schedule of each unit of the Medupi TPS. The project should be completed by the end of March 2025 by the NEMAQA.

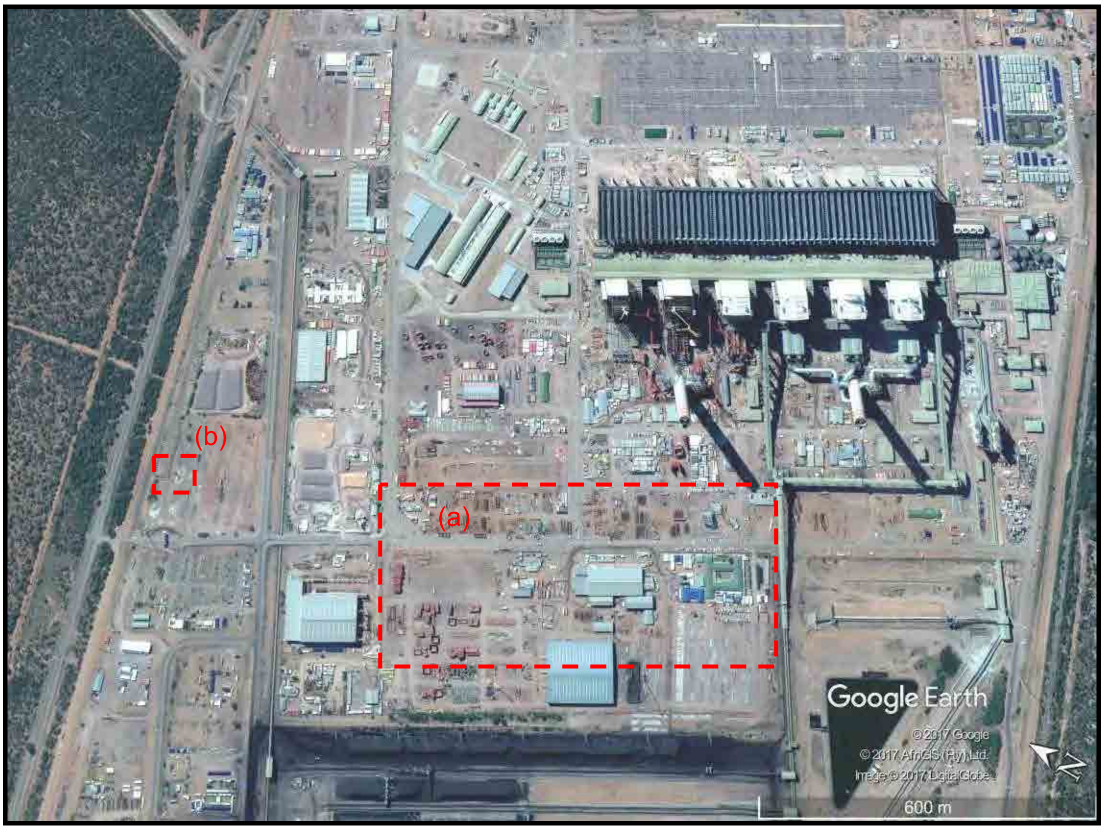
Table 12.3-1 Planned Implementation Schedule



Source: Prepared by the JICA Study Team

(1) Points to consider regarding temporary construction

For the project implementation, a temporary yard for the site office, workshop, materials, and construction equipment is needed. A space for the temporary yard is available at the TPS. However, there is also a temporary yard for the ongoing construction project for generating units, shown as (b), in Figure 12.4-2-1 below. The expected completion of the project for generating units is at the end of 2019. Therefore, the use of their office and workshop for FGD retrofit project is recommended. The temporary office, factory, and material storage place are shown in Figure 12.3-1.



(a)	Temporary Office, Fabricating Lab and Material Storage Space
(b)	Temporary Gate & Transportation Entrance of Large Equipment

Source: Prepared by the JICA Study Team using Google Earth (taken in May 2017)

Figure 12.3-1 Temporary Space

The contractors of Medupi TPS under construction uses the temporary power supply. On the other hand, A power supply from Medupi TPS for the FGD retrofit project can be taken from Medupi TPS at the time. The JICA Study Team recommends that Eskom coordinates to supply power from Medupi TSP.

(2) Points to consider regarding the construction stage

It is necessary to be precise and to work with caution when hanging a load or turning the crane because this project shall be carried out under a live condition of the TPS. The construction order is as follows so that FGD's are installed within six years after the start of each unit operation.

i. Com Equipment

ii. Unit 6 FGD

iii. Unit 5 FGD

iv. Unit 4 FGD

v. Unit 3 FGD

vi. Unit 2 FGD

vii. Unit 1 FGD

The construction site of Unit 4 FGD will be narrow because the Com Equipment is built first. The operation of the crane in a narrow area has the risk of damaging the existing equipment, which will cause delays in the work progress. In order to avoid this risk, it is recommended that the construction of the Com Equipment (Limestone Preparation Building and Process Water Tank) be in close proximity to Unit 4 FGD. The order of construction and overview of narrow spots are presented in Figure 12.3-2 and Table 12.3-2.

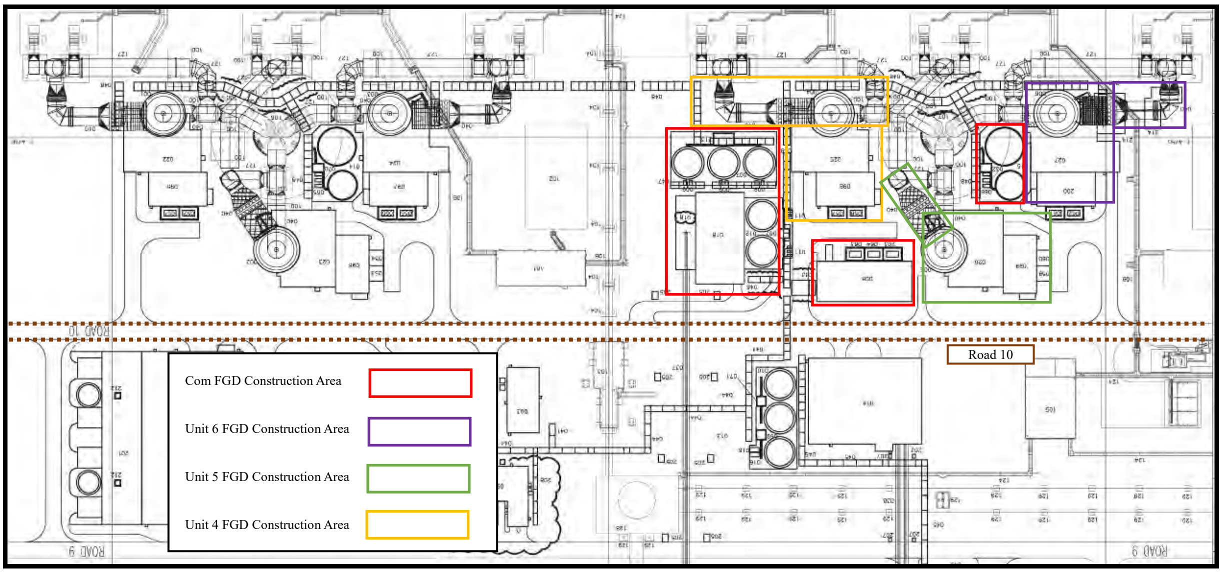
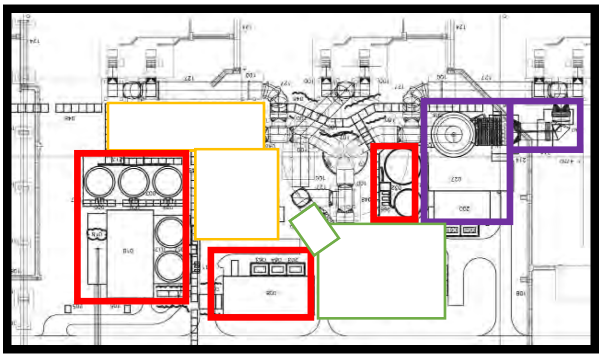
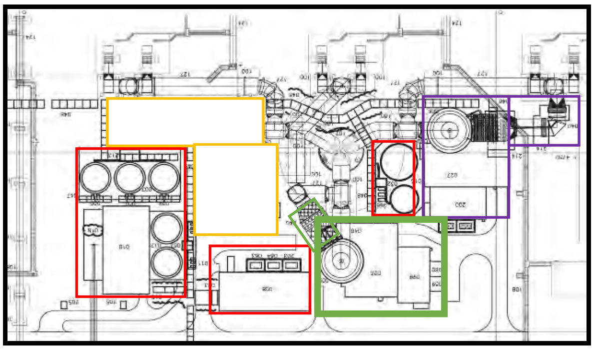
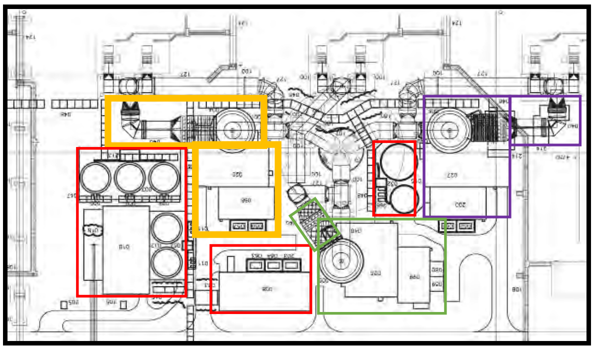
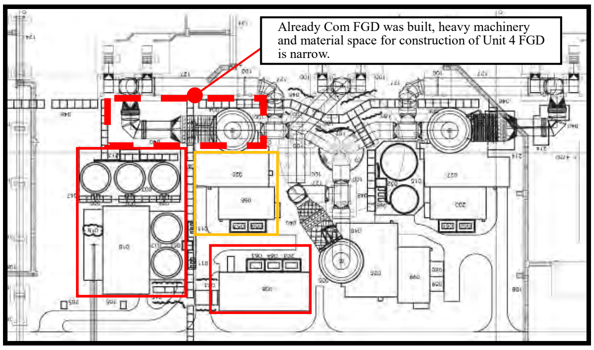


Figure 12.3-2 Overall Layout for the Future FGD

Table 12.3-2 Steps in the Schedule of Construction

<table>
<tr><td>Step 1 (Construction of Com FGD and Unit 6 FGD)</td><td>Step 2 (Construction of Com FGD and Unit 5 FGD)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Step 3 (Construction of Com FGD and Unit 4 FGD)</td><td>Point of Concerns for FGD Construction</td></tr>
<tr><td></td><td>
</td></tr>
</table>

Source: Prepared by the JICA Study Team based on the layout plan received from Eskom last September 2017

(3) Points to consider regarding transportation

Limit of Inland Transportation

When the trailer travels along the National Road, it conforms to the National Road Traffic ACT 93 of 1996. The size of the vehicle that is capable of traveling and its axial load limits are shown in Table 12.3-3 and Table 12.3-4, respectively.

Table 12.3-3 Vehicle Capability

Length	Width	Height
Less than 18.5 m	Less than 2.5 m	Less than 4.65 m

Source: Sorted by JICA Study Team, based on the National Road Traffic ACT 93

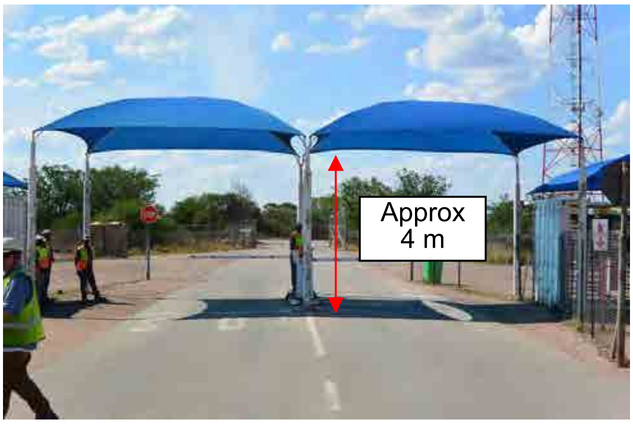
Table 12.3-4　Defined Maximum Axle Loads

National Road Traffic Act-Reg. 240 (Defined maximum axle loads)			
REG. 240: (Max. axle mass load)	STEERING:	NON-STEER: (2 wheels/axle)	NON-STEER: (4 wheels/axle)
per wheel:	3850kg	4000kg	
per axle:	7700kg	8000kg	9000kg
2 axle unit:	15400kg	16000kg	18000kg
3 axle unit:	23100kg	24000kg	24000kg

Source: Prepared by the JICA Study Team, Quote website of South African Sugarcane Research Institute

Entrance of Large Sized Equipment to Medupi TPS

The entrance of large equipment to Medupi TPS is shown in Figure12.4-2-1 and Figure12.4-2-7. Currently, this entrance is a temporary one. A permanent entrance will be built in a few years.

Temporary Gate	Gate for Transportation of Large Equipment
	

Source: Taken by the JICA Study Team

Figure 12.3-3　Medupi Power Station Gate East

12.4. Estimation of Project Costs

12.4.1. Basis of Capital Cost Estimation

Capital cost estimates were developed for building six units of 800 MW wet-type FGD at the Medupi site. All costs are presented in ZAR or JPY by exchange rates, as of December 2018. The estimation includes the EPS or EPC, or construction contractor's costs; however, it does not include financing costs. The financing cost is assumed in another chapter.

Each contractor has the responsibility to implement the activities specified in each agreement. Unlike the general EPC project by one packaging, the employer cannot enjoy a "turnkey." This means that the employer shall be the one to control and coordinate the interface of each package.

The capital cost was estimated with reference to the cost estimation prepared by Eskom.

The final project price after competitive bidding will depend on the overall market conditions at the time of bidding and the country where the major equipment will be acquired. Usually, less-developed countries, in terms of technology, can offer equipment with lower prices than developed countries such as Japan, Western Europe, and the USA. However, it is strongly recommended that the equipment supplier be selected through a wider view. This is so that the selection is able to consider not only the capital cost, but high equipment reliability as well. Therefore, it is recommended for the equipment supplier to satisfy the qualifications specified in the following section.

12.4.2. Estimated Construction Cost (Including Equipment)

The estimated cost for the FGD (six units) is shown in Table 12.4-1. The construction cost for the Project's plant is approximately JPY 299 billion.

Basically, the construction cost is estimated based on the estimate for Eskom.

Table 12.4-1 Estimated Costs for the FGD (JPY 1: ZAR 7.94)

No.	Item	Cost ZAR in Million (JPY in Million)
CP-1	Supply of Equipment Absorber, Limestone Slurry Preparation, and Gypsum Dewatering (EPS)	7,862 (62,421)
CP-2	Civil Work and Installation for CP-1 (C)	3,689 (29,289)
CP-3	Distributed Control System	174 (1,385)
CP-4	Power Supply System	1,127 (8,952)
CP-5	Waste Water Treatment Plant	5,760 (45,735)
CP-6	Rail and Materials Handling Systems for Limestone Supply and Gypsum Disposal	2,351 (14,663)
CP-7	Civil Work for CP-6	1,513 (12,017)
CP-8	Site Service	1,484 (11,781)
CP-9	MCWAP connection	70 (557)
Total Cost		23,526 (186,799)

EPS: Engineering, Procurement, and Supply

C: Construction

Source: Prepared by the JICA Study Team

12.4.3. Estimated Consulting Service Fee

The required input for competent engineers for each stage is shown in Table 12.4-2.

Table 12.4-2 Input of Required Engineers

Implementation Stage	Foreign Engineers (MM)	Local Engineers (MM)
Construction Stage	1,365	1,569
Total	1,365	1,569

Source: Prepared by the JICA Study Team

Based on the above assumptions of the required input of engineers, the consulting service fee was estimated at ZAR 162 million (JPY 1,396 million).

12.4.4. Dispute Board

JICA provided a Dispute Board (DB) Manual in 2012. The International Federation of Consulting Engineers (FIDIC, acronym for its French name *Fédération Internationale Des Ingénieurs-Conseils*) also mandated the establishment of dispute boards in the FIDIC MDB Harmonized Edition, 2010 Edition. These show the trend of the establishment of dispute solution organizations eyeing a third party prior to the commencement of a construction project. The JICA Study Team strongly recommends the establishment of a dispute board for the Project.

The dispute board consists of one to three members as a permanent standing organization. They give advice and judgement through periodical site visits to prevent serious dispute troubles, i.e., arbitration and litigation.

The employer (Eskom) must decide on the number of DB members prior to the Invitation to Tender.

In the FIDIC Contracts Guide (2000), it is suggested that a three-person DB would typically be regarded as appropriate for a contract involving an average monthly payment certificate exceeding the equivalent of USD 2.0 million (at year 2000 prices) until the end of the liability period.

12.4.5. Estimated Project Implementation Cost

The project cost was estimated through FGD BD by design company who was outsourced by Eskom. The cost that is adjusted due to change of estimation condition is adopted.

Cost estimation for the project implementation includes:

- ✓ Capital Cost (spare parts inclusive)
- ✓ Financing Cost
- ✓ Administrative Cost (owner's fee)
- ✓ Taxes and Fees
- ✓ Contingency
- ✓ Cost for EIA
- ✓ Cost regarding Obtaining Permission from local government

Capital cost is approximately JPY 298,980 million as mentioned above.

Financing cost is estimated as mentioned hereinafter in the Chapter of "Economic/Financial Analysis."

The spare parts cost should be included in the capital cost as these are supplied during the construction period. Recommendable item and number for spare parts are the same as the item and number specified in the coal TPP model case of "Cost and Performance Baseline for Fossil Energy Plants" that is published by the Department of Energy (DOE). The summary of the number of spare parts is shown in Table 12.4-3. In case of the adoption of high-quality equipment and implementation of maintenance with the recommended methodology by their manufacturer, the life cycle of facilities is expected to be at least seven to ten years without using spare parts. However, spare parts should be provided in the event of accidents in the span of expected lifetime of the equipment from the start of operation. Before they are used, spare parts will retain their original capacity in the long run. In Japan, renovation cost is generally derived from about 3% per year of construction cost, which means it will take JPY 1,800 million annually to maintain the project plant.

The project cost for the application of the Medupi FGD Retrofit Project is shown in Table 12.4-4.

The cost estimation for project implementation is assumed in the application for the Japanese Official Development Assistance (ODA) Loan. Price escalation was set at 1.83% for Foreign Cost (FC) and 1.0% for Local Cost (LC). The interest rate applied was for the Japanese Yen Loan (Construction: 1.5%, Consultant: 0.01%).

The eligible cost, interest during construction, and commitment charge in Table 12.4-4 correspond to the JICA-financed portion.

Table 12.4-3 Summary of Number of Spare Parts

	Spare Item	Number
Sorbent Preparation and Feed	Limestone Weigh Feeder	1
	Limestone Ball Mill	1
	Auxiliaries	1
Flue Gas Clean up FGD and ESP	Pumps	1 respectively
	Belts	1
	Blower	1

Source: Prepared by the JICA Study Team based on the "Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity," DOE.

Table 12.4-4 Project Implementation Cost (FC and Total: JPY in Million, LC: ZAR in Million)

Item		Total		
		FC	LC	Total
A. ELIGIBLE PORTION				
Ⅰ)	Procurement / Construction	73,845	4,240	107,507
	CP-1 Supply of Equipment Absorber, Limestone Slurry Preparation, and Gypsum Dewatering (EPS)	62,421	0	62,421
	CP-2 Civil Work and Installation for CP-1 (C)	117	3,674	29,289
	Base Cost for JICA Financing	62,539	3,674	91,710
	Price Escalation	4,593	180	6,024
	Physical Contingency	6,713	385	9,773
Ⅱ)	Consulting Services	7,177	362	10,051
	Base Cost	6,338	330	8,961
	Price Escalation	498	14	661
	Physical Contingency	342	17	479
Total (Ⅰ + Ⅱ)		81,022	4,602	117,559
B. NON-ELIGIBLE PORTION				
a	Procurement / Construction	24,493	10,638	108,958
	CP-6 Rail and Material Handling Systems for Limestone Supply and Gypsum Disposal (EPC)	208	148	1,385
	CP-3 Distributed Control System (EPC)	1,343	958	8,952
	CP-4 Power Supply System (EPC)	6,860	4,896	45,735
	CP-5 Waste Water Treatment Plant (EPC)	12,463	277	14,663
	CP-7 Civil Work for CP-3, CP-4, CP-5, and CP-6 (C)	0	1,513	12,017
	CP-8 Site Service	0	1,484	11,781
	CP-9 MCWAP Connection	0	70	557
	Base Cost	20,874	9,347	95,089
	Price Escalation	1,392	324	3,964
	Physical Contingency	2,228	967	9,905
b	Land Acquisition	0	0	0
	Base Cost	0	0	0
	Price Escalation	0	0	0
	Physical Contingency	0	0	0
c	Administration Cost	0	2,337	18,552
d	VAT	0	3,994	31,712
e	Import Tax	0	619	4,917
Total (a+b+c+d+e)		24,493	17,588	164,139
TOTAL (A+B)		105,515	22,189	281,698
C. Interest during Construction		16,056	0	16,056
	16,051	0	16,051	4,860

5	0	5	1
D. Front End Fee	1,227	0	1,227
GRAND TOTAL (A+B+C+D)	122,798	22,189	298,980
E. JICA-finance Portion Incl. IDC (A + C)	86,554	4,602	123,090

Source: Prepared by the JICA Study Team

12.5. Disbursement Schedule

The disbursement schedule including all packages is shown in Table 12.5-1. Payment for 2019 will be about 4.9% of the total cost since construction will start on this year. This consists of the construction cost mainly for advance payment. Payment from 2020 to 2024 will be approximately 20.6%, 18.2%, 20.6%, 17.1%, and 10.0% of the total cost, respectively. Payment for 2025 will be approximately 4.9% of the total cost after the approval of the completion of construction, while the payment for 2026 will be about 3.9% of the total cost after the warranty period is completed during this year. The payment is composed of the construction cost, installation cost, and consultant fee for the construction stage.

Table 12.5-1 Medupi FGD Construction Cash Disbursement Schedule including All Packages

Schedule	Payments	
Year	USD in Million	In %
FY2019 (Construction 1st)	13,668	4.6%
FY2020 (Construction 2nd)	61,675	20.6%
FY2021 (Construction 3rd)	54,274	18.2%
FY2022 (Construction 4th)	61,728	20.6%
FY2023 (Construction 5th)	51,190	17.1%
FY2024 (Construction 6th)	29,934	10.0%
FY2025 (Construction 7th)	14,776	4.9%
FY2026 (Warranty)	11,735	3.9%
Total	298,980	100.00%

Source: Prepared by the JICA Study Team
Note: Including consultant fee for construction supervision

12.6. Permission and Clearance

12.6.1. Permission

(1) Procedure for Waste

All activities for management of waste is regulated by the National Environmental Management Waste Act, 2008 (Act No. 59 of 2008) (NEM:WA) and related laws. NEM: WA sets the management waste licenses to avoid the negative impact for human health or to the environment by regulating waste management activity. In case of an activity that is listed in the Act, a license shall be obtained from the authority before starting the said activity.

Activities related to the waste treatment are shown in Table 12.6-1.

Table 12.6-1 Description of Applicable Waste Management Activities Listed in GN R718 (2008)

Activity Number	Description of Listed Activity
Government Notice No.718 NEMA 2008 as amended in 2013: Category B	
7	The disposal of any quantity of hazardous waste to land.
10	The construction of a facility for the waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity).
Government Notice No.718 NEMA 2008 as amended in 2013: Category C	
2	The storage of hazardous waste at a facility that has the capacity to store in excess of 80 m^3 of hazardous waste at any given time, excluding the storage of hazardous waste in lagoons or the temporary storage of such wastes.

Source: Government Notice No.718 NEMA 2008 as amended GNR921 on 2013

(2) National Water Act

The activities associated with the proposed Medupi FGD retrofit project trigger some of the water uses that are defined in Section 21 of the National Water Act, 1998 (Act No. 36 of 1998) (NWA). Accordingly, these water uses may not be undertaken without being granted a water use license from the DWS. In accordance with Sections 40 and 41 of the NWA (1998), a water use license application process shall be carried out.

Table 12.6-2 Timeframes for Receiving and Steps in the Processing of a Water Use License Application

Step	Steps in Processing of Water Use License Applications	Maximum Days Allocated	Cumulative Days	Responsible
0	Pre-application inquiry	0	0	Applicant / Responsible authority
1	Application submission	1	1	Applicant
2	Responsible authority acknowledges receipt of the application	10	11	Responsible authority
3	Applicant confirms arrangement for site inspection with an allocated case officer	5	16	Applicant
4	Site inspection to confirm water uses, determine information requirements and the need for public participation	20	36	Responsible authority / Applicant
5	Confirm requirements for water use license application technical report based on site visit and meeting	5	41	Responsible authority
6	Compilation, consultation, and submission of water use license application technical report by applicant	105	146	Applicant
7	Reject or accept water use license application technical report	10	156	Responsible authority
8	Assessment	139	295	Responsible authority / Applicant
9	Decision and communication to applicant	5	300	Responsible authority

Source: Water Use License Application and Appeals Regulation, 2017 (Act No. 36 of 1998)

(3) Environmental Side

As for the permission and clearance regarding the impact to the environment, an Environmental Impact Assessment (EIA) will be conducted and a countermeasure is proposed.

(4) Labor Side

The working conditions of contractors and suppliers are secured by the Safety, Health, and Environmental (SHE) specifications. These specifications are provided to potential contractors during the tender phase and these specifications form part of the technical criteria used to select successful bidders.

(5) PPPFA

Eskom needs to set the rate of local contents and obtain the permission from the Department of Treasury.

12.6.2. Clearance from Customs

Tax can be exempted by applying the staged consignment.

A staged consignment comprises a multitude of components that make up a "plant" or "machinery." This functional unit is generally shipped separately, over an extended period due to the size and magnitude of the goods destined for the final product or plant.

One of the main benefits of importing goods under a staged consignment is that the importer of record ("IOR") is allowed to use a single tariff heading ("that of the final product or plant") for all goods that form part of the plant being imported in a staged manner. The tariff heading to be utilized is determined according to the rules of classification as set out in the General Rules for Interpretation ("GRI") 2 (a) in Schedule 1 of the Harmonized System.

The conditions set in order to apply the staged consignment are as follows:

- The components must form a plant or machinery as the final product once they are assembled
- The completed plant or machinery must be classifiable under Chapters 84 or 85 of the Tariff;
- The weight of the unassembled or disassembled plant or machine must exceed 500 tons or the shipping measurement must exceed 500 cubic meters.

Chapter 13 Financial and Economic Analysis

13.1. Objectives and Methodology of the Financial and Economic Analyses

The financial and economic analyses aim to examine the financial and economic viability of the Project by calculating the internal rate of return (IRR) and the net present value (NPV).

Financial analysis is conducted to evaluate the profitability of the Project from the viewpoint of the project executing organization (i.e., Eskom). To obtain the financial internal rate of return (FIRR) and the financial net present value (FNPV), the net benefit of the Project is calculated considering 1) the benefits, i.e., incremental revenue of tariff from the Project and 2) the cost based on the market price.

Financial cost excludes price escalation, interest during construction (IDC), and other financial charges from the project cost. FIRR and FNPV are calculated based on the cash flow before interest payments.

Economic analysis is conducted to evaluate the viability of the Project from the viewpoint of the national economy. To obtain the economic internal rate of return (EIRR) and the economic net present value (ENPV), the benefit of the Project is calculated considering 1) the environmental levy, one of the components in the standard tariff, and 2) the economic costs.

In the EIRR and ENPV calculation, the cost of the Project is converted to economic cost in order to evaluate the actual cost for the national economy. In this regard, the transfer payment within the national economy (e.g., tax) is excluded from the calculation as it is neither a benefit nor a cost for the country.

The cash flow of the Project is prepared in order to calculate the IRR and NPV. These figures are calculated based on the formula below. The IRR is equal to the hurdle rate that results in zero NPV. For the calculation of the NPV, a predetermined discount rate is used.

$$\sum_{t=1}^{n}\left\{(B-C)_t \div (1+r)^t\right\}=0$$

Where, B=Benefit, C=cost, t=tth year (1,2,3…n), n=project life, r= IRR

For the calculation of both the IRR and NPV, two cases, namely, “with project” and “without project,” are normally considered to determine the net incremental benefit and cost. The foregone benefit of the “with project” case is not taken into consideration in the analysis in order to estimate the net incremental benefit of the Project. This is because the Project is to be constructed on the site of the existing Medupi Power Plant and that the loss of benefit due to the Project (e.g., agricultural production) is not expected.

13.2. Assumption Used in the Financial and Economic Analyses

This section lists and describes major assumptions that are used for calculating the IRR and NPV based on the findings in the study.

13.2.1. Cases for Financial and Economic Analyses

The case of financial analysis is divided into two cases. Case 1 is conducted based on the combined cost of 1) coal-fired TPS and 2) FGD and the benefit based on electricity tariff. On the other hand, Case 2 is based on the cost of FGD alone and the benefit of the tariff, which is equivalent to the FGD-related cost.

Economic analysis is conducted for only one case, which is based on the cost related to FGD alone and the revenue from the environmental levy.

Table 13.2-1 Cases of Financial and Economic Analysis

Analysis	Project Cost	Benefit
Financial Analysis (Case 1)	Combined cost of TPS and FGD	Tariff
Financial Analysis (Case 2)	Cost of FGD	Tariff calculated for FGD cost
Economic Analysis	Cost of FGD	Environmental levy

Source: Prepared by the JICA Study Team
Note: TPS stands for "Thermal Power Station"

13.2.2. Project Life, Salvage Value, and Price Base

The durable life of 1) buildings and facilities and 2) a generation plant has a wide range from 6 to 80 years, according to the accounting principle applied by Eskom. In addition, the units of the Medupi Power Plant and FGD will start to operate in different years, depending on construction schedule.

To make the analysis simple, the Project is assumed to have a useful economic life of 50 years including the construction period.

Table 13.2-2 Depreciation Years Based on Types of Asset

Type of Asset	Years of Depreciation (Years)
Buildings and Facilities	10-40
Plant (Generating)	6-80

Source: Eskom, "Annual Financial Statements 31 March 2017," p. 34

At the end of the economic life, the Project is assumed to have no salvage value.[1] Benefits and costs are expressed in terms of 2017 constant prices in the South African Rand.

[1] There may remain some residual monetary value at the end of operation if the facility and equipment are scraped and sold in the market. However, such possible monetary value is not taken into account the financial and economic analyses due to the uncertainty and difficulty in estimating monetary value.

13.2.3. Schedule of Commercial Operation of Medupi Power Plant

The commercial operation of the units of the Medupi Power Plant is scheduled as shown in Table 13.2-3. Units 4, 5, and 6 have started their commercial operation last November 2017, April 2017, and August 2015, respectively.

The incremental electricity generated in the financial analysis for Case 1 is calculated based on the schedule of commercial operation.

Table 13.2-3 Schedule of Commercial Operation of Medupi Power Plant

Unit	Commercial Operation Dates
Unit 6	23-Aug-15
Unit 5	3-Apr-17
Unit 4	28-Nov-17
Unit 3	Jun-19
Unit 2	Dec-19
Unit 1	May-20

Source: Eskom, "Medupi Power Station Project," June 2017 (Presentation for JICA)

Note: Unit 4 has achieved commercial status in November 2017, which is ahead of the scheduled timeline (July 2018). See the Eskom website for more details. (http://www.eskom.co.za/news/Pages/Novv28.aspx).

13.2.4. Tariff

(1) Financial analysis (Case 1)

The standard tariff price is used as unit financial benefit per kWh for Case 1. The current standard tariff price is 89.13 c (=ZAR 0.8913)/kWh, which was calculated based on the Multi Year Price Determination (MYPD) decision 2017/18.

Eskom has submitted the Revenue Application for 2018/19 to NERSA in September 2017, requesting to increase the projected revenue for 2018/19 to up to ZAR 219.5 billion, which will result in the adjusted standard tariff price of 106.87 c (ZAR 1.0687)/kWh.[2]

The National Electricity Regulator of South Africa (NERSA) has made a decision on the revenue application of Eskom on 15 December 2017. Based on this decision, 93.79 c (ZAR 0.9379)/kWh will be used for the financial analysis (Case 1).

(2) Financial analysis (Case 2)

The financial analysis (Case 2) is conducted based on the cost of FGD alone, which does not justify using the standard tariff that covers all necessary costs and return of the asset. The equipment of FGD does not generate electricity for sales. Therefore, the tariff for Case 2 is calculated to make the financial net present value nearly zero to see the impact of this additional cost on the tariff.[3]

[2] See more detailed explanation of the Revenue Application 2018/2019 in 13.5.3 "Measures to Address the Financial Issues".

[3] See 13.3.2 "Financial Benefit" for more detailed explanation of this tariff.

13.2.5. Coal

The cost of coal is included in the financial cost for Case 1 as this is based on the combined cost of the TPS and FGD and the tariff for electricity generated by the TPS.

The coal cost per kWh is calculated as follows:

Table 13.2-4 Calculation of Coal Cost per kWh

	Item	Figure	Unit	Formula
A	Unit Cost of Coal	393	Rand/ton	
B	Calorific Value of Coal (kcal/kg)	4696	kcal/kg	
C	Net Thermal Efficiency	41.2%		
D	Conversion Factor (kcal/kWh)	860	kcal/kWh	
E	Generation per kg	2.25		CxC/E
	Coal Cost per kWh	0.175	Rand/kWh	A/E

Source: Unit cost of coal is based on Eskom, "Revenue Application FY2018/19" FIGURE 31: AVERAGE DELIVERED R/TON COAL COST, p. 77, August 2017

Based on the calculation, ZAR 0.175/kWh is applied for the financial analysis (Case 1).

13.2.6. Water

Water is utilized for both the TPS and FGD as follows. The unit cost of water is assumed to be ZAR 14/m³.[4]

Table 13.2-5 Estimate of Necessary Amount of Water for TPS and FGD

	Annual Estimated Consumption (mil. m³/year)
TPS	6.0
FGD	6.0 (with gas cooler)

Source: Prepared by the JICA Study Team

The financial analysis (Case 1) includes the cost of water for both the TPS and FGD, while Case 2 includes that for FGD alone.

The economic analysis does not take into consideration water cost as economic cost since water is sourced locally and that the sales of water to the Project is neither a revenue nor a cost to the economy of the country.

[4] See “Table 6.2 1 Comparison of Wet FGD with/without gas cooler” for more detailed analysis of water consumption and cost.

13.2.7. Limestone and Gypsum

The consumption of limestone is estimated to be 3,500 tons/day (1.26 mil. tons/year) for six units of FGD. The cost of limestone per GWh and unit is calculated at ZAR 0.02 million based on the unit cost of limestone (ZAR 475/ton).

Table 13.2-6 Cost of Limestone per kWh

	Item	Figure	Unit	Formula
A	Consumption per day/six units	3,500	ton/day/six units	
B	Consumption per day/unit	583	ton/day/unit	A/6
C	Consumption per year/unit	212,917	ton/year/unit	Bx365 days
D	Unit price of limestone/ton	475	ZAR/ton	
E	Cost of limestone/year/unit	101	ZAR in mil./year/unit	CxD
F	Electricity generated/year/unit	5,008	GWh/year/unit	
G	Cost of limestone/GWh/unit	0.02	ZAR in mil./GWh	E/F

Source: Unit price of limestone per ton is taken from the cost of limestone (96% $CaCO_3$) in Table 3-2 Economic Evaluation Criteria, Capital and O&M Cost Estimates, Medupi FGD Retrofit Project, 29 September 2014.

The production of gypsum is estimated to be 6,000 tons/day (2.19 mil. tons/year) by operating six units of FGD. However, it is not clear at present whether the gypsum to be produced by FGD can be sold at the domestic and international market. Therefore, the revenue from the sales of gypsum is not taken into account as the benefit of the Project.

13.2.8. Operation and Maintenance (O&M) Cost

The report on capital and O&M cost estimates that the percentage of O&M cost in the EPC cost is 1.25%, consisting of material cost (0.75%) and labor cost (0.5%).[5]

The operating and maintenance cost for financial analysis is assumed to be 1.25% of the EPC cost of 1) the TPS and FGD for the financial analysis (Case 1) and 2) FGT for Case 2.

The cost for economic analysis is assumed to be 0.75%, for material cost only, as labor cost is neither regarded as a revenue nor a cost within the economy of South Africa. On the other hand, material cost is assumed to be paid overseas.

13.2.9. Hurdle Rate

The hurdle rate is used as a deciding factor to determine whether the Project is viable from the viewpoint of the implementing organization and the national economy by comparing it with the FIRR and the EIRR, respectively.

In principle, the hurdle rate adopted in the financial analysis is calculated based on the concept of opportunity cost of the capital. Eskom refers to the weighted average cost of capital (WACC) at 2.97% as the basis for the return to asset in its revenue application for 2018/19.[6] This is also used as the opportunity cost of capital for calculating the FNPV in this report. The real pre-tax WACC

[5] The percentage is based on the figure in "3.7 Maintenance Material and Labor Cost," Capital and O&M Cost Estimates, Medupi FGD Retrofit Project, 29 September 2014.

[6] Eskom, "Revenue Application FY2018/19," Table 4: Allowable Revenue, p. 28, August 2017.

of Eskom is 8.4%.[7] However, Eskom has decided to use 2.97% instead of 8.4% in the revenue application in order to minimize the negative impact on consumers.

The World Bank and African Development Bank used 10% and 11%, respectively, as the social discount rate for the economic analysis in the project appraisal for Medupi Coal-fired Thermal Power Plant Project, assuming that significant economic benefit (i.e., replacement of expensive alternative generation method such as diesel generators) will be produced. However, the Project (the installation of FGD) is unlikely to produce such significant tangible economic benefit as the avoided health cost is difficult to estimate and the causal relationship between the emission of SO_2 and incremental mortality and morbidity is difficult to prove as explained in "13.4.2 Economic Benefit."

Therefore, this report applies 2% for calculating the ENPV, which is slightly lower than the hurdle rate for financial analysis.

13.2.10. Auxiliary Consumption and Transmission and Distribution Loss

The figures of auxiliary consumption (7.81%), transmission loss (2.8%), and distribution loss (7.5%) are used to calculate 1) the net amount of electricity that has reached the consumers and 2) the incremental revenue in the financial analysis.

Table 13.2-7 Auxiliary Consumption and Transmission and Distribution Loss

Item	Percentage
Auxiliary Consumption	7.81%
Transmission loss	2.8%
Distribution loss	7.5%

Source: Auxiliary consumption is the projection in 2017/18 based on Eskom, "Revenue Application 2018/19," Table 29 Environmental Levy, August 2017. The figures of transmission and distribution loss are from Figure 11: Energy Wheel 2017/18.

13.2.11. Standard Conversion Factor

The standard conversion factor (SCF) is an indicator to estimate the level of distortion in the market due to policies, duties, or subsidies of the Government of South Africa. The SCF is applied in the economic analysis when the local cost, which is assumed to be distorted, is to be converted into the economic cost in order to eliminate distortion.

The SCF is calculated at 0.92 based on the following formula and figures from the recent terms of trade and duties. As the figure of SCF is nearly equal to one, it can be concluded that there is little distortion in the prices in the local market.

SCF= [Import (CIF) + Export (FOB)] / [(Import + Import Duty) + (Export + Export Subsidy - Export Tax)]

[7] Eskom, "Revenue Application FY2018/2019," Table 6: Cost of Capital, p. 57, August 2017.

Table 13.2-8 Terms of Trade

Import	Export	Import Duty	Export Tax	Export Subsidy	SCF
1,098	1,096	197	0	0	0.92

Source: Figures of import and export are from "SA Trade Statistics for December 2016 (including BLNS)." The figure of Import Duty is from "2016 Tax Statistics Chapter 5 Import VAT Customs Collections, Figure 5.1, 5.2."

Note: Figures of import and export are the cumulative figure from January to December of 2016, while that of import duty is from April 2015 to March 2016.

Regarding labor cost, it is assumed that there are no significant distortions in the wage of skilled labor in the economic analysis. In the case of unskilled labor, unemployment exists in South Africa. The percentage of unemployment is 27.7% in the third quarter of 2017.[8] Therefore, giving salaries under the minimum wage may be the prevailing situation in the labor market. Moreover, the opportunity cost of unskilled labor being employed by the Project is assumed to be 50% of the wage, which is equivalent to the economic cost of the unskilled labor.

13.3. Financial Analysis

In this section, the financial costs for the two cases (Cases 1 and 2) of the Project are identified first. Secondly, the financial benefit is identified and quantified. Lastly, based on the assumptions, costs and benefits calculated, the FIRR and FNPV are calculated and presented.

13.3.1. Financial Cost

The financial cost is derived from the project cost, which is indicated in the estimate of the project cost. Financial cost consists of 1) initial investment cost and 2) annual operation and maintenance cost including coal, water, and limestone cost.

The project cost includes the engineering, procurement, and construction (EPC) cost, consulting services, physical contingency and price escalation, financial charges, administration, tax, and other costs. On the other hand, financial cost is used to estimate the performance of the Project from the viewpoint of the implementing organization and excludes price escalation and interest during construction (IDC) and financial charges from the project cost.

It is important to note that the financial cost of Case 1 includes the cost of a coal-fired TPS, which was disbursed in the past and will be disbursed in the future based on the recognition that the TPS and FGD are regarded as a non-divisible project.[9] The past and future cost will be discounted by the hurdle rate to convert these costs to the present value.

[8] Statistics South Africa, "Quarterly Labor Force Survey Quarter 3: 2017," Table E: Unemployment rate by province, 31 October 2017

[9] From the theory underlying the net present value, the past disbursement of the power plant project should be regarded as sunk cost, which does not have to be included in the cost as it was already disbursed in the past. Moreover, the sunk cost does not affect the calculation of IRR as there is no difference in the amount of the sunk cost between the case of "with project" and "without project."

Table 13.3-1 Present Value of Cost Disbursed in the Past for TPS

	Total	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1. Past disbursement of Medupi TPS (Foreign cost)	18,662	2,068	3,056	2,808	3,280	2,527	1,347	503	944	531	745	853
2. Past disbursement of Medupi TPS (Local cost)	69,015	2,424	5,603	6,570	9,612	8,611	6,357	5,955	6,226	5,731	5,926	6,002
3. Total past disbursement (1+2)	87,677	4,491	8,659	9,378	12,892	11,138	7,704	6,458	7,170	6,261	6,670	6,854
4. Present value of foreign cost	22,673	2,771	3,977	3,549	4,026	3,012	1,559	565	1,031	563	767	853
5. Present value of local cost	79,933	3,248	7,292	8,303	11,797	10,264	7,359	6,695	6,797	6,076	6,102	6,002
6. Total present value (4+5)	102,606	6,018	11,269	11,852	15,823	13,276	8,918	7,260	7,828	6,639	6,868	6,854

Source: Prepared by the JICA Study Team based on the figures provided by Eskom.

Note: The cost includes the EPC cost and contingency only. Costs such as administration, tax, and interest during construction are not included.

The summary and annual disbursement of the financial cost (Case 1) are indicated in the table below.

Table 13.3-2 Financial Cost of the Project upon Completion of Construction (Case 1: With TPS cost)

(Unit: ZAR in Million)

Items	Financial Cost		
	Foreign Cost	Local Cost	Total
EPC cost	7,876	3,674	11,550
Consulting service	798	330	1,129
Price escalation	0	0	0
Physical contingency	889	403	1,291
Interest during construction	0	0	0
Subtotal: Eligible Portion	**9,563**	**4,407**	**13,970**
Subtotal: Non-eligible Portion	**2,909**	**17,264**	**20,173**
Medupi TPS cost	917	12,676	13,593
Total	**13,389**	**34,347**	**47,737**

Source: Prepared by the JICA Study Team

Note: The present value of the past disbursement for Medupi Power Plant is not included in the table.

Table 13.3-3 Annual Allocation of Financial Cost (Case 1: With TPS Cost)

(Unit: ZAR in Million)

Year	Power Plant			FGD			Total
	Foreign Cost	Local Cost	Sub Total	Foreign Cost	Local Cost	Sub Total	
Year 1	678	6,438	7,116	0	0	0	**7,116**
Year 2	278	2,951	3,229	0	0	0	**7,116**
Year 3	(38)	3,287	3,248	615	981	1,596	**4,826**
Year 4	0	0	0	2,709	4,844	7,554	**10,802**
Year 5	0	0	0	2,357	4,130	6,488	**6,488**
Year 6	0	0	0	2,626	4,584	7,210	**7,210**
Year 7	0	0	0	2,122	3,691	5,813	**5,813**
Year 8	0	0	0	1,182	1,983	3,166	**3,166**
Year 9	0	0	0	497	855	1,352	**1,352**
Total	**917**	**12,676**	**13,593**	**12,473**	**21,671**	**34,143**	**47,737**

Source: Prepared by the JICA Study Team

Note: The present value of the past disbursement for Medupi Power Plant is not included in the table.

The summary and annual disbursement of the financial cost (Case 2) are indicated in Table 13.3-4.

Table 13.3-4 Financial Cost of the Project upon Completion of Construction (Case 2: Without TPS Cost)

(Unit: ZAR in Million)

Items	Financial Cost		
	Foreign Cost	Local Cost	Total
EPC cost	7,876	3,674	11,550
Consulting service	798	330	1,129
Price escalation	0	0	0
Physical contingency	889	403	1,291
Interest during construction	0	0	0
Subtotal: Eligible Portion	**9,563**	**4,407**	**13,970**
Subtotal: Non-eligible Portion	**2,909**	**17,264**	**20,173**
Total	**12,473**	**21,671**	**34,143**

Source: Prepared by the JICA Study Team

Table 13.3-5 Annual Allocation of Financial Cost (Case 2: Without TPS Cost)

(Unit: ZAR in Million)

Year	Financial Cost		
	Foreign Cost	Local Cost	Total
Year 1	0	0	0
Year 2	615	981	1,596
Year 3	2,709	4,844	7,554
Year 4	2,357	4,130	6,488
Year 5	2,626	4,584	7,210
Year 6	2,122	3,691	5,813
Year 7	1,182	1,983	3,166
Year 8	497	855	1,352
Year 9	363	602	966
Total	**12,473**	**21,671**	**34,143**

Source: Prepared by the JICA Study Team

13.3.2. Financial Benefit

The financial performance of the Project is evaluated from the viewpoint of the implementing organization (i.e., Eskom). The financial benefit of the Project is identified as the incremental revenues from the electricity sold to consumers.

The gross incremental electricity generated per unit of Medupi Power Plant is calculated as follows:

Gross generation (GWh) per unit/year: 794 MW x 8,760 hours x 80% (Availability factor) x 90% (Plant load factor) = 5,008 GWh

The amount of electricity generated, used for calculating the financial benefit, is different between Case 1 and Case 2. Case 1 uses the net incremental electricity that has reached consumers after deducting auxiliary use and transmission and distribution loss, while Case 2 uses the one generated by the units equipped with FGD only. This is because the financial cost of Case 2 consists of the FGD-related cost only and the financial benefit of Case 2 should be limited to the electricity generated from the units with FGD.

Table 13.3-6 Financial Benefit

Analysis	Electricity Generated	Benefit
Financial Analysis (Case 1)	Electricity generated by units	Tariff
Financial Analysis (Case 2)	Electricity generated by units with FGD	Tariff that covers the cost related to FGD only

Source: Prepared by the JICA Study Team

For Case 1, the benefit of incremental revenue can be calculated in a particular year, by multiplying the net incremental generated electricity with the average tariff (ZAR 0.9379/kWh).

Incremental revenue per unit/year = Net incremental electricity for sale x ZAR 0.9379/kWh

Table 13.3-7 Incremental Revenue (Case 1: With TPS Cost)

(Unit: ZAR in Million)

FY	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
2018	0	0	0	3,846	3,846	3,846	11,539
2019	0	321	2,244	3,846	3,846	3,846	14,103
2020	2,564	3,846	3,846	3,846	3,846	3,846	21,796
2021 onward	3,846	3,846	3,846	3,846	3,846	3,846	23,078

Source: Prepared by the JICA Study Team

For Case 2, the benefit of incremental revenue is calculated in a particular year by multiplying the net incremental electricity generated by the units with FGD with the hypothetical tariff (ZAR 0.0984/kWh), which will make the FNPV of Case 2 nearly zero. This is because the equipment of FGD does not directly produce the financial revenue. Instead, the financial analysis of Case 2 intends to estimate the required level of tariff to make the FNPV zero and the impact on the tariff as a whole.

Incremental revenue per unit with FGD/year = Net incremental electricity for sale x ZAR 0.0763/kWh

Table 13.3-8 Incremental Revenue (Case 2: Without TPS Cost)

(Unit: ZAR in Million)

FY	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
2018-2020	0	0	0	0	0	0	0
2021	0	0	0	0	0	168	168
2022	0	0	0	0	0	404	404
2023	0	0	0	67	135	404	606
2024	0	0	168	404	404	404	1,380
2025	236	404	404	404	404	404	2,255
2026 onward	404	404	404	404	404	404	2,424

Source: Prepared by the JICA Study Team

13.3.3. FIRR and FNPV

Benefit and cost are compiled and calculated considering the 2017 prices in order to obtain the FIRR. Moreover, 2.97% is used as the discount rate for calculating the FNPV. By using the discount rate, the FNPV of Case 1 with TPS cost becomes positive.

Table 13.3-9 FIRR and FNPV (Case 1: With TPS Cost)

FIRR	FNPV (ZAR in Million)	FNPV (USD in Million)
10.77%	252,058	17,876

Source: Prepared by the JICA Study Team

This result needs to be seen with care because the cost disbursed, so far, for the TPS only contains the EPC and contingency costs. Costs such as administration and tax, which are normally included in the financial cost, are not included. In addition, the incremental revenue from the TPS constructed (Units 4, 5 and 6) up until 2017 is not taken into account.

It is also important to note that the applied tariff reflects the cost of the TPSs including the purchase from the independent power producers (IPPs), which include both cost efficient and inefficient operating TPSs.

On the other hand, the FNPV of Case 2 becomes slightly positive simply because the tariff applied to the calculation for Case 2 is set to make the FNPV nearly zero.

Table 13.3-10 FIRR and FNPV (Case 2: Without TPS Cost)

FIRR	FNPV (ZAR in Million)	FNPV (USD in Million)
2.97%	4	0

Source: Prepared by the JICA Study Team

Although the tariff applied to Case 2 is hypothetical, it is worth analyzing because of the impact of such tariff on the overall standard tariff. If the tariff for Case 2 is divided by the electricity for distribution, the tariff per kWh becomes ZAR 0.0984/kWh, which is 10.49% of the expected standard tariff determined by NERSA. This figure implies that there may be a pressure to increase prices in order to recover the FGD related cost in the future.

Table 13.3-11 Estimated Impact on the Level of the Standard Tariff of the Tariff Applied to Case 2

Item	Figure	Unit
A. Hypothetical tariff revenue for Case 2	2,424	ZAR in Million
B. Electricity available for distribution	24,606	GWh
C. Hypothetical tariff for Case 2 (A/B)	0.0984	ZAR/kWh
D. Expected standard tariff	0.9379	ZAR/kWh
E. % of hypothetical tariff to expected standard tariff (C/D)	10.49%	

Source: Prepared by the JICA Study Team

Sensitivity analysis is conducted for Case 1 and Case 2 as the actual condition may be different from those assumed for the base case. In the sensitivity analysis, 1) cost increase (+10%), 2) delay in construction (one year), and 3) the hurdle rate (8.4%[10]) are considered.

The FNPV of Case 1 remains positive in all cases of sensitivity analysis. Even if the hurdle rate of 8.4% is applied, the FNPV still remains positive. Cost increase and delay in construction could have a small negative impact on the FIRR and FNPV.

[10] The figure of 8.4% is the pre-tax weighted average cost of capital of Eskom.

Table 13.3-12 Sensitivity Analysis for Financial Analysis (Case 1: With TPS Cost)

Case	Benefit	Cost	FIRR	FNPV	
			(%)	(ZAR in Million)	(USD in Million)
Base case	No change	No change	10.77%	252,058	17,876
Cost increase (+10%)	No change	+10%	10.51%	247,796	17,574
Delay in construction (1 year)	No change	No change	9.98%	240,049	17,025
Hurdle rate (8.4%)	No change	No change	10.77%	36,325	2,576

Source: Prepared by the JICA Study Team

The FNPV of Case 2 (without TPS cost) becomes negative except for the base case. This leads to the conclusion that careful management for the implementation of the Project is required, although the tariff assumed for Case 2 is rather hypothetical.

Table 13.3-13 Sensitivity Analysis for Financial Analysis (Case 2: Without TPS Cost)

Case	Benefit	Cost	FIRR	FNPV	
			(%)	(ZAR in Million)	(USD in Million)
Base case	No change	No change	2.97%	4	0
Cost increase (+10%)	No change	+10%	2.47%	(2,965)	(210)
Delay in construction (1 year)	No change	No change	2.91%	(323)	(23)
Hurdle rate (8.4%)	No change	No change	2.97%	(12,972)	(920)

Source: Prepared by the JICA Study Team

13.4. Economic Analysis

In this section, the economic costs (with FGD cost only) of the Project are identified first. Secondly, the economic benefit is quantified based on the environmental levy. Lastly, based on the assumptions, costs and benefits calculated, the EIRR and the ENPV are calculated and presented.

13.4.1. Economic Cost

Economic cost is derived from the estimation of the project cost. Costs of project items in local currency are converted to economic costs by applying the corresponding conversion factors. Costs of items that are already at border price do not need to be adjusted.

Economic cost is used to estimate the performance of the Project from the viewpoint of the national economy, and excludes price escalation, duty and taxes, and interest during construction. Taxes are not included in the economic cost as they are transfer payments within the economy of a country and are not real cost to the national economy. Water cost is also not included in the economic cost.

Unlike the financial analysis, the economic benefit is mainly based on the reduction of SO_2 by the operation of FGD. The economic cost only includes the FGD-related cost in the EPC cost and excludes the cost related to the construction of the TPS.

Table 13.4-1 Economic Cost of the Project upon Completion of Construction (FGD Cost Only)

(Unit: ZAR in Million)

Items	Economic Cost		
	Foreign Cost	Local Cost	Total
EPC cost	7,876	3,372	11,248
Consulting service	798	303	1,101
Price escalation	0	0	0
Physical contingency	889	370	1,258
Interest during construction	0	0	0
Subtotal: Eligible Portion	**9,563**	**4,044**	**13,607**
Subtotal: Non-eligible Portion	**2,909**	**11,609**	**14,519**
Total	**12,473**	**15,654**	**28,126**

Source: Prepared by the JICA Study Team

Table 13.4-2 Annual Allocation of Economic Cost

(Unit: ZAR in Million)

Year	Economic Cost		
	Foreign Cost	Local Cost	Total
Year 1	0	0	0
Year 2	615	713	1,328
Year 3	2,709	3,490	6,199
Year 4	2,357	2,981	5,339
Year 5	2,626	3,309	5,935
Year 6	2,122	2,666	4,788
Year 7	1,182	1,439	2,621
Year 8	497	619	1,116
Year 9	363	436	799
Total	**12,473**	**15,654**	**28,126**

Source: Prepared by the JICA Study Team

13.4.2. Economic Benefit

(1) Limitation on Quantifying the Economic Benefit

Before starting the economic analysis, it should be mentioned that there is a difficulty inherent to the economic analysis of a project with an impact on the environment and on human health. The avoided health cost (i.e., reduction in morbidity and mortality) can be regarded as a major economic benefit from the Project. However, there is no empirical and rigorous study on the estimation of the avoided health cost of the Medupi Power Plant.

(2) Environmental Levy

Based on the above recognition, the economic analysis uses the environmental levy[11], which is one of the components of the tariff, as the second option of calculating economic benefit. This is by assuming that the environmental levy approximately represents the cost of human health that is negatively influenced by the generation or the cost of the measures to prevent such negative impact on human health.

Since July 2012, 3.5 c (ZAR 0.035)/kWh has been applied as the environmental levy and is used to calculate the economic benefit.

(3) Economic Benefit

The flow of the economic benefit is indicated in Table 13.4-3.

Table 13.4-3 Incremental Economic Benefit

(Unit: ZAR in Million)

FY	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
2018-2020	0	0	0	0	0	0	0
2021	0	0	0	0	0	73	73
2022	0	0	0	0	0	175	175
2023	0	0	0	29	58	175	263
2024	0	0	73	175	175	175	599
2025	102	175	175	175	175	175	979
2026 onward	175	175	175	175	175	175	1,052

Source: Prepared by the JICA Study Team

13.4.3. EIRR and ENPV

Based on the assumptions, costs and benefits calculated and described so far, the EIRR and ENPV are calculated and presented in this section.

The economic benefit and cost are compiled and calculated in order to obtain EIRR and are discounted using the social discount rate (2%) for attaining the ENPV. When the EIRR is -3.25%, the ENPV becomes a negative value. However, if a higher environmental levy (ZAR 0.05904/kWh) is applied, the EIRR becomes 2.0%, which is equal to the hurdle rate, and the ENPV becomes a small positive value.

Table 13.4-4 EIRR and ENPV

EIRR	ENPV (ZAR in Million)	ENPV (USD in Million)
-3.25%	(18,650)	(1,323)

Source: Prepared by the JICA Study Team

[11] The environmental levy was enforced for the generation of electricity from non-renewable generators since July 2009, according to Eskom Holdings Revenue Application FY2018/2019, p. 86. The environmental levy is paid to the South African Revenue Service (SARS), the national tax collecting authority. See “Environmental Levy on Electricity Generated in South Africa” at http://www.sars.gov.za/ClientSegments/Customs-Excise/Excise/Environmental-Levy-Products/Pages/Electricity-Generation-Levy.aspx

A sensitivity analysis is conducted for the economic study. The cost increase, delay in construction, and lower hurdle rate (1%) are considered.

Table 13.4-5 Sensitivity Analysis for Economic Analysis

Case	Benefit	Cost	EIRR	ENPV	
			(%)	(ZAR in Million)	(USD in Million)
Base case	No change	No change	-3.25%	(18,650)	(1,323)
Cost increase (+10%)	No change	+10%	-3.57%	(21,208)	(1,504)
Delay in construction (1 year)	No change	No change	-3.40%	(18,382)	(1,304)
Lower hurdle rate (1%)	No change	No change	-3.25%	(17,850)	(1,266)

Source: Prepared by the JICA Study Team

The ENPV of cost increase, delay in construction, and lower hurdle rate remains negative.

13.5. Financial Situation and Governance Issues of Eskom[12]

In addition to the financial and economic analysis for the Project, it is important to analyze the overall financial situation and governance issues of Eskom as a business entity. This is to examine its overall ability to continue its business and repay the Project loan.

First, the report reviews the recent overall financial situation of Eskom based on the financial statement of the last three fiscal years, focusing on the income statement, the balance sheet, the cash flow statement, and the recent liquidity crisis facing Eskom. Secondly, governance issues are presented and analyzed as the governing body has an influence on the financial performance of Eskom. Thirdly, measures to address the financial and governance issues, which are and will be taken by Eskom, are presented. Lastly, the financial ability of Eskom to continue to operate its business and repay the loan will be analyzed.

13.5.1. Financial Situation of Eskom

(1) Income Statement of Eskom

The recent financial statement of Eskom reveals that the revenue has been steadily increasing by around 7%-9% per year in the last three fiscal years. The earnings before interest, tax, depreciation, and amortization (EBITDA) have been increasing more than the revenue in terms of annual change compared to the previous year by 41.1% in 2016 and 14.4% in 2017.

[12] The analysis in this section is based on the data and information obtained by April, 2018.

However, the net finance cost significantly increased, which led to the net loss after tax in 2015 and 2017 on the non-consolidated income statement. Nevertheless, Eskom could still make the net profit after income tax in the consolidated income statement.

Table 13.5-1 Consolidated Income Statement of Eskom (2015-2017)

	Unit: ZAR in million			% change from previous year	
	2015	2016	2017	2016	2017
A. Total revenue	**152,135**	**166,629**	**178,709**	**9.5%**	**7.2%**
B. Operating expense (1+2+3)	**(128,874)**	**(133,818)**	**(141,177)**	**3.8%**	**5.5%**
1) Primary energy	(83,425)	(84,728)	(82,760)	**1.6%**	-2.3%
2) Employee benefit expense	(25,912)	(29,257)	(33,178)	**12.9%**	13.4%
3) Other expenses	(19,537)	(19,833)	(25,239)	**1.5%**	27.3%
C. Earning before interest, tax, depreciation and amortization (EBITDA) (A-B)	**23,261**	**32,811**	**37,532**	**41.1%**	**14.4%**
1) Depreciation and amortisation expense	(14,115)	(16,633)	(20,300)	17.8%	22.0%
2) Other expense	(2,807)	(455)	(1,731)	-83.8%	280.4%
D. Profit before net finance cost	**6,339**	**15,723**	**15,501**	**148.0%**	**-1.4%**
Net finance cost & other cost	(6,060)	(7,876)	(14,342)	30.0%	82.1%
E. Profit before tax (C-D)	**279**	**7,847**	**1,159**	**2712.5%**	**-85.2%**
Income tax	(37)	(2,696)	(271)	7186.5%	-89.9%
F. Net Profit after Income Tax	**242**	**5,151**	**888**	**2028.5%**	**-82.8%**
F. Net Profit after Income Tax (non consolidated)	**(622)**	**3,136**	**(870)**	**-604.2%**	**-127.7%**

Source: Eskom, "Annual Financial Statements 31 March 2017," "Annual Financial Statements 31 March 2016"
Note: Fiscal year of Eskom starts from April and ends in March. FY 2017 means the year from April 2016 to March 2017.
Note: Figures of 2016 are restated based on the accounting principles applied in 2017, while those of 2015 are not restated.

The figures indicated as the percentage of each item with the total revenue clearly show the effort of Eskom to contain the operating expense and the negative impact on the profit level of the increasing finance cost.

The percentage of operating expense in the total revenue has been steadily decreasing from 84.7% in 2015 to 79.0% in 2017. The cost of primary energy in particular declined by nearly eight points in this period. As a result, EBITDA improved from 15.3% of the total revenue in 2015 to 21.0% in 2017.

Table 13.5-2 Percentage of Cost and Profit to Total Revenue

	2015	2016	2017
A. Total revenue	100.0%	100.0%	100.0%
B. Operating expense (1+2+3)	-84.7%	-80.3%	-79.0%
1) Primary energy	-54.8%	-50.8%	-46.3%
2) Employee benefit expense	-17.0%	-17.6%	-18.6%
3) Other expenses	-12.8%	-11.9%	-14.1%
C. Earning before interest, tax, depreciation and amortization (EBITDA) (A-B)	**15.3%**	**19.7%**	**21.0%**
1) Depreciation and amortisation expense	-9.3%	-10.0%	-11.4%
2) Other expense	-1.8%	-0.3%	-1.0%
D. Profit before net finance cost	**4.2%**	**9.4%**	**8.7%**
Net finance cost & other cost	-4.0%	-4.7%	-8.0%
E. Profit before tax (C-D)	**0.2%**	**4.7%**	0.6%
Income tax	0.0%	-1.6%	-0.2%
F. Net Profit after Income Tax	0.2%	3.1%	0.5%

Source: Prepared by the JICA Study Team based on Eskom, "Annual Financial Statements 31 March 2017," "Annual Financial Statements 31 March 2016"

On the other hand, the burden of financial cost has doubled in the last three fiscal years from 4% of the total revenue in 2015 to 8% in 2017. The financial cost has increased mainly due to the fact that 1) Eskom has been implementing large-scale investment programs, including Medupi and Kusile TPSs, and 2) that the outstanding balance of debt has been increasing in line with this.

In addition to the increasing balance of debt, the borrowing cost has been increasing more rapidly than the pace of increasing of debt. The gross financing cost of 5.8% in 2017 nearly doubled compared with the 3.3% in 2015.

Table 13.5-3 Balance and Borrowing Cost of Debt of Eskom

	2015	2016	2017
A. Debt securities and borrowings	**277,458**	**306,970**	**336,770**
% change from previous year		10.6%	9.7%
B. Finance Cost	**9,105**	**11,366**	**19,589**
% change from previous year		24.8%	72.3%
C. Borrowing cost (A/B)	**3.3%**	**3.7%**	**5.8%**

Source: Prepared by the JICA Study Team based on Eskom, "Annual Financial Statements 31 March 2017," "Annual Financial Statements 31 March 2016"

Note: Financial cost is gross financial cost. The financial revenue such as interest on the bank deposit account is not deducted to calculate the net financial cost.

The reason for increasing borrowing cost can be partly explained by the low credit ratings on Eskom. Credit ratings are an important indicator to judge the creditworthiness of Eskom for investors, lenders, and other stakeholders.

Table 13.5-4 Summary of Eskom's Credit Ratings on 31 March 2017

Rating	Standard and Poor's	Moody's	Fitch: Local Currency
Foreign currency	BB-	Ba1	n/a
Local currency	BB-	Ba1	BBB-
Standalone	ccc+	b3	B–
Outlook	Negative	Negative	Negative

Source: Eskom, "Integrated Report," p.89, 31 March 2017

Note: Standalone is an opinion on the creditworthiness of the issuer, in the absence of extraordinary intervention from its parent or affiliate or related government and are but one component of a rating.

Moody's downgraded the corporate family rating of Eskom to Ba2 from Ba1 in April 2017 and B1 in January 2018. Furthermore, in November 2017, Standard and Poor's lowered Eskom's long-term foreign and local currency corporate credit rating to "B-," keeps a negative outlook on Eskom, and changed Eskom's stand-alone credit profile to "ccc-" from "ccc+".[13] Credit agencies assess the creditworthiness of Eskom as junk and there is a high possibility of default on its debt in the medium term as Eskom refers to it at a public hearing for the revenue application for 2018/19.[14]

Eskom recognizes that the current level of credit ratings is likely to lead to the higher borrowing cost and difficulty in securing financing.[15]

(2) Balance Sheet of Eskom

As explained in the previous section, the outstanding balance of 1) the non-current asset (property, plant, and equipment) and 2) debt securities and borrowings[16] have been increasing at the rate of 10% - 13% per year due to the implementation of large-scale capital programs.

[13] See Eskom's website for more details (http://www.eskom.co.za/news/Pages/Novv29B.aspx).

[14] Eskom, "Eskom 2018/19 Revenue Application" at NERSA Public Hearing Midland, 16 November 2017, p. 25

[15] See "17.1 Impact of Credit Rating on Funding" in Eskom "Integrated Report 31 March 2017" for the perspective of Eskom on credit rating.

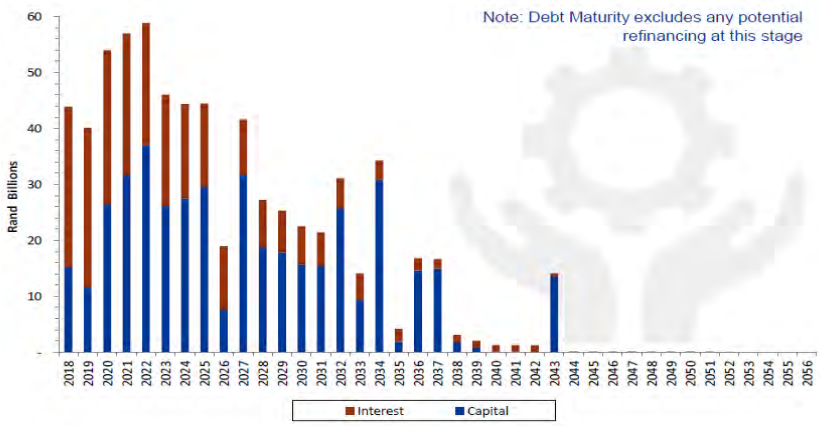
[16] Section 66, Part I General Principles, Chapter 8 "Loans, Guarantees and Other Commitments" of Public Finance Management Act No. 1 of 1999 (PFMA) allows public enterprises, including Eskom, to borrow money through loans and other methods. However, the conditions are attached to borrowing with government guarantee. Eskom needs to obtain the National Treasury's agreement in terms of timing before it utilizes the guaranteed schemes and is required to regularly report the situation of utilization of the government guarantee to the National Treasury and the Department of Public Enterprises.

Table 13.5-5 Consolidated Balance Sheet of Eskom (2015-2017)

	Unit: ZAR in million			% change from previous year	
	2015	2016	2017	2016	2017
Current assets	57,686	90,282	78,879	56.5%	-12.6%
Non-current assets	502,002	592,618	622,331	18.1%	5.0%
-Property, plant and equipment	457,720	520,521	588,867	13.7%	13.1%
Non-current assets held for sale	0	8,925	8,799	-	-1.4%
Total Assets	**559,688**	**691,825**	**710,009**	**23.6%**	**2.6%**
Current liabilities	74,635	74,037	78,607	-0.8%	6.2%
Non-current liabilities	366,634	427,545	453,777	16.6%	6.1%
-Debt securities and borrowings	277,458	306,970	336,770	10.6%	9.7%
Non-current liabilities held for sale	0	1,686	1,683	-	-0.2%
Equity	118,419	188,557	175,942	59.2%	-6.7%
Total Liabilities and Equity	**559,688**	**690,139**	**708,326**	**23.3%**	**2.6%**

Source: Eskom, "Annual Financial Statements 31 March 2017," "Annual Financial Statements 31 March 2016"
Note: Figures of 2016 are restated based on the accounting principles applied in 2017, while those of 2015 are not restated.

The increasing balance of debt is likely to impose additional financial burden on Eskom in the future. According to the estimate by Eskom, the payment of interest and principal of its existing debt is likely to increase until 2022 and will remain at around more than ZAR 40 billion for a few years after 2023.



Source: Eskom, "Eskom 2018/19 Revenue Application" at NERSA Public Hearing Midland, 16 November 2017, p. 23

Figure 13.5-1 Debt Maturity Profile of Eskom for Existing Debt, as of 31 March 2017

(3) Cash Flow Statement of Eskom

The recent cash flow of Eskom clearly shows that the cash generated by operating activities is not enough to cover the required amount of cash for investing activities including the capital programs such as Medupi and Kusile projects. In 2017, the business of Eskom generated ZAR 45.8 billion, while Eskom invested ZAR 62.2 billion, which is 35% larger than the cash generated.

Table 13.5-6 Consolidated Cash Flow Statement of Eskom (2015-2017)

	Unit: ZAR in million			% change from previous year	
	2015	2016	2017	2016	2017
Net cash flow from operating activities	27,311	37,242	45,841	36.4%	23.1%
Net cash flow from investing activities	(56,386)	(58,590)	(62,286)	3.9%	6.3%
Net cash flow from financing activities	17,954	40,927	7,855	128.0%	-80.8%
Increase/Decrease in Cash During the Year	(11,121)	19,579	(8,590)	-276.1%	-143.9%
Cash and cash equivalents at beginning of the year	19,676	8,863	28,454	-55.0%	221.0%
Movement of exchange rate etc.	308	12	561	-96.1%	4575.0%
Cash and cash equivalents at end of the year	**8,863**	**28,454**	**20,425**	**221.0%**	**-28.2%**

Source: Eskom, “Annual Financial Statements 31 March 2017,” “Annual Financial Statements 31 March 2017”

As a result, Eskom had to secure the fund to make up for the shortage of cash by equity injection and additional borrowing. Regarding the equity, Eskom received a ZAR 23 billion government equity injection and the shareholder agreed to the conversion of the subordinated loan (ZAR 60 billion) into the share capital in 2016.[17]

Eskom relies on the government guarantee to secure financing. The current ceiling of the government guarantee to Eskom is ZAR 350 billion. The guarantee facility is extended to March 2023. Eskom has utilized the guarantee up to approximately ZAR 291 billion at present.[18]

Table 13.5-7 Government Guarantee to Eskom

		Amount (ZAR in Million)	**% of the ceiling**
A.	Government guarantee to Eskom (ceiling)	350,000	100.0%
B.	Committed guarantee	291,379	83.3%
C.	Available guarantee (not committed) (A-B)	58,621	16.7%
D.	Debt under negotiation	53,607	15.3%
E.	Net available guarantee (C-D)	5,014	1.4%

Source: Eskom Treasury

Note: The figures in the table is as of October 2017.

Although the guarantee facility has been extended, the Minister of Finance expressed concern on Eskom in the letter of approval of the government guarantee facility and attached the various conditions to the facility.[19]

As one of the negative factors on cash flow, it is worth pointing out the increasing municipal debt in arrear despite the effort of Eskom.[20] According to Eskom’s interim report for 2017/18, the amount has reached up to ZAR 12.4 billion in September 2017 at a growth rate of ZAR 0.5 billion per month from ZAR 9 billion in March 2017.

[17] See “Note 24 Share Capital” in Eskom, “Annual Financial Statements 31 March 2016,” p. 76

[18] The part of the planned JICA’s loan (USD 500 million) has already been included in the amount debt under negotiation.

[19] Minister of Finance, “Eskom Application for the Approval for the Availability Period Extension from March 2017 to 31 March 2023,” Ref. M4/1/5 (2179/16), March 22, 2017

[20] See “(a) Trade and Other Receivables” in “5.1.2 Financial Instruments Managed by Various Divisions and Subsidiaries,” Eskom, “Annual Financial Statements 31 March 2017,” p. 49 for the past effort of Eskom to contain the arrear debt of municipalities.

Table 13.5-8 Balance of Arrear Municipal Debt

Unit: ZAR in Billion, %, Days

	2015	2016	2017	2018 (Interim)
A) Amount of Arrear Municipal Debt	5.0	6.0	9.4	12.4
Year to Year Change		20.0%	56.7%	31.9%
B) Monthly Electricity Sales Revenue	12.3	13.5	14.6	16.0
C) % of Arrear Municipality Debt in Monthly Electricity Sales Revenue (A/C)	40.6%	44.5%	64.4%	77.3%
D) Average debtors day (Municipality)	47.58	42.93	53.25	63

Source: Prepared by the JICA Study Team based on Eskom, "Integrated Report," p.35. Eskom, "Annual Financial Statements," p.6 & 8, 31 March 2017, Eskom, "Eskom Group Interim Results for the Six Months Ended 20 September 2017", p. 18, January 2018

Note: Monthly electricity sales revenue of 2018 (Interim) is calculated based on that of the six-month revenue from April to September 2017.

Note: Change of payment terms of municipalities, from a maximum of 15 days to 30 days, partly contributes to the longer debtors' day.

In addition, the percentage of the municipality debt in arrear to monthly electricity sales revenue has been rising from 40.6% in 2015 to 64.4% in March 2017 and 77.3% in September 2017. The average number of days for debt collection has become longer (42.93 days to 53.25 days and 63 days). These situations impose a pressure on the cash flow management of Eskom and is likely to force Eskom to obtain financing to secure the working capital for operation.

(4) Recent Liquidity Crisis

Although the precise figures are not available, the mass media has been reporting the liquidity crisis facing Eskom.[21] According to a newspaper article, the current level of the working capital is 20 times less than the normal amount to continue its business. Moreover, its cash position is likely to fall in the deficit of ZAR 5 billion in January 2018.

This situation is caused by a combination of several factors.[22] First, the tariff based on the determination on the revenue application by the National Energy Regulatory of South Africa (NERSA) increased by only 2.2% in 2017/18, which is lower than the inflation rate, while the absolute amount of operational cost has been increasing. According to Eskom's document, this increase resulted in "an effective decrease in electricity prices" for consumers.[23] Secondly, Eskom failed to sell its subsidiary (Eskom Finance Company) this year and could not obtain additional cash.[24] Thirdly, the approval of auditing for the financial statements of Eskom was delayed, which resulted in a lower confidence rating among lenders. Lastly, as mentioned earlier, the accumulating balance of the debt of the municipality is tightening the cash flow of Eskom.

[21] Business Day, "Eskom runs out of cash as loan facilities dry up," 14 November 2017
[22] Based on the interview with Treasury, Eskom on 24 November 2017
[23] Eskom, "Eskom 2018/19 Revenue Application" at NERSA Public Hearing Midland, 16 November 2017, p.2
[24] See the plan of this planned sale at IOL Business Report, "Eskom's Home Loan Firm for Sale," 17 July 2016 (https://www.iol.co.za/business-report/companies/eskoms-home-loan-firm-for-sale-735154)

(5) Interim Financial Results of Eskom (2017/4-9)

The interim financial results of Eskom (2017/4-9) was made public at the end of January 2018. The tariff increase of 2.2% combined with the decline of sales by 1.9% in the first six months of FY 2018 resulted in the decline of the total revenue to approximately ZAR 96.2 billion. This is lower by 2 points compared with the corresponding period of the previous year.

The net profit after tax resulted in ZAR 6 billion due to the higher depreciation cost and net finance cost (from ZAR 9.5 billion to ZAR 6.3 billion).

Table 13.5-9 Consolidated Interim Income Statement of Eskom (2017/4-9)

	Unit: ZAR in million		% change from previous year
	2017 (Interim)	2018 (Interim)	
A. Total revenue	**98,213**	**96,235**	**-2.0%**
B. Operating expense (1+2+3)	(66,388)	(66,579)	0.3%
1) Primary energy	(40,380)	(41,257)	2.2%
2) Employee benefit expense	(15,758)	(15,153)	-3.8%
3) Other expenses	(10,250)	(10,169)	-0.8%
C. Earning before interest, tax, depreciation and amortization (EBITDA) (A-B)	**31,825**	**29,656**	**-6.8%**
1) Depreciation and amortisation expense	(10,068)	(10,877)	8.0%
2) Other expense	(1,875)	105	-105.6%
D. Profit before net finance cost	**19,882**	**18,884**	**-5.0%**
Net finance cost & other cost	(6,517)	(10,000)	53.4%
E. Profit before tax (C-D)	**13,365**	**8,884**	**-33.5%**
Income tax	(3,822)	(2,572)	-32.7%
F. Net Profit after Income Tax	**9,543**	**6,312**	**-33.9%**

Source: Eskom, "Eskom Group Interim Results for the Six Months Ended 20 September 2017," January 2018

The sale of electricity tends to fluctuate seasonally. The revenue in the first six months of the financial year tends to be higher than the last six months. Eskom expects to make a net loss for FY 2018 due to the expected decline of revenue in the remaining period.

The non-current asset characterized by property, plant, and equipment continues to be increasing. This reflects the ongoing implementation of large-scale projects in line with the increasing balance of debt at the annual increase rate of around 10%.

Table 13.5-10 Consolidated Interim Balance Sheet of Eskom (2017/4-9)

	2017 (Interim)	2018 (Interim)	% change from previous year
	Unit: ZAR in million		
Current assets	90,282	71,400	-20.9%
Non-current assets	592,618	643,351	8.6%
-Property, plant and equipment	557,300	614,195	10.2%
Non-current assets held for sale	8,925	8,823	-1.1%
Total Assets	**691,825**	**723,574**	**4.6%**
Current liabilities	74,037	74,202	0.2%
Non-current liabilities	427,545	465,074	8.8%
-Debt securities and borrowings	317,267	347,584	9.6%
Non-current liabilities held for sale	1,686	1,680	-0.4%
Equity	188,557	182,618	-3.1%
Total Liabilities and Equity	**691,825**	**723,574**	**4.6%**

Source: Eskom, "Eskom Group Interim Results for the Six Months Ended 20 September 2017," January 2018

Net cash generated from operating activities significantly decreased to ZAR 22 billion from ZAR 32 billion in the corresponding period of previous year due to lower profits and larger amounts of arrear in the debt of municipalities.

Table 13.5-11 Consolidated Interim Cash Flow Statement of Eskom (2017/4-9)

	2017 (Interim)	2018 (Interim)	% change from previous year
	Unit: ZAR in million		
Net cash flow from operating activities	31,933	22,361	-30.0%
Net cash flow from investing activities	(29,262)	(29,663)	1.4%
Net cash flow from financing activities	(851)	(4,561)	436.0%
Increase/Decrease in Cash During the Year	1,820	(11,863)	-751.8%
Cash and cash equivalents at beginning of the year	28,454	20,425	-28.2%
Movement of exchange rate etc.	37	(55)	-248.6%
Cash and cash equivalents at end of the year	30,311	8,507	-71.9%

Source: Eskom, "Eskom Group Interim Results for the Six Months Ended 20 September 2017," January 2018

Eskom secured 54% of the required funds in the first six months of FY 2018 and resulted in the cash decrease of ZAR 4.56 billion from financing activities, compared with ZAR 0.85 billion in the previous year. As a result, the cash and cash equivalents in September 2017 significantly decreased by 72%, from ZAR 30.3 billion to ZAR 8.5 billion, in the corresponding period of 2017.

13.5.2. Governance Issues of Eskom

Governance[25] is one important factor that may influence the operational and financial performance of Eskom.[26] However, there seems to be a weakness in the governance of Eskom. Eight board members of Eskom have resigned in 2016/17. Several members in management positions have been suspended due to allegations of governance irregularities.

Furthermore, there are reports that relate to procurement and governance. These reports have identified 135 issues in the areas of procurement, contract management, document management, capital project, finance, stakeholder management, generation, and governance.[27]

Weak governance seems to have negatively contributed to the financial mismanagement of the company. The balance of the irregular expenditure in 2017 has reached nearly ZAR 3 billion, which is 2.1% of the total operating expenses.

Table 13.5-12 Irregular Expenditure of Eskom

Unit: ZAR in Billion, %

		2016	2017
A	Balance at beginning of the year	418	348
B	Current year expenditure	106	4,043
C	Amounts condoned	(146)	(1,084)
D	Amounts not recoverable (not condoned)	(30)	(311)
E	**Balance at end of the year (A+B+C+D)**	**348**	**2,996**
F	Operating expenses	135,778	143,241
G	**% of Balance at end of the year to Operating Expenses (E/F)**	**0.3%**	**2.1%**

Source: Prepared by the JICA Study Team based on Eskom "Annual Financial Statements 31 March 2017."

The types of irregular expenditures range from the breach of and non-compliance with relevant regulations, wasteful expenditure, criminal conduct (such as theft of equipment), and fraud.[28] The board of Eskom identifies the root causes of irregular expenditure as mainly people, process, systems, and governance categories.[29]

13.5.3. Measures to Address Financial and Governance Issues

Eskom has been taking measures to tackle the difficulties regarding financial and governance issues. The measures focus on 1) revenue increase, 2) cost management, 3) cash flow management, and 4) strengthening of governance.

[25] Governance in this report is confined to the management team, procurement, and expenditure management.

[26] For example, Moody's report clearly states that "Eskom has faced mounting liquidity risks in recent weeks, primarily driven by lenders' unwillingness to provide additional funding to the company in the context of serious questions around corporate governance, a lack of leadership and failing trust in the company." See https://www.moodys.com/research/Moodys-downgrades-Eskoms-ratings-to-B1B2Baa2za-NSR-review-for-downgrade--PR_378663 for more detail.

[27] See "Eskom governance reviews of procurement processes," in Eskom, "Annual Financial Statements 31 March 2017," p. 10 for more details.

[28] See Eskom, "Annual Financial Statements 31 March 2017," Note 52, p. 113 for more detailed explanation on the irregular expenditure.

[29] Eskom, "Annual Financial Statements 31 March 2017," p. 10

(1) Revenue Increase

Revenue Application for 2018/19

Eskom submitted the revenue application for 2018/19 to NERSA in August 2017. Eskom requested NERSA, in its revenue application, that the total allowable revenue should be increased to ZAR 219.5 billion from ZAR 205.2 billion in 2017/18 (a 7% of year to year percentage change), with the intention to achieve a balance between consumer interest and the financial sustainability of Eskom.

The proposed revenue is calculated based on the following formula, consisting of 1) the return to asset and 2) various cost items.

Allowable Revenue = (Regulated Asset Base x WACC) + Expenditure + Primary Energy + IPPs (local) + International purchases + Depreciation + IDM + Research & Development + Levies & Taxes + RCA[30]

Note: WACC=Weighted Average Cost of Capital, IDM=Integrated Demand Management, RCA=Regulatory Clearing Account

Table 13.5-13 Breakdown of Total Allowable Revenue for 2018/19

Unit: ZAR in Billion, %

Item		Formula	Application for 2018/19	% of TAR
Regulated Asset Base	RAB		763,859	
WACC (%)	ROA	x	2.97%	
Returns			22,690	10.3%
Expenditure	E	+	62,221	28.3%
Primary Energy	PE	+	59,340	27.0%
IPPs (local)	PE	+	34,209	15.6%
International purchases	PE	+	3,216	1.5%
Depreciation	D	+	29,140	13.3%
IDM	I	+	511	0.2%
Research and Development	R&D	+	193	0.1%
Levies and Taxes	L&T	+	7,994	3.6%
RCA	RCA	+	0	0.0%
Total Allowable Revenue	**TAR**		**219,514**	**100.0%**

Source: Eskom, "Revenue Application FY2018/19," Table 1: Total Allowable Revenue for 2018/19, August 2017, p.10.

Note: The revenue application does not include any RCA applications for the MYPD 3 period based on the understanding that NERSA will process RCA for years 2, 3, and 4 of the MYPD 3 period at a later stage.

30 Regulatory Clearing Account is a mechanism that allows for adjustment of future tariffs to address past variations (in accordance with the MYPD methodology) between the revenue decision and the actual revenue.

The revenue of Eskom is recovered from 1) standard tariff customers, 2) negotiated pricing agreement (NPA) customers, and 3) international customers. If the above revenue application is fully approved, it will result in a 19.9% increase of the standard tariff, which is significantly higher than the 2.2% increase in 2017/18.[31]

Table 13.5-14 Standard Tariff Price Increase

Unit: ZAR in Billion, %

Standard tariff price impact	Unit	MYPD Decision 2017/18	Application 2018/19
Standard tariff revenue	ZAR in Million	198,954	206,205
Standard tariff sales volumes	GWh	223,217	192,953
Standard tariff price	c/kWh	89.13	106.87
Standard tariff price adjustments	%	**2.2%**	**19.9%**

Source: Eskom. "Revenue Application FY2018/19," August 2017, p.14.

On 15 December 2017, NERSA announced its decision on the Eskom's revenue application and approved the allowable revenue of ZAR 190.348 billion for the 2018/19 financial year, which will result in an average percentage price increase of 5.23%. The figure is significantly lower than 19.9%, which is requested by Eskom.[32]

Eskom has received the details regarding the decision on the revenue application from NERSA in February 2018. Eskom will review the document, consult with the stakeholders, such as the Department of Public Enterprises, and decide on which actions to take with respect to the decision of NERSA.

Application for Regulatory Clearing Account

NERSA recently announced the process and schedule for making a decision on the application of the Regulatory Clearing Account (RCA).[33] The outstanding balance of the RCA for Year 2 (2014/15), Year 3 (2015/16), and Year 4 (2016/17) amounts to ZAR 66.6 billion. Eskom has already submitted the RCA application requesting this amount. The decision of NERSA is scheduled to be made in June, 2018.

[31] Once NERSA has made a decision on the allowable revenue, Eskom needs to submit its retail tariff and structural adjustment application for the standard tariffs to NERSA in accordance with the Eskom Retail Tariff and Structural Adjustment (ERTSA) methodology. See "7 Indicative Standard Tariff Increase" in Eskom, "Revenue Application FY2018/19," p. 33 for more details.

[32] NERSA Media Statement, "NERSA Decision on Eskom's Revenue Application for 2018/19 Financial Year," 15 December 2017. The details of the reasons for this decision are not yet disclosed by NERSA.

[33] For more information on the schedule and the process of review and decision making, visit the NERSA website at http://www.nersa.org.za/Admin/Document/Editor/file/News%20and%20Publications/Latest%20News/Media%20Statement%20-%20Revised%20Timelines%20for%20processing%20Eskom%20Regulatory%20Clearing%20Account.pdf.

Table 13.5-15 Breakdown of RCA Balance

Unit: ZAR in Million, %

RCA for 2016/17	RCA 2014/15	RCA 2015/16	RCA 2016/17	Total RCA	% contribution
Revenue	8,787	15,578	20,016	44,381	66.6%
Independent Power Producers	4,346	620	2,452	7,418	11.1%
Coal	574	3,258	(359)	3,473	5.2%
International Purchases	3,299	3,567	2,283	9,149	13.7%
Open Cycle Gas Turbines (OCGTs)	1,944	689	(1,259)	1,374	2.1%
Other Primary Energy	1,355	728	722	2,805	4.2%
Environmental Levy	(683)	-1180	(1,404)	(3,267)	-4.9%
Subtotal	**19,622**	**23,260**	**22,451**	**65,333**	**98.0%**
Other	(437)	372	1,418	1,353	2.0%
RCA balance	**19,185**	**23,632**	**23,869**	**66,686**	**100.0%**

Source: Eskom, "RCAs submitted for FY2014/15, FY2015/16, and FY2016/17," Durban NERSA Public Hearing, April 19, 2018, p. 4

The item of revenue alone contributes to 66.6% of the total RCA over the three fiscal years mainly due to the lower volume of sales than expected. The percentage of the gap between the planned and actual sales in the last three years has reached 5% - 10%. Eskom analyzes that the lower sales volume was caused by a combination of economic recession, decrease in reliance on Eskom, and other factors.

Table 13.5-16 Planned and Actual Total Sales Volume of Electricity

Unit: GWh, %

	2014/15	2015/16	2016/17
A. Planned sales	229,183	235,210	239,113
B. Actual sales	216,274	214,487	214,601
C. Gap (B-A)	(12,909)	(20,723)	(24,512)
D. % of Gap in planned sales (C/A)	(5.6%)	(8.8%)	(10.3%)

Source: Eskom. "RCAs submitted for FY2014/15, FY2015/16, and FY2016/17," Durban NERSA Public Hearing, April 19, 2018, p. 5

Eskom plans to recover the amount of RCA in a phased manner and utilize the remaining balance as the collateral for the new loan.

(2) Cost Management

Eskom has been implementing various cost management measures to achieve a significant reduction in cost. In FY 2017, Eskom reduced the cost of its own generation by 8.5% and the total primary energy cost by 2.3%.[34] Eskom could also reduce the dependence on the expensive Open Cycle Gas Turbines (OCGTs) by reducing its cost from ZAR 8.7 billion in 2016 to ZAR 340 million. OCGTs have been used to manage the peak energy demand and the new coal-fired TPSs have already started operation. The cost was reduced by ZAR 20 billion against the target of ZAR 17 billion.

Furthermore, Eskom has set the target for cost management as two of the five critical targets over the next five years in its corporate plan for FY 2017/18-2021/22.[35]

- Reducing Primary Energy spending by ZAR 43 billion over the next five years through greater efficiencies and industry restructuring
- Reducing planned capital expenditure spend by ZAR 25 billion over the next five years

Eskom is currently planning to review the coal supply agreement, contain the salary increase to less than the inflation rate, and manage the number of the workforce by utilizing retirement and natural attrition.

(3) Cash Flow Management

Eskom has to manage the cash flow for the sustainable operation of its business. Eskom Corporate Plan shows three directions for the management of the cash flow in the short term by 1) reviewing its operational and cost efficiency, 2) managing capital expenditure, and 3) assessing the options for the rescheduling of debt redemption.

In addition, Eskom intends to increase cash on hand by collecting the debt of municipalities in arrears through the introduction of measures such as automated metering and the prepaid system.[36]

At the end of February 2018, Eskom has signed an agreement of a ZAR 20 billion short-term credit line facility with seven financial institutions. Although Eskom has to refinance the loan in August 2018, it has secured the amount of cash for the working capital.

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34 The breakdown of the reduction of primary energy cost is indicated in Eskom, “Integrated Results for the Year Ended 31 March 2017,” 19 July 2017, p. 11.

35 Eskom, “Corporate Plan FY2017/18-FY2021/22,” February 2017, p. 9. See “7.7.4 Operating Expenditure” and “7.7.6 Capital Expenditure” for more details.

36 See “Strategies to Improve Debt Collections” in Eskom, “Revenue Application FY2018/19,” p. 49 for more details. Eskom recognizes the effectiveness of smart meters and prepaid meters introduced in several states and municipalities. See fin 24 “R13.5bn municipal debt burden 'really beyond Eskom',” April 18, 2018.

(4) Strengthening of Governance

Eskom has taken several measures to strengthen its governance.

Appointment of New Board Members

As one of the important steps for strengthening governance of Eskom, the Minister of Public Enterprise has proposed new members for the board of Eskom to the Cabinet. The members of the board have been approved on a three-year term by the Cabinet in early December 2017.[37] After this appointment, the chairperson of Eskom resigned on January 19, 2018. A new chairperson and a new set of board members have been appointed immediately, through the chief executive officer (CEO). The chief financial officer (CFO) is likely to be appointed within three months.

Implementation of the Eskom Corporate Plan

Eskom has formulated its Corporate Plan FY2017/18-FY2021/22 in February 2017. The Corporate Plan is a document for Eskom to engage its stakeholders on how it aims to implement Eskom's strategy. It is prepared in accordance with the Public Finance Management Act (PFMA) and other relevant legislations of the Department of Public Enterprise and National Treasury. Eskom is currently preparing the corporate plan for FY 2018/19-FY2022/23.

Formulation of the Five-Path Plan

To address the governance issue, the management of Eskom announced the five-path plan to rebuild a governance process.[38] The plan consists of five major directions as follows:

- Strengthening of internal ethics and fraud framework by approving ethics and fraud management policy.
- Implementation of independent audits on leadership. Those members in management positions undergo regular lifestyle and conflict of interest audit.
- Termination of irregular supplier contracts.
- Enhancing of internal commercial governance process by ensuring that the decision-making powers fall into within appropriate levels of management.
- Instituting disciplinary charges and taking legal actions.

At the time of writing this report, the detail of the five-path plan has not yet been made available and its implementation plan not clear.[39]

[37] See the announcement of Ministry of Public Enterprises at http://www.eskom.co.za/news/Pages/Decc8B.aspx
[38] Online Tenders, "Eskom Taking 'Bold Steps' to Shift Company's Reputation," https://www.onlinetenders.co.za/news/eskom-taking-bold-steps-to-shift-companys-reputation
[39] Eskom plans to finalize the turnaround plan by September 2018 according to a newspaper article (fin 24, "Eskom still heavily reliant on debt - Acting CEO," April 24, 2018).

Investigation of Misconduct by Eskom Employees

As one of the efforts to address corruption, strengthen governance, and rebuild confidence in Eskom by stakeholders, Eskom has been investigating the cases of employee misconduct.[40] Eskom has been investigating 239 cases of misconduct by employees and has completed 75 cases by the end of March 2018. Eskom is also going to implement a policy to prohibit the employees from doing business with Eskom to avoid conflict of interest and corruption.

(5) Impact on the Creditworthiness among Stakeholders and the Financial Situation of Eskom

Although the result of the above measures is not yet known, it is expected that these measures will positively have impact on the creditworthiness of Eskom among stakeholders and financial institutions. This is also expected to strengthen the financial basis of Eskom by rebuilding the confidence in the company and securing better access to funding.

The appointment of new board members, for example, seems to have a positive impact on the sentiment among stakeholders. However, the some of the measures mentioned above are ongoing and some are scheduled to be implemented. Therefore, it remains to be seen whether the financial situation and ability to repay the debt of Eskom is likely to improve or not.

13.5.4. Analysis on the Financial Ability of Eskom to Repay the Loan

The financial ability of Eskom is worth analyzing based on the past and future financial and governance situation. This is to check whether Eskom can continue to operate the Project and other businesses with sufficient financial resources and repay the loan for the Project in the long term. The table lists the indicators for monitoring to check Eskom's financial ability.

Table 13.5-17 Indicators for Monitoring

Indicator	Due date	Source of information
1. Revenue, cost, and profit		
1.1 Result of RCA application	6/2018	NERSA
1.2 Result of revenue application	Regular monitoring	NERSA
1.3 Trend of sales volume of electricity	Regular monitoring	Eskom
1.4 Cost management	Biannual monitoring	Eskom financial statements
1.5 Trend of EBITDA	Biannual monitoring	Eskom financial statements
2. Cash flow management		
2.1 Refinancing of the loan for working capital	8/2018	Eskom Treasury
2.2 Financing ZAR 72 billion by debt for FY2019	Regular monitoring	Eskom Treasury
2.3 Collection of arrear in debt of municipalities	Regular monitoring	Eskom Treasury
2.4 Net cash flow	Biannual monitoring	Eskom financial statements
3. Audited financial statements		
3.1 Audited financial statements for FY 2018	7/2018	Eskom financial statements
3.2 Audited interim financial statement for FY2019	12/2018	Eskom financial statements
4. Governance		
4.1 Formulation and implementation of Eskom's turnaround plan	9/2018	Eskom press release
4.2 Appointment of new CEO and CFO	5/2018	Eskom press release
5. Credit rating		
5.1 Change of credit rating	Regular monitoring	Eskom press release

Source: Prepared by the JICA Study Team

[40] fin24, "Eskom investigating 239 cases of misconduct by officials", April 18, 2018.

(1) Revenue, Cost, and Profit

1.1 Result of the RCA application [6/2018]

NERSA is scheduled to make a decision on the application of the RCA by June 2018. The decision by NERSA will not only influence the revenue level, but also increase the cash position of Eskom. This will also make it easier for them to obtain a loan by using the approved amount, which can be regarded as the receivable, as collateral of the loan.

Furthermore, the approval on the RCA is likely to give a positive impact on the sentiment among credit rating agencies and may change the credit rating of the company in the long run.

1.2 Result of Revenue Application [Regular Monitoring]

A) Action for Revenue Application for FY2019

NERSA has made decision on Eskom's revenue application for FY2019 in December 2017. Eskom received the detailed reasons for NERSA's decision on the application in February 2018. Though it is not clear at this stage whether Eskom will take any concrete action for the decision.

B) Result of Revenue Application for FY2020

Eskom will submit the revenue application for FY2020 within this year. Though it is not clear at this stage whether the application is for a single year or for multiple years. This will definitely influence the revenue forecast and the sentiment among stakeholders. It is necessary to check how Eskom analyzes the past performance, recognizes the status quo, and predicts the situation in the future for the application.

1.3 Trend of Sales Volume of Electricity [Regular Monitoring]

The tariff is regulated by NERSA and fixed for the applicable fiscal year, as the gap between the planned and actual revenue will be adjusted in the RCA mechanism at a later stage.

Table 13.5-18 Planned and Actual Total Sales Volume of Electricity

Unit: GWh, %

	2014/15	2015/16	2016/17	2018/19 (Projected)
A. Planned sales	229,183	235,210	239,113	216,206
B. Actual sales	216,274	214,487	214,601	
C. Gap (B-A)	(12,909)	(20,723)	(24,512)	
D. % of Gap in planned sales (C/A)	(5.6%)	(8.8%)	(10.3%)	
E. Year to year growth of actual sales		(0.8%)	0.1%	

Source: Prepared by the JICA Study Team based on Eskom. "RCA's submitted for FY2014/15, FY2015/16, and FY2016/17," Durban NERSA Public Hearing, April 19, 2018, p. 5. The figure of FY 2018/19 is from Table 12: Forecasted sales volume in Eskom, "Revenue Application FY2018/19," August 2017, p. 42.

Therefore, the change of sales of electricity is a single factor that influences the revenue level under the condition that the tariff is fixed. Sales volume of electricity as well as revenue needs to be regularly monitored in comparison with the past trend as the basis for estimating the ability of Eskom to continue its business and repay the loan.

1.4 Cost Management [Biannual Monitoring]

As described in 13.5.3 (2) Cost management, Eskom has been making an effort to contain the operating cost.[41] Operating cost as well as revenue are those factors that decide the level of EBITDA (Earning Before Interest, Taxes, Depreciation and Amortization). Therefore, the operating cost consisting of 1) primary energy, 2) employee expense, and 3) other operating expenses needs to be monitored in comparison with the past trend.

Table 13.5-19 Percentage of Cost to Total Revenue

	2015	2016	2017
A. Total revenue	152,135	166,629	178,709
B. Operating expense (1+2+3)	84.7%	80.3%	79.0%
1) Primary energy	54.8%	50.8%	46.3%
2) Employee benefit expense	17.0%	17.6%	18.6%
3) Other expenses	12.8%	11.9%	14.1%

Source: Eskom, "Annual Financial Statements 31 March 2017," "Annual Financial Statements 31 March 2016"

Primary energy cost in particular is the largest expense in the operating cost and shares approximately 50% of the total revenue. The mass media is recently reporting that seven TPSs fail to meet the requirement of coal stock level. This may result in a higher cost of procuring additional coal.[42]

The analysis should focus not only on the absolute amount that each item costs, but also the percentage of 1) annual change and 2) the cost to the total revenue and attempt to identify any abnormal value with the reasons underlying such figures. The analysis should also explore the changes in the fixed and variable costs.

[41] Eskom Holdings Corporate Plan FY2017/18–FY2021/22 describes the cost management in "3.4.3 Continue Efficiencies in Operating and Capital Costs to Help Achieve a Sustainable Tariff Path for Economy" with several tangible targets, though this may be revised in the new turnaround plan, which is scheduled to be finalized in September 2018.

[42] fin24, "Eskom Warns Coal Stock Levels Below 20-day Target at Seven Plants," April 25, 2018. The stock of coal for an operation of 20 days is below the requirement.

1.5 Trend of EBITDA [Biannual Monitoring]

EBITDA is calculated by deducting the operating cost from the total revenue. If the EBITDA is positive, it can be assumed that Eskom is spending money to continue its business.

Table 13.5-20 Percentage of EBITDA to Total Revenue

	2015	2016	2017
A. Total revenue	152,135	166,629	178,709
B. EBITDA	15.3%	19.7%	21.0%

Source: Eskom, "Annual Financial Statements 31 March 2017," "Annual Financial Statements 31 March 2016"

However, it does not guarantee whether Eskom is spending enough money to keep the minimum standard of operation, facility, and equipment. Therefore, the operational indicators need to be monitored as well to check whether sufficient money is being spent for the operation of Eskom.[43]

Although the percentage of EBITDA to the total revenue is showing a steady improvement in the last three years, it should be kept in mind that this percentage may decline in FY 2018 due to the 2.2% increase in tariff.

(2) Cash Flow Management

2.1 Refinancing of the Loan for Working Capital [8/2018]

Eskom has secured the short-term loan of ZAR 20 billion at the end of February 2018, which needs to be repaid in August 2018. Given the volume of the loan, it needs to be refinanced at the due date. As the loan is intended for a working capital, the refinancing of the loan will be a milestone to estimate the credibility and ability of Eskom to continue its business.

2.2 Financing ZAR 72 Billion by Debt [Regular Monitoring]

Eskom plans to raise ZAR 72 billion by debt for FY 2019, including the refinancing of ZAR 20 billion for the working capital.[44] The remaining amount of loan (ZAR 52 billion) is to be spent for capital expenditure. The success in financing for this fiscal year will have an impact on both the working capital and the completion of capital projects.

2.3 Collection of Arrear in Debt of Municipalities [Regular Monitoring]

Eskom has been making an intensive effort to reduce the unpaid amount of receivables of municipalities by 1) the negotiation and agreement with the municipalities on the payment of their outstanding debt, 2) the introduction of smart meters and prepaid meters and 3) the termination of electricity to default municipalities. However, the amount of arrears of municipalities has been steadily increasing.[45]

[43] Eskom lists and monitors various financial and operational indicators. See Eskom, "Eskom integrated report," March 31 2017.

[44] fin24, "Eskom still heavily reliant on debt - Acting CEO," April 24, 2018.

[45] See Table 13.5 8 Balance of Arrear Municipal Debt for the past trend of the debt of municipalities.

Eskom requested a full support from the Parliament and the Government of South Africa at the portfolio committee on public enterprises.[46] The trend of the volume of the debt of the municipality needs to be regularly monitored, as the change of this balance significantly influences the cash flow position of Eskom.

2.4 Net Cash Flow [Biannual Monitoring]

It is critical to check whether Eskom is generating the net cash enough to pay the principal and interest of the loan.

The future of the cash flow of Eskom is expected to change. If the demand of electricity and operating cost is constant, the cash generated from operating activities is expected to increase, reflecting the tariff increase. The deficit of cash from investing activities is expected to decrease as the capital projects are completed. The cash from financing activities is likely to decrease or become negative as the capital project is completed. This result in the reduction of borrowing and therefore the company starts to repay the loan for the projects.

Table 13.5-21 Past Trend of and Expected Cash Flow of Eskom

Unit: ZAR in million

	2015	2016	2017	Expected future trend
Net cash flow from operating activities	27,311	37,242	45,841	Increase
Net cash flow from investing activities	(56,386)	(58,590)	(62,286)	Decrease
Net cash flow from financing activities	17,954	40,927	7,855	Decrease or become minus
Increase/Decrease in Cash During the Year	(11,121)	19,579	(8,590)	
Cash and cash equivalents at beginning of the year	19,676	8,863	28,454	Keep >0

Source: Prepared by the JICA Study Team based on Eskom, "Annual Financial Statements 31 March 2017," "Annual Financial Statements 31 March 2017"

The net cash flow (= cash flow from operating activities – cash from investing activities) should be positive at the least and enough to cover the amount of the scheduled repayment of the principal and the interest of the loan. It is also necessary to check whether Eskom is repaying the loan without delay or rescheduling.

(3) Audited Financial Statements

3.1 Audited Financial Statements for FY 2018 [7/2018]

As the fiscal year of Eskom ends in March, its financial statements will be audited and made public within several months. As it is likely that Eskom falls into the red for FY 2018 (2017/4-2018/3), the detail of the financial statements needs to be analyzed to estimate the status of growing concern and the future financial performance of Eskom. The financial statements also provide the data for the aforementioned indicators.

[46] fin24, "R13.5bn Municipal Debt Burden 'Really Beyond Eskom'," April 18, 2018.

3.2 Audited Interim Financial Statements for FY2019 [12/2018]

The interim financial reports for FY2019 need to be analyzed in detail. Based on the decision of NERSA, the tariff increase is applied from April 2018.[47] The interim financial statements for FY2019 need to be reviewed and analyzed as it reflects the change in revenue, cost, profit, and cash flow due to tariff increase and other factors.

If the tariff increase based on the decision on the RCA application is already scheduled in FY2019 or beyond, the impact of the tariff increase based on the approval on RCA needs to be estimated for the future financial situation.

(4) Governance

4.1 Formulation and Implementation of Eskom's Turnaround Plan [9/2018]

Eskom has been preparing its turnaround plan to address the financial, operational, and governance issues. The company has also presented the plan to the Portfolio Committee on Public Enterprise last April 18, 2018. Although the detail of the plan is not yet disclosed, it is scheduled to be finalized in September 2018.

As the turnaround plan is expected to describe the detail of the action plans to improve Eskom's operational and financial performance, the implementation status and the indicators to evaluate the performance need to be regularly monitored.

4.2 Appointment of New CEO and CFO [2018/4]

New CEO and CFO were supposed to be appointed within three months after the appointment of the new board members including the interim CEO and CFO in January, 2018. Therefore, the appointment of new CEO and CFO needs to be monitored as it is likely to have impact on the implementation of the turnaround plan and the measures to improve the financial, operational, and governance situation of Eskom.

(5) Credit Rating

5.1 Change of Credit Rating [Regular Monitoring]

The financial and governance situation of Eskom, which are monitored by the above indicators, significantly influences the view of credit rating agencies and their ratings. This in turn influences the borrowing cost and the ability to access funds. Credit agencies keep low credit ratings on Eskom, although recent reports of various credit agencies show a mixed view on Eskom.[48]

[47] New tariff is applied to municipalities from July 1, 2018.

[48] For example, Fitch recently decided to keep the credit rating on Eskom, as it recognizes the measures taken by the new board of Eskom. See Eskom's press release, "Fitch Ratings Affirms Eskom's 'BB-' credit rating" on May 2, 2018 at http://www.eskom.co.za/news/Pages/2018May2.aspx.

13.6. Expected Impact of the Project (Operation and Effect Indicators)

Operation indicators are intended to evaluate the operational condition of the Project, which quantitatively checks whether the Project is being operated properly.

Table 13.6-1 Operation Indicators

Indicator	Formula	Target
SOx Emission Concentration at Rated Output (mg/Nm^3)	As shown by the name of the indicator	500 mg/Nm^3
SOx Removal Efficiency (%)	= (1 - amount emitted from the funnel / amount emitted from the boiler) × 100	90%
Desulfurization Availability to Generator Operation Hours (%)	= (FGD operating hours per year/boiler operating hours per year) × 100	100%

Source: Prepared by the JICA Study Team based on JICA, "JICA Operational Indicator and Effect Indicator Reference in ODA Loan Projects," July 2014

Note: SOx Emission Concentration needs to be measured by environmental monitoring instruments.

The target value of SOx emission concentration at a rated output is set at 400 mg/Nm^3. The target value of SOx removal efficiency is set at 90% as the design value of the design coal case with 96% limestone. As the FGD system is assumed to have no trouble in operation, FGD operating hours is expected to be same as the boiler operating hours.

The effect indicators are intended to evaluate the outcome of the Project.

Table 13.6-2 Effect Indicators

Indicator	Formula	Target
Amount of SOx Reduction (Ton/Year)	= Amount emitted from the boiler-amount emitted from the funnel	271 Ton/Year（=45.297 ton×6 units） (3,405 - 500) x 2,225 x 8,760 x 0.8 / 1,000,000,000 =45.297 ton/unit

Source: Prepared by the JICA Study Team based on JICA, "JICA Operational Indicator and Effect Indicator Reference in ODA Loan Projects," July 2014

The target value of the amount of SOx reduction is set at 271 Ton/year based on the following calculation.

Amount of SOx reduction = (A-B) x C x D x E x F = (3,405 - 500) x 2,225 x 8,760 x 0.8 / 1,000,000,000 x 6

= 271 Ton/Year

A: SOx Emission Concentration at Rated Input (3,405 mg/Nm^3)

B: SOx Emission Concentration at Rated Output (500 mg/Nm^3)

C: Hourly Flow Volume of Flue Gas in 100% Boiler Maximum Continuous Rating (BMCR) at Case of Design Coal (2,225 Nm^3/hour, dry)

D: Annual Hours (8,760 hours = 365 days x 24 hours)

E: Load Factor (0.8)

F: Number of the Units