Chapter 8

Project Implementation Plan

Chapter 8 Project Implementation Plan

8.1 Implementation Schedule in ODA Scheme

This Project will be funded by a Japanese ODA loan, and EDM expects the early implementation of the Project due to high demand for electricity in Maputo.

In consideration of the above, the Project implementation schedule including Project preparation activities is proposed as shown in Figure 8.1-1, and the schedule of each phase of the Project is explained in this chapter.

8.1.1 Project Preparation

(1) Environmental Impact Assessment ("EIA")

As mentioned in Chapter 11, EDM is responsible for the EIA process and the Ministerio para Coordenacao de Accao Ambienal ("MICOA", in English – Ministry of Coordination of Environmental Affairs) has classified this Project as Category A, which requires a full EIA process. According to recent experiences in Mozambique, it usually takes more than a year to complete the full EIA process. Therefore, the EIA process is a critical task to commence the project.

(2) Selection of Consultant

After the execution of the loan agreement, EDM will select a consultant. Eight months are needed for the selection of a consultant in consideration of the necessary processes such as preparation of the terms of reference ("TOR"), tender, evaluation and contract.

8.1.2 Selection of EPC Contractor

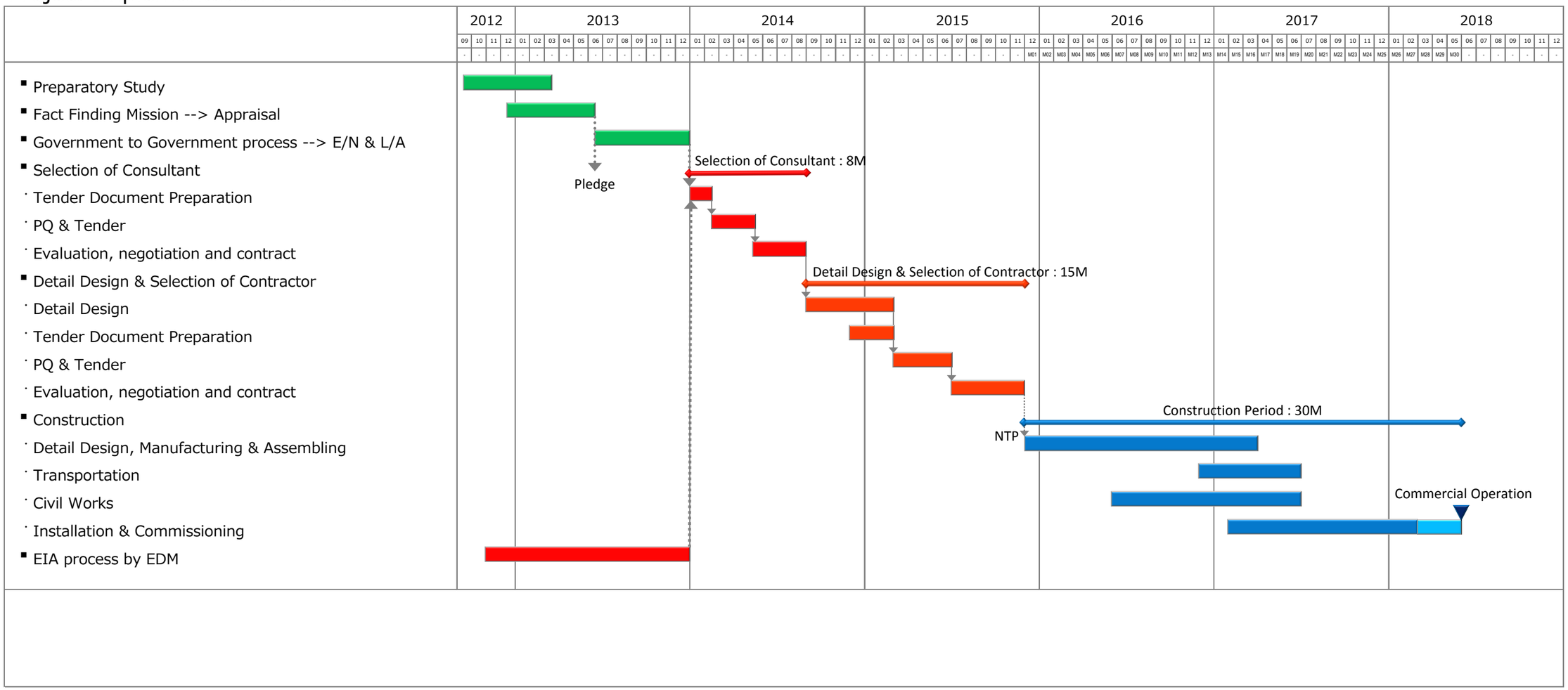
As mentioned in Chapter 8.3.4, an EPC contract will be adopted for this Project. EDM and the consultant will select a contractor by international competitive bidding. Fifteen months are needed for the selection of the contractor in consideration of the necessary processes such as detail design, preparation of tender documents, prequalification ("PQ"), tender, evaluation, negotiation and contract.

8.1.3 Construction

As shown in Figure 8.1-1, the construction of combined cycle power plant will be completed in 30 months through the process of the following activities, and will be ready for the commercial operation.

- Detail design of the plant and manufacturing & assembling of the equipment
- Transportation of the materials and equipment
- Civil and building works (equipment foundations, buildings and external works)
- Installation of the equipment and commissioning of the plant

Project Implementation Schedule



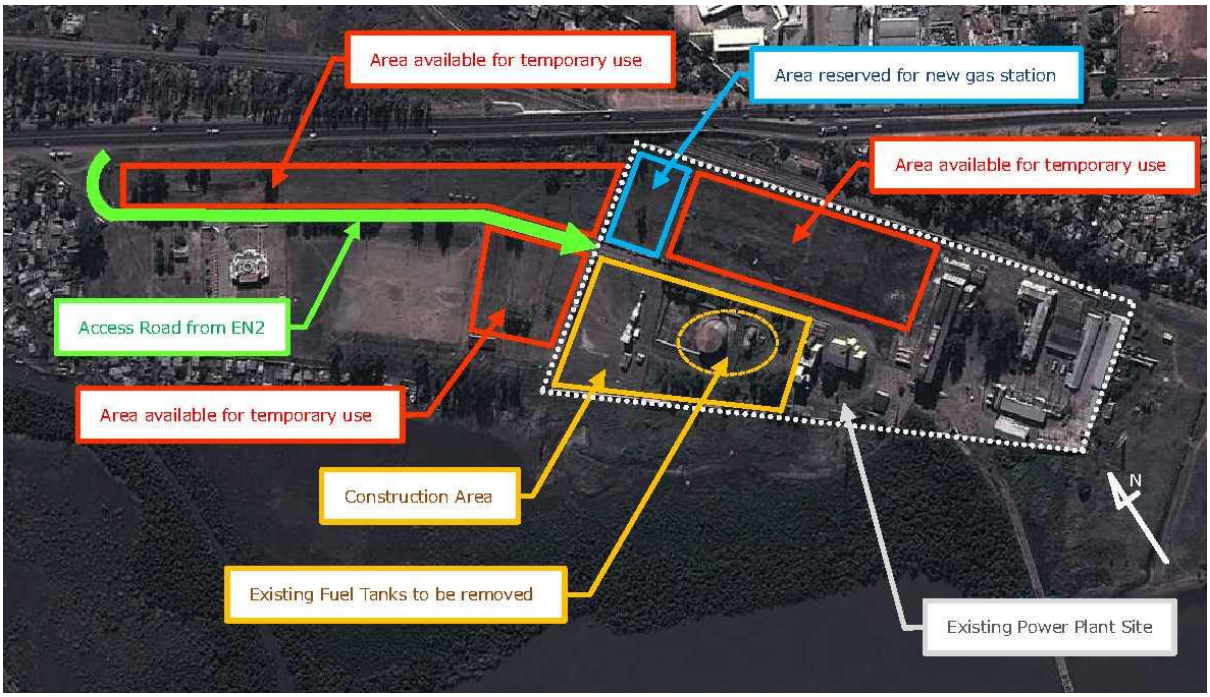
(Source: JICA Study Team)

Figure 8.1-1 Project Implementation Schedule

8.2 Construction, Procurement and Transportation

8.2.1 Present State of Site

Figure 8.2-1 is the overhead view of the CTM Maputo site showing the present state of the site and its surroundings.



(Source: JICA Study Team)

Figure 8.2-1 Overhead View of CTM Maputo Site

(1) Site Preparation

As mentioned in Chapter 3, no land preparation or resettlement are required at the CTM Maputo site.

(2) Infrastructure for Construction

Since the construction site is located at an existing power plant site, there will be no problems in arranging infrastructure required for construction such as water supply, power supply and access road.

(3) Construction Area

As mentioned in Chapter 6.4.3, the new power plant layout is proposed to be in the west corner of the CTM Maputo site (see solid yellow border of Figure 8.2-1).

Existing fuel tanks that are no longer used (see dashed yellow border of Figure 8.2-1) should be removed prior to the start of construction. This removal work is considered as land preparation work and would not be covered by the ODA loan.

(4) Temporary Yard

EDM has confirmed that the following area owned by EDM (see red border of Figure 8.2-1) can be used as a temporary yard during construction.

- Vacant land at north side of construction area
- Vacant land on both sides of the access road from EN2 to CTM Maputo site

The total area of the above is approximately 30,000 m^2 and is quite sufficient for the laydown area, stockyard and other necessary temporary facilities.

(5) Gas Station

The north corner of CTM Maputo site (see blue border of Figure 8.2-1) is reserved for a new gas station required for natural gas supply to the power plant.

8.2.2 Transportation of Heavy Equipment

The CTM Maputo site faces the river mouth to Maputo Bay, however, the shore in front of the site is a tidal flat with mangroves so there is no possibility of direct unloading from the river.

Therefore, heavy equipment for the Project, such as the main transformer and GT, which weigh approximately 100 tons, should be unloaded at Port Maputo and transported by road to the site.

(1) Unloading at Port Maputo

Port Maputo is currently operated and controlled by Maputo Port Development Company ("MPDC") with the concession given by the Mozambique government up to 2033. According to an interview with MPDC, berth No. 15 is designed for heavy cargo with a connecting road, and it is most suitable for unloading heavy equipment for this Project. Table 8.2-1 provides a list of berths at Port Maputo.

Table 8.2-1 List of Berths at Port Maputo

Berth No.	Type of Construction	Bollard No. Ref		Length (m)	Design Depth (m)	Recent Survey Depth(m)+ Avg Offset to Design Depth (m)		Load Limits		Recommended Use
						Depth Along	*Offset to Dsn*	*Super-imposed*	*Line*	
	MAPUTO									
1	Suspended deck on lattice structure on piles	25	32,33	163	4.2-7.2	7.9		3-5 kN/m2		Small ships
2	Suspended deck on lattice structure on piles	32,33	39	150	4.2-7.2	9		3-5 kN/m2		Small ships
3	Suspended deck on lattice structure on piles	39	50,51	225	4.2-7.2	9.7		3-5 kN/m2		Small RoRo, Cruise liner
4	Suspended deck on lattice structure on piles	50,51	61,62	225	5.4-8.0	10		3-5 kN/m2		Small ships, Small RoRo
5	Anchored sheet pile with failed block wall behind	61,62	76,77	227	12	11.7		50 kN/m2		Break bulk, Bulk RoRo
6	Suspended deck on lattice structure on piles	78	79	55	7.6-8.0	10		300 kN/m2		Break bulk, Bulk RoRo
6	Suspended deck on lattice structure on piles	79	82	43	6.9-8.0	10		20 kN/m2	35 kN/m	Small ships
7	Suspended deck on lattice structure on piles	82	92,93	106	6.9-8.0	11.1		20 kN/m2	35 kN/m	Small ships
7	Suspended deck on lattice structure on piles	92,93	?	94	5.8 - 11.7	11.1		20 kN/m2	35 kN/m	Bulk, Mollasses, Tankers
8	Suspended deck on lattice structure on piles	?	?	46	11.6 -11.8	11.1		20;10;5 kN/m2	35kN/m	Reefers
8	Suspended deck on lattice structure on piles	95	108,109	154	11.6 -11.8	11.1		25;18;5 kN/m2	100kN/m	Reefers
9	No berth 9									
10	Suspended deck on lattice structure on piles	101,102	108,109	149	12	10.7		25;18;5 kN/m2	100kN/m	Bulk sugar, Break bulk, Bulk
10	Concrete wall block	108,109	120	251	12	10.7		40 kN/m2		Bulk sugar, Break bulk, Bulk
11	Concrete wall block	120	122	60	12	10		40 kN/m2		Bulk sugar, Break bulk, Bulk
11	Anchored sheet pile wall	122	129	140	12	10		70 kN/m2		Break bulk, Bulk
12	Anchored sheet pile wall	129	138	200	12	11		70 kN/m2		Containers, Break bulk
13	No berth 13									-
14	Anchored sheet pile wall	138	150	253	12	11		70 kN/m2		Containers, Unit Load
15	Concrete Caissons	150	159	185	12	10.7		280;90 kN/m2	170 kn/M	Bulk, Break bulk
16	Concrete Caissons	159	168	172	12	10		280;90 kN/m2	170 kn/M	Break bulk, bulk
				2898						

(Source: MPDC)

There is no lifting equipment for 100-ton class cargo at Port Maputo, therefore, heavy equipment should be transported by a heavy-lift ship.

(2) Inland Transportation

(a) Weight and Size Limit

The weight and size of vehicles on roads are limited by Decree No. 14/2008 and the limits for trailers are as follows:

- Weight: Total weight should not exceed the following limits
  3 axles: 25 tons
  4 axles: 34 tons
  5 axles: 42 tons
  6 axles: 48 tons
  7 axles or more: 56 tons

- Size: Maximum length: 22 m
  Maximum height from the ground: 4.3 m

The weight and size of heavy equipment, such as the main transformer and GT, exceed the above limits. In such a case, the transportation method (e.g., using multi-axle trailers designed for super-heavy cargo) based on a road survey should be proposed to National Roads Administration ("ANE") for their approval.

It should be noted that the special multi-axle trailer necessary for the transportation of super-heavy equipment is not available in Mozambique, and needs to be arranged from South Africa.

(b)Route of Inland Transportation

As shown in Figure 8.2-2, the route of inland transportation from Port Maputo to CTM Maputo site will be as follows:

Berth No.15 → Road in Port Maputo → EN1 → Crossover-1 above railway → EN2 → Crossover-2 above railway → CTM Maputo site

(Source: JICA Study Team)

Figure 8.2-2 Transportation Route from Port Maputo to CTM Maputo Site

This route, including two crossovers (see Figure 8.2-3 and Figure 8.2-4), is on major trunk roads with heavy daily traffic. Therefore, it is considered that the heaviest equipment, such as the main transformer and GT, can be transported by special multi-axle trailer designed for super-heavy cargo.

(Source: JICA Study Team)

Figure 8.2-3 Crossover-1

(Source: JICA Study Team)

Figure 8.2-4 Crossover-2

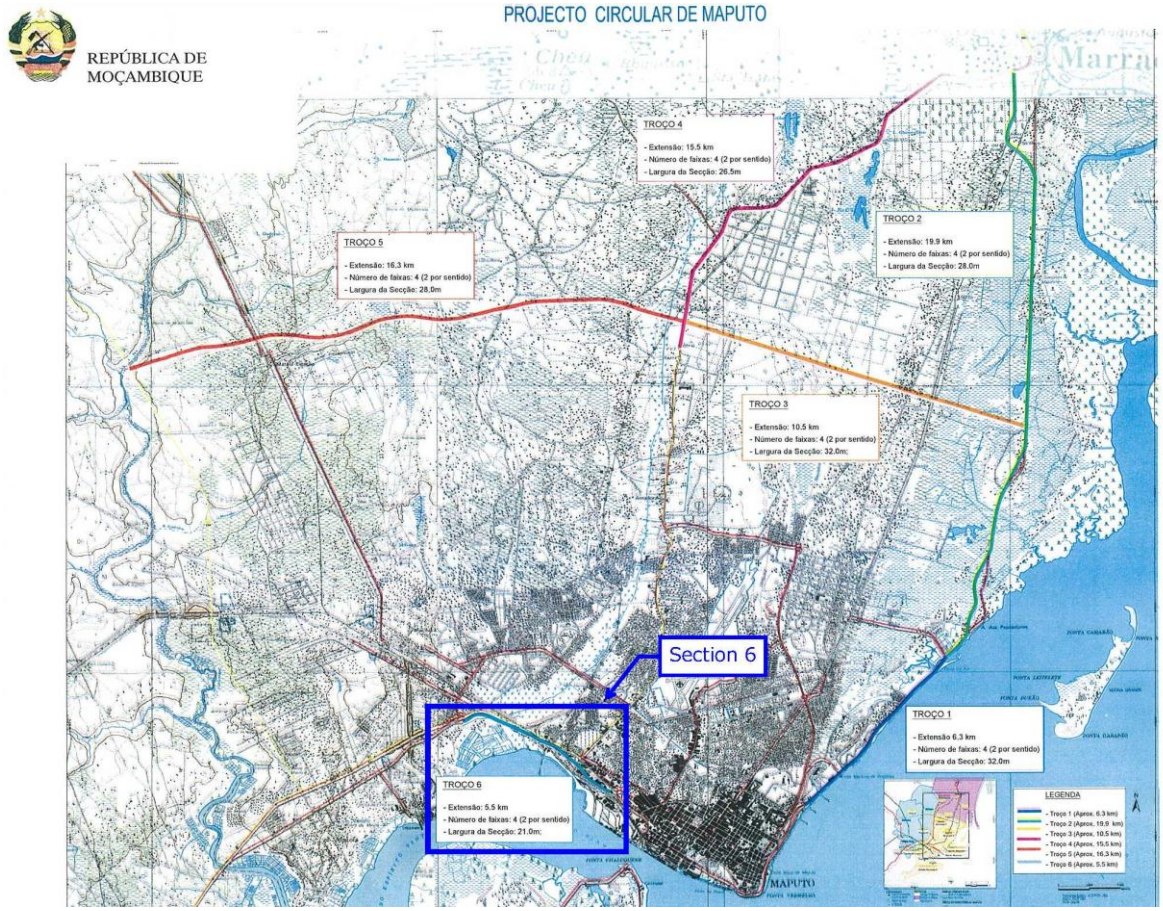
As mentioned in the next section, there is a plan to construct the Maputo Ring Road parallel to EN2. If the construction of Maputo Ring Road is completed before the construction of the new power plant, the transportation route will be changed.

8.2.3 Maputo Ring Road Project

During the first survey in Maputo, it was learned that there is a project called the "Maputo Ring Road" that includes the construction of a new road parallel to the existing EN2, and it may interfere with a part of the CTM Maputo site.

Thus, the JICA Study Team (with EDM) visited Maputo Sul, a governmental body specially organized to control the Maputo Ring Road project, and studied the outline of the project and the possibility of interference with the CTM Maputo site.

Figure 8.2-5 is the general view of the Maputo Ring Road project including Section 6, which seems to interfere with the CTM Maputo site.



(Source: Maputo Sul)

Figure 8.2-5 General View of Maputo Ring Road Plan

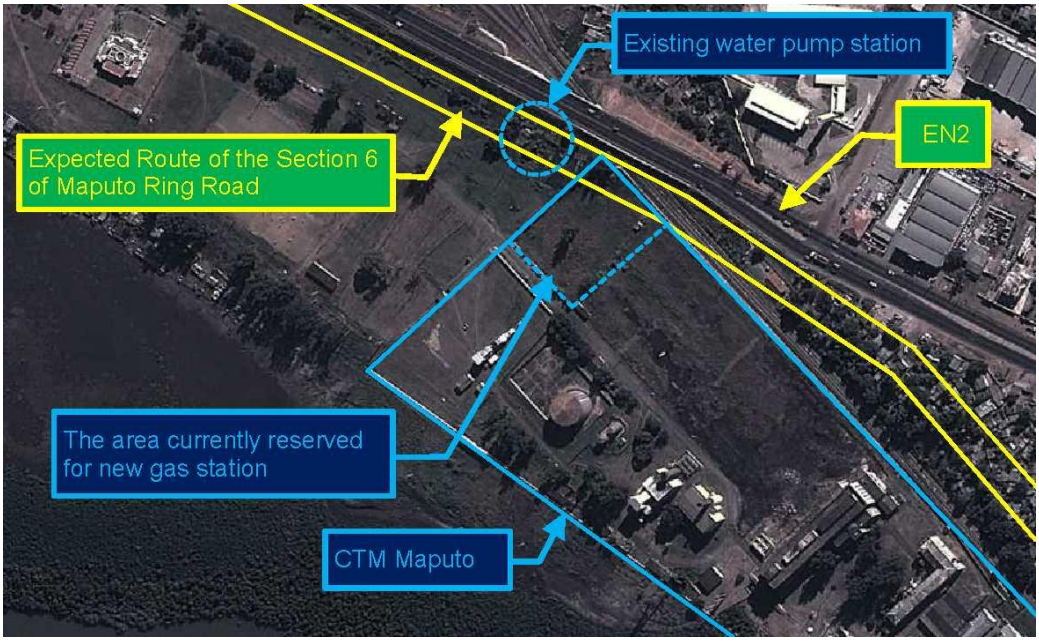
Figure 8.2-6 shows the route of Section 6 assumed by the JICA Study Team based on information from Maputo Sul and satellite images. Section 6 is the construction of a new 5.5-km long four-lane road parallel to EN2 between the roundabout in Maputo city and the tollgate at Matola. The CTM Maputo site is located around the midpoint of Section 6.

(Source: JICA Study Team)

Figure 8.2-6 Assumption of the Route of Section 6 and the Location of CTM Maputo Site

According to Maputo Sul, the route of Section 6 is not yet finalized in detail and the negotiations with land owners will start soon.

Figure 8.2-7 shows how Section 6 of Maputo Ring Road may interfere with the CTM Maputo site.



(Source: JICA Study Team)

Figure 8.2-7 Assumed Route of Section 6 and Interference with the CTM Maputo Site

There is a possibility that Section 6 may interfere with:

- The north corner of the CTM Maputo site currently reserved for the future gas station to supply natural gas to the new power plant
- The existing water pump station considered as the tie-in point for water supply to the new power plant

Under these circumstances, the progress of the Maputo Ring Road project should be carefully monitored for the construction of the new power plant.

8.2.4 Other Issues for Construction Planning

(1) Special Methods of Construction

Since the A.C.C. system is adopted for the ST condenser cooling, a water intake structure in the front river that needs marine construction technology is no longer required. There are no other special items that need special methods of construction in this Project.

(2) Connection with Power Transmission Line

The power generated by the new power plant will be transmitted through the existing sub-station and transmission tower in the CTM Maputo site. Therefore, there are no special issues to be considered for construction planning.

(3) Climatic Conditions

According to interviews with construction companies based in Maputo city, construction activities are not greatly affected by rainfall and cyclones in the rainy season (i.e. December to March), and there is no remarkable difference in productivity at the site between rainy and dry seasons.

(4) Long Holidays

Construction sites in Mozambique are normally closed during Christmas and New Year's holidays (mid/December to early/January), and special care is needed for procurement of imported materials in this period because most materials are imported from South Africa, and businesses are also closed during this time.

8.3 Points of Concern for Project Implementation

8.3.1 Procurement in Mozambique

Methods and procedures of the procurement for public works in Mozambique are stipulated by Decree No.15/2010. However, it stipulates that this decree is not applicable to projects funded by other countries or multilateral financing organizations.

According to the interviews with construction companies based in Maputo and from EDM, the projects funded by such overseas assistance, the International Federation of Consulting Engineers ("FIDIC") standards and/or World Bank's guidelines are normally used for the procurement of consultants and contractors.

8.3.2 Tendering Method and Contract Conditions

As mentioned above, FIDIC standards are largely used for the procurement of consultants and contractors. Therefore, the following JICA standard documents, also based on FIDIC standards, will be used for the procurement of a consultant and contractor for this Project.

- For the procurement of consultant:
  Standard Request for Proposals under Japanese ODA Loans
  - Selection of Consultants (October 2012)
- For the procurement of contractor:
  Standard Bidding Documents under Japanese ODA Loans
  - Procurement of Plant Design, Supply and Installation (February 2013)
- Guidelines
  - Guidelines for The Employment of Consultants under Japanese ODA Loans (April 2012)
  - Guidelines for Procurement under Japanese ODA Loans (April 2012)

8.3.3 Selection of a Consultant

According to the JICA guidelines, the consultant will be selected by the QCBS (Quality and Cost Based Selection) method through the process of the following activities:

(a) Preparation of a short list of consultants
(b) Preparation of the Request for Proposal
(c) Invitation to submit proposals
(d) Evaluation of proposals
(e) Negotiation and conclusion of a contract

These activities for the selection of consultant may commence after the Japanese government pledges an ODA loan to this Project.

8.3.4 Selection of an EPC Contractor

(1) Package for Tender

An EPC contract is usually adopted for power plant construction projects because the detail design of the plant is highly dependent on the composition and specifications of equipment supplied by the contractor. Thus, an EPC contract will be adopted for this Project.

(2) PQ and Tender

The EPC contractor will be selected by International Competitive Bidding ("ICB") as stipulated in JICA guidelines.

In consideration of the necessity for advanced technologies in wide-ranged and extensive management ability for the construction of the power plant as well as the scale of the Project, the following conditions shall be specified in the PQ documents:

(a) Experience of and past performance on similar projects
(b) Capabilities in engineering, procurement and construction of combined cycle power plant

(c) Financial position

In addition, since the specifications of which EPC contractor will propose in the tender differ in capacity and thermal efficiency, the evaluation in price will be made based on kWh generation cost in the same manner with the general ICB.

8.4 Management at Construction Stage

The management of the construction work consists of quality control, process control and safety control. In order to carry out these three control items, it is necessary to establish an organization within EDM that will supervise the power plant construction work.

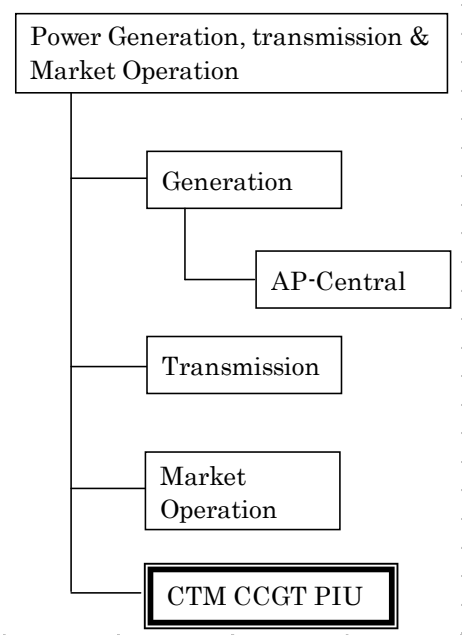
8.4.1 Project Implementation Organization

This section mentions an implementation organization which will implement the CTM Maputo CCGT project. It is recommendable that a Project Implementation Unit ("PIU") will be established to manage and implement the CTM Maputo CCGT project. And personnel and staff belonging to PIU will be transferred to CCGT or to the O&M Department of EDM.

(1) Organization of EDM

1) Establishment of PIU

EDM has proposed the organization as shown below, to install a PIU directly under the CEO. PIU will play the central role of implementation of this project.



(Source: JICA Study Team)

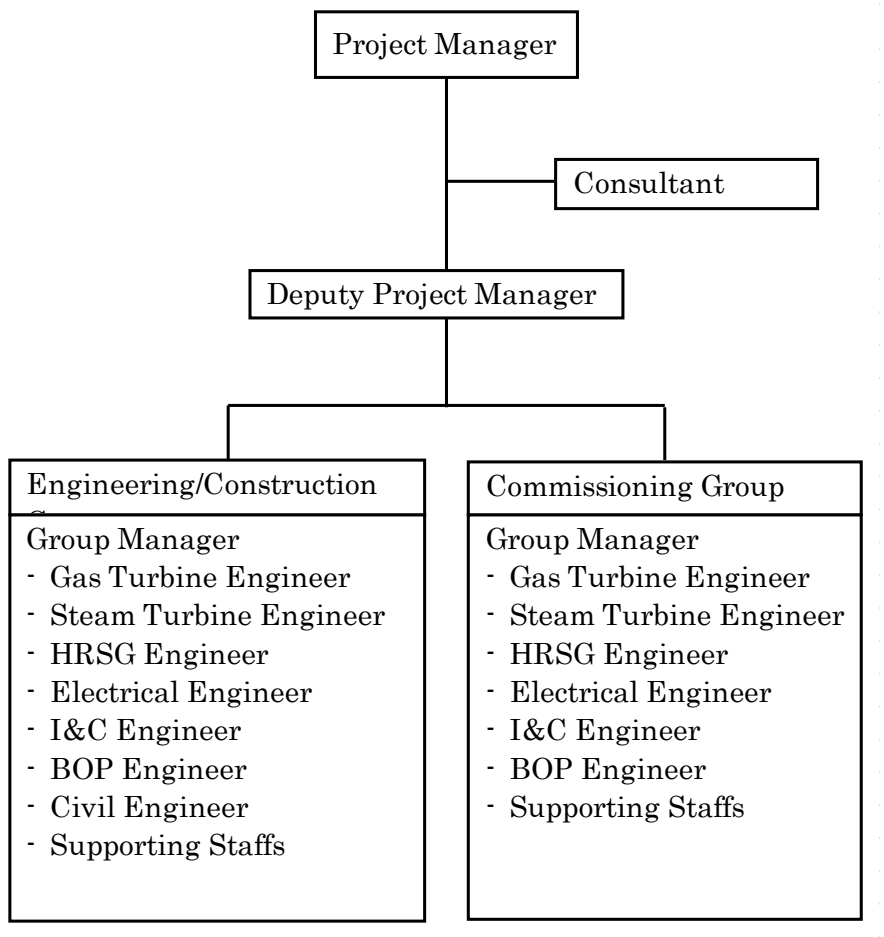
Figure 8.4-1 PIU in EDM

2) Organization of PIU

PIU will consist of a Project Manager, Deputy Project Manager and two sections of an Engineering/ Construction Group and Commissioning Group, and a Consultant as an adviser. The Engineering/ Construction Group will conduct quality control and process management of detailed design and construction of the CCGT to be conducted by contractors with the assistance of consultants. Through operating the business, it will perform technology acquisition-related maintenance on the combined cycle power plant. Commissioning Group equipment by itself, it is implemented in conjunction with overall plant commissioning contractor of it would acquire of operating instructions with the operation of the combined cycle power plant by itself

It is important to establish an organization which is small and can take quick and flexible action with certain responsibility given to the Project Manager of PIU (e.g., Project Manager has the right to purchase goods under USD 1 Million). Consultants to be hired as engineers, can play a critical role in technically supporting the entire organization of PIU.

(a) Organization of PIU



(Source: JICA Study Team)

Figure 8.4-2 Organization of PIU

(b) Role of PIU and Engagement Period

Table 8.4-1 Role of PIU and Engagement Period

Phase		Engineering Phase	Construction Phase	Commissioning Phase	Position after commissioning
Project Manager (P/M)		■	■	■	Superintendent of Maputo CCGT
Deputy P/M		■	■	■	Deputy-superintendent of the power plant
Engineering/Construction Group	Group Manager	■	■	■	All personnel's will shift to O&M sections in CCGT. Capacity building will be carried out to assign the main post (Head of department or chief of section) Or EDM will employ the personnel who has a capability to achieve the works
	Gas Turbine Engineer	■	■	■	
	Steam Turbine Engineer	■	■	■	
	HRSG Engineer	■	■	■	
	Electrical Engineer	■	■	■	
	I&C Engineer	■	■	■	
	BOP Engineer	■	■	■	
	Civil Engineer	■	■		
Commissioning Group	Group Manager		■	■	All personnel's will shift to operation sections in CCGT after CCGT taking over.
	Gas Turbine Engineer		■	■	
	Steam Turbine Engineer		■	■	
	HRSG Engineer		■	■	
	Electrical Engineer		■	■	
	I&C Engineer		■	■	
	BOP Engineer		■	■	
[EDM permanent personnel]		10	17	16	

(Source: JICA Study Team)

8.4.2 Construction management

To carry out the quality, process and safety controls in the construction work, ordinarily there would be a review of the details of each control method with regard to the project implementation procedure (PIP) with the contractor and later agreed to by EDM, the consultant and the contractor, who will implement each control item in the phases of detailed design, construction work and commissioning. Management of quality control differs among the phases of engineering, construction and commissioning.

(1) Quality control

In the engineering phase, to ensure that the design by the contractor satisfies the order requirements,

EDM will check and approve the contents of the contractor's design with support provided by the consultant. If the contractor's design is unsatisfactory, EDM will give the contractor a written request of correction. A witnessed inspection will be carried out with regard to the major equipment before being shipped from the factory to ensure that the required performances are satisfied.

During the construction work, EDM will determine important check items with the contractor, and give confirmation in the process of work and approvals when necessary. If any defects are found, EDM will give the contractor a written request of correction.

In the commissioning phase, the contractor will first be asked to submit commissioning instructions for each device and each facility. After checking and approving them, EDM will carry out unit commissioning of each device and each facility to ensure that they can perform as designed. If any defects are found, EDM will give the contractor a written request of correction.

In the comprehensive plant commissioning phase, the output, efficiency and operational performance in the commissioning specifications should be confirmed to be those which are required by the plant. Any defects in the design, construction and commissioning phases must be listed and monitored in order to eliminate them.

(2) Process control

Before starting construction, EDM will have the contractor submit an entire construction schedule and validate the construction process with support provided by the consultant.

In the construction phase, EDM will hold meetings with the contractor to regularly check the process, i.e., monthly, weekly and daily. By doing so, EDM can monitor the progress of the construction and, if finding any delays, carry out reviews with the contractor for countermeasures to be taken and have the contractor take those measures. In addition, EDM will have the contractor submit a progress report every month to understand the progress in construction and any issues with regard to such items as civil engineering, architecture, machinery, and electric power.

(3) Safety control

Having the contractor submit a safety plan prior to construction, EDM will evaluate and approve the validity of items including contractor's safety procedures, safety measures, and organization for communication in the case of an accident. If further measures are necessary, EDM will ask the contractor to take them.

Through regular and irregular on-site inspections, EDM will check whether the contractor is carrying out the safety controls in the construction as provided in the safety plan. Upon finding any unsatisfactory items, EDM will have the contractor correct them and ensure on-site safety by carrying out the safety plan-do-check-act ("PDCA") cycle all the time.

8.5 Management at O&M Stage

In this chapter, in order to achieve "highly-reliable power supply," we will make proposals for the operation and maintenance ("O&M") management towards the realization of O&M by actively using total quality management ("TQM") and the promotion of management optimization.

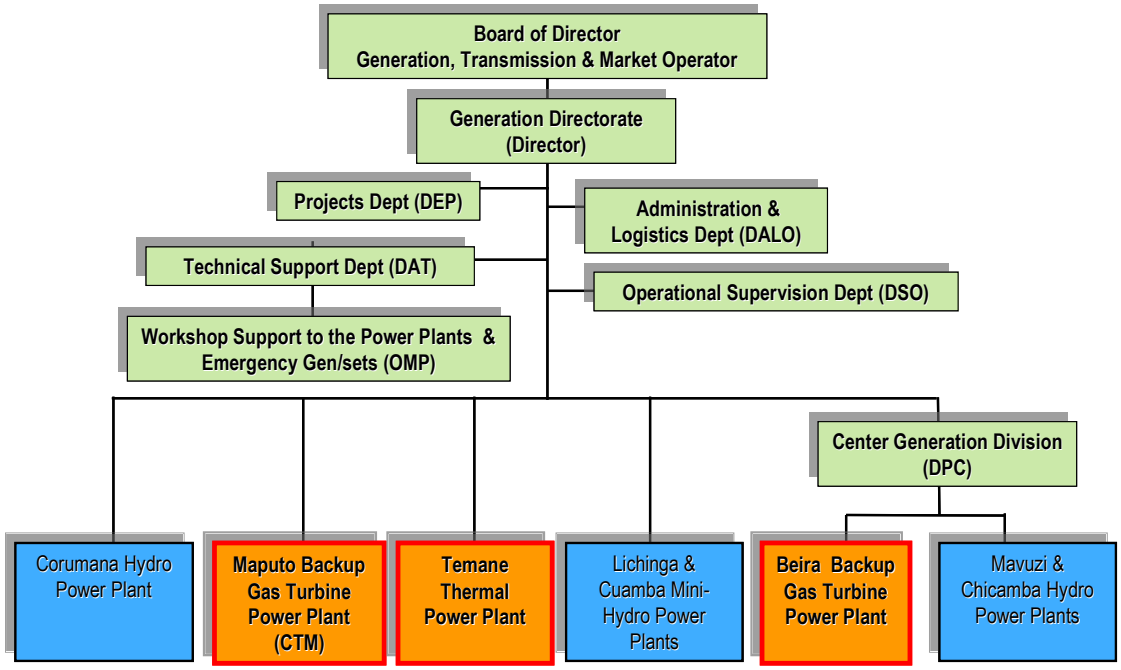
8.5.1 Current State of EDM Capability

(1) Current state analysis

The organization structure of the current EDM is shown in the following figure. The EDM owns 3 thermal power stations. At the CTM site, there are four engineers who work full time, consisting of 1 Electrical Engineer, 2 Mechanical Engineers and 1 Operator. The CTM Maputo Power Plant currently has three GTs installed. GT #1 is currently out of order. Using gas oil as fuel, GTs #2 and #3 are operable but hardly in service due to expensive fuel. As for GT #3, for example, although approximately twenty years have passed since the commencement of commercial operations, during the primary survey it was clearly stated that it had run for a total of only 404.5 hours only. It still did not even reach the minimum operation hours recommended by the GT manufacturer at which maintenance work should be necessary. Therefore, it appears that there was no inspection of the combustor and inspection/replacement of the high-temperature components.

It appears that the GTs were operated regularly, once every several months, just to check whether or not the GTs could still be run. As described above, it is assumed that the periodic inspection and maintenance for GTs were not carried out well.

Therefore, in consideration that there is no experience of O&M for the combined cycle generation unit, prior to the introduction of capacity building, an O&M is to be established from the start.



(Source: EDM, 2012)

Figure 8.5-1 Organization of O&M Management Flow

(2) Importance of capacity building for O&M

Since this project will be the first experience of CCPP introduction in Mozambique, the capacity building for O&M is the top priority of tasks in order to operate and maintain the constructed structures. As an illustration, one example of capacity building by utilizing an Operator Training Simulator ("OTS") is shown as follows:

- Operator's skill up and stable and efficient plant operation

  In relation to a set of models that replicates the field equipment (GT, Turbine, HRSG, etc.) and a faithful replica of the complete CCPP, the plant control system can be tested on the simulator before it is installed in the real plant. This results in any errors in the Distributed Control System ("DCS") logic being discovered on the OTS and not the plant, thereby minimising any possible risks to the plant. The Operators can achieve confidence and gain appropriate skill levels in a safe and efficient manner through training.

- Smooth commissioning and flexibility with modifications

  Also the customers' control Engineers can become very familiar with the DCS via the OTS so that when the control system is transferred to the physical plant, the Engineers will have been working with it on the OTS for a number of months. When the plant is commissioned, these Engineers will have been trained to the maximum level possible on the OTS.

  When the plant is operating and the Engineers start to make modifications to the control system, these modifications can be tested and fine-tuned on the OTS, and when the Engineers are happy with their modifications, the controls can be copied from the OTS and installed in the plant with the confidence that any bugs, etc., have been sorted out.

8.5.2 Reinforcement of Organization Management

(1) Segregation of Duties between Head Office and Power Station

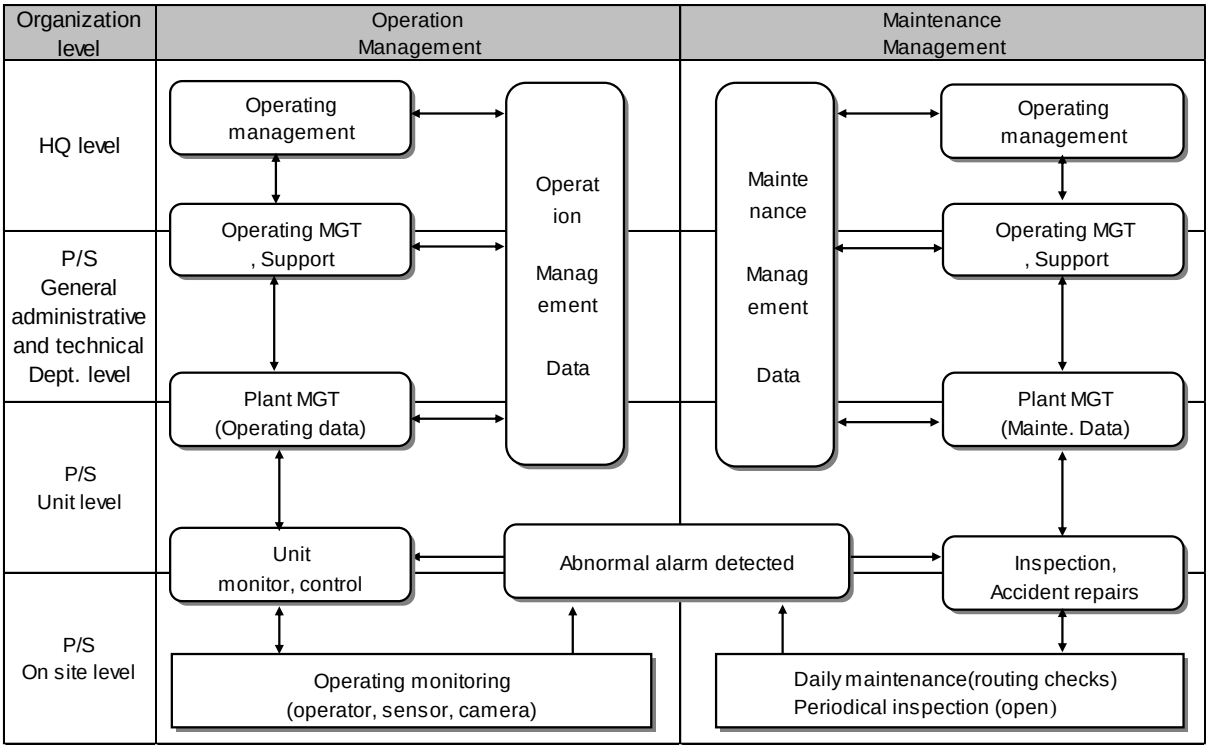
The segregation of duties between head office ("HQ") and the power station ("PS") is as follows. The function of the HQ is divided into general business management function, sectoral business management function and general staff function. That of PS is divided into general staff function and operation team whose members perform actual operation of the PS. General, long-term and systematic planning is developed at HQ level, while basic policy and plan of the department are developed by the management department of the PS. The data at the PS unit/ on site level is collected, monitored at the PS level, and it is fed back to the business management function at the HQ level.

Table 8.5-1 Functions between HQ and PS

Organization level	Category	Work
HQ level	Top management	Management for the corporation (1) Setting management targets, (2) Long term planning (3) Coordination and controls (4) Analyzing operating conditions
	Each department	(1) Operating mismanagement function -Section-wise policy, planning, target, and monitoring -General staffing: PS administrative works

Organization level	Category	Work
PS level	General administration and technical	General staffing: PS administrative works, data collecting, analysis
	Unit and on site	Actual work on site

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 8.5-2 Organization of O&M Management Flow

8.5.3 Reinforcement of Cause Analysis Capability

(1) Selection of Maintenance Management Method

1) Improvement of maintenance management level (necessity of shift from Level 1 to Level 3)

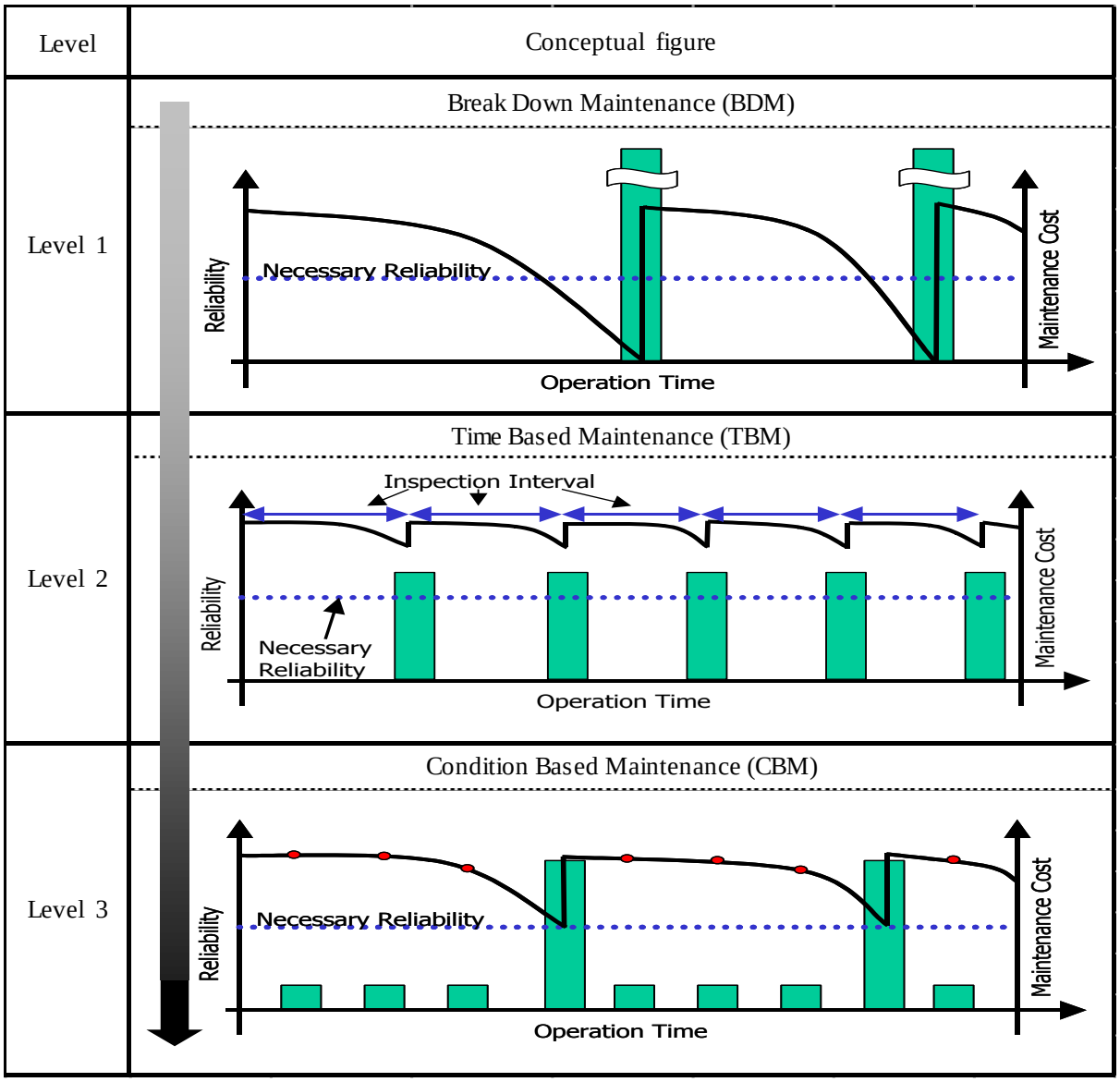
Maintenance management is divided into three types, with different characteristics as shown below.

In many PSs, the condition of Level 1 is that in which the equipment is operated until it breaks. In the case of Japan, periodic legal inspections have been established by the regulatory authorities, and time-based maintenance ("TBM") which is Level 2 was mainly used. However, regulatory authorities in Japan have studied the maintenance activities of electric power suppliers with the result of conditions shifting to the maintenance method Level 3 in which condition based maintenance ("CBM") is used with TBM (the interval of periodic inspections is extended while maintaining current safety). Therefore, it is desirable that in order to strengthen both organizational power and technical capabilities to have flexible maintenance management, both TBM and CBM should be used together, like in Japan.

In the case of shifting maintenance management methods from Level 1 to Level 3, it is necessary to acquire the ability to judge situations accurately and ensure the reliability and safety of the facilities. The following are definitely required.

- Comparison between operating state standards and reference standards (temperature, pressure, current, vibration)
- Periodic diagnoses of leaks, abnormal sounds, corrosion, deformation, discoloration, expansion and others problems observed by the five senses of the persons on patrol (i.e., sight, smell, hearing, touch, taste)
- Quantitative diagnostic technology in overhaul during periodic checks and maintenance
- Liquid penetrant test (detection limit – surface flaw of approximately 20μ)
- Magnetic particle test (detection limit – depth of approximately 0.5mm)
- Ultrasonic test (detection of inside flaws in thick member – 0.2mm – 0.3mm)

In Japan, for engineers of nondestructive tests, a national examination system is implemented for each inspection method and only qualified persons are engaged in such inspections.



(Source: JICA Study Team)

Figure 8.5-3 Conceptual Figure of Maintenance Management (By Level)

(2) Proposal of Concrete Management Method

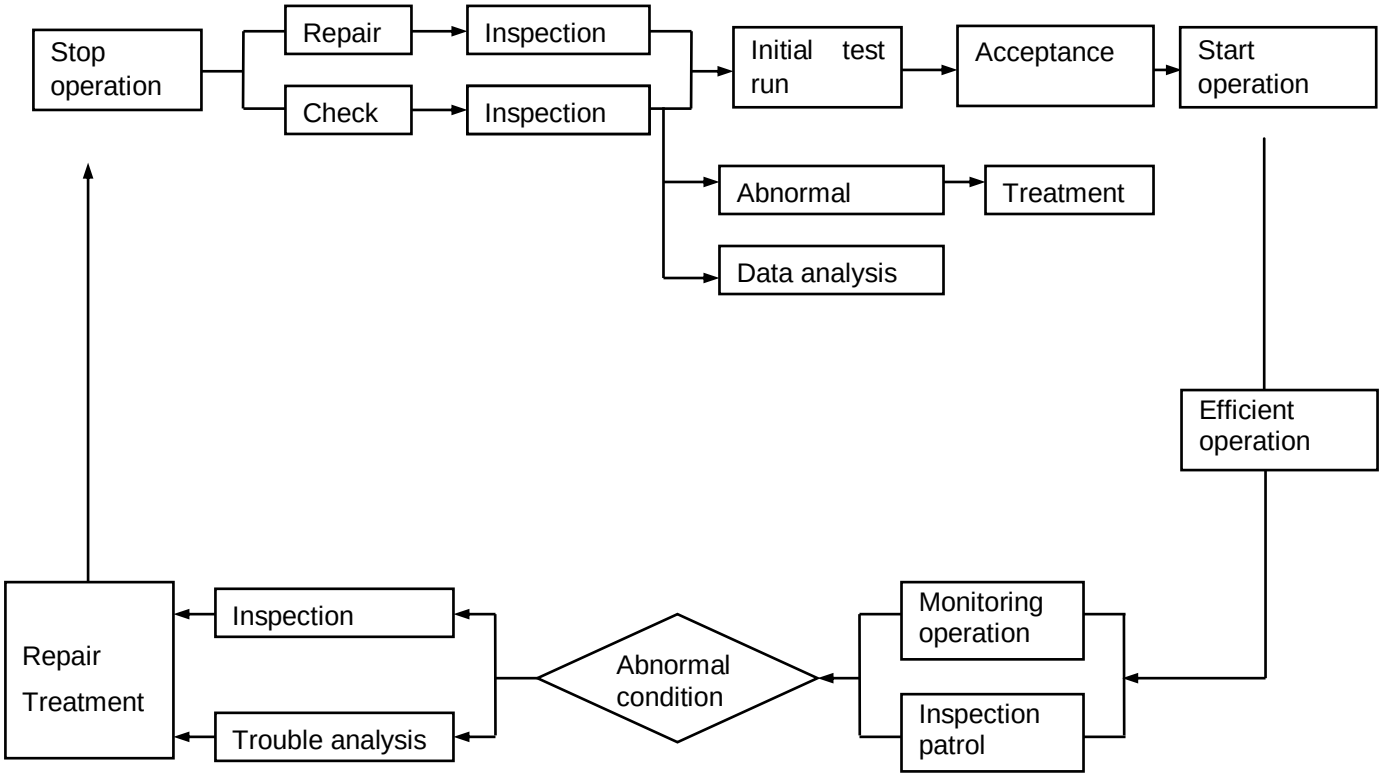
1) Standard Management Flow Based on PDCA

PDCA (plan–do–check–act) is an iterative four-step management method used in business for the control and continuous improvement of processes and products. By repeating the four stages of the PDCA plan (planning)–do (run)–check (evaluation)–act (improvement), this will lead to continuously improving the business. After completing each step, the last step of the four steps is intended to lead to the next PDCA cycle , to improve the cycle in each lap, thereby continuously improving operations.

- Plan (plan): To create a business plan and forecast based on previous experience
- Do (implement and run): To do work according to plan

- Check (inspection and evaluation): To check whether the implementation of the work is according to plan
- Act (improvement treatment): To correct actions by examining whether or not the implementation part is according to plan.

The management flows of operation and maintenance based on PDCA are shown below.



(Source: JICA Study Team)

Figure 8.5-4 Standard Management Flow Based on PDCA

(a) Monitoring and Checking during Operation

It is important to always monitor temperature, pressure, flow rate, water level and the level of oil, etc., of various parts and check that they are within the predetermined reference standards in the operation of the PS. Also, it is necessary to strictly check that the following operations are within the predetermined reference standards (steam conditions, burn conditions, etc.): realization of equipment functions, holding of heat efficiency, reduction of equipment wear, and reduction of creep and fatigue degradation in high temperature members.

All data relating to the actual performance of electricity generation and heat efficiency must be inputted into the process computer for the management of operation, data of actual performance of electricity generation and that of heat efficiency for management must be created, trend management of conditions of various parts must be conducted, in addition to finding any abnormal conditions in the early stages. Concurrently, daily inspection tours must be conducted in order to find any abnormal conditions, such as slight differences of vibration, noise, odor and color which are difficult to be measured, and any tiny quantities of oil and/ or water leakages (exudations), in the early stages.

(b) Prevention of trouble

If any abnormal conditions are found, the data must be analyzed in order to determine the cause. If the need arises, the operations must be urgently and temporarily stopped, and necessary inspections and diagnosis must be conducted. Based on the results of such inspections, the problems must be evaluated and any countermeasures determined.

(c) Repair, inspection and maintenance

Before conducting periodic inspections, in addition to undertaking periodic work, all work to be conducted at the time of shutdown must be clarified, including the repair of abnormal parts which have been found during the operation, a detailed work plan created, and in advance obtain any necessary parts, if required.

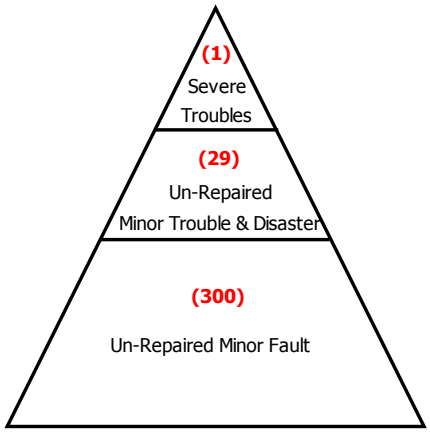
As for any abnormalities which are found during inspections, basically they should be repaired during the periodic inspections. Any difficulties regarding the abnormalities must be evaluated, and the lead times in preparing parts and any countermeasures (emergency measures, permanent measures) to be taken should be determined. For any small-scale abnormalities which are carried over to the next periodic inspection and any temporarily repaired abnormalities, countermeasures, such as setting of special measuring equipment, must be taken in order to monitor the status of the progress of any abnormalities.

The contents of inspections, measurement results and other data must be recorded in the predetermined format, with trend management conducted at each inspection, and all data to be used in the remaining life assessment.

2) Maintenance Management

(a) Daily maintenance

The most important part in the maintenance management of equipment of the PS is to perform careful daily maintenance. In Heinrich's Principle shown below, it is said that 29 disasters with light injury will occur when there are 300 events where sudden fear is felt (bud of the disaster) behind the occurrence of one serious injury. This is an experimental rule in work accidents, but it can also apply to daily maintenance.



(Source: JICA Study Team)

Figure 8.5-5 Heinrichs Principle Disaster Pyramid

The base of daily maintenance is to discover any small problems in the early stages and take preventative measures. Small problems hide in various places over a widespread area. The detection of any abnormalities (vibration, noise, bad smells, oil leakages, etc.), changes of operation status standards, should be frequently noted in daily inspection tours. Daily visual checks are important. The technique of discovering problems is based on guesswork, hunches and long experience, and it is a technique developed on site through on the job training by building up cooperation between experienced and young staff.

Also, in daily maintenance, it is important to check monitoring instruments, as there is no point in conducting daily maintenance if monitoring instruments do not function normally. Therefore, it is necessary to correctly calibrate monitoring instruments in the early stages.

(b) Periodical inspections

Periodic inspections are mainly divided into simple inspections and full-scale inspections. Both should be conducted at optimum times in view of the time (total operation time x number of starts) and the condition of the plant.

Inspection is required for all parts whose materials deteriorate due to creep thermal fatigue damage, cracks and fissures, such as hot parts of GTs, and inlets of main steam/ reheated steam of STs, etc. As for other parts, there are many target parts spread widely which are large in number; so selected parts should be inspected based on the problem of cost and time. The priority order and a development chart of the inspection of selected parts should be created based on the operation status standards, heat efficiency and the data of the first inspection. It is important not to leave any uninspected parts.

In particular, for setting the schedules of periodic inspections and maintenance, consideration should be given to the actual performance of other IPP plants, ensuring safety on site (minimization of vertical work, open inspection and maintenance place and work environment), the operation rate of overhead cranes, etc., and the promotion of the streaming of work and shortening of processes as the object in which parallel decomposition can be conducted. Also, it is important to boost the morale of workers and make them compete against each other in striving for improvements of quality control by adopting a system of bonuses and financial incentives if the construction period can be shortened.

In addition, at planned stoppages, it is important to conduct visual inspections of the PS, such as checks of the remaining work of daily repairs planned to be conducted during the stoppages, the condition of parts which were repaired temporarily in the previous periodic inspection and maintenance work, and parts which were left unprepared however changes had been observed, and reflect the repair time to the next stoppage plan, or future stoppage plans.

(c) Monitoring of Accidents

In the case of any sudden accidents (during operation and inspections), a site investigation must be conducted and the situation understood. In addition, based on the database, such as past operation records and the record of the previous periodic inspection, the true cause of the accident must be understood.

As for problematic parts which are found during the periodic inspections, if repair materials cannot be prepared, then emergency measures must be taken. For these emergency measures, if the part reliability until the next periodic inspection and maintenance cannot be secured, then permanent measures must be taken using the next planned stoppage. On the other hand, if the problematic parts where the emergency measures were taken were used until the next periodic inspection and maintenance work, the relevant parts must be checked at the planned stoppage, and the investigation continued to check the trend data of any changes.

(d) Maintenance plan

In consideration of the time needed to change consumable parts, deteriorated parts, and hot parts of GTs where the equivalent operation hours ("EOH") recommended by manufacturers are used as a guide, EDM will establish medium- and long-term repair plans. To that end, the type of maintenance, stoppage times and number of stoppage days should be included. The actual time and number of stoppage days should be decided in coordination with the central power feeding center in consideration of the power demand/ supply situation, but basically it is important to keep the predetermined schedule of the medium- and long-term repair plans from the viewpoints of maintaining the reliability of equipment and efficient maintenance management. If there are any postponements of repairs from the predetermined medium- and long-term repair plans, due to any increases of parts deterioration, expansion of the inspection range, expansion of repair range and parts where unexpected problems are found, this may require additional orders of spare parts and urgent change of parts, which may lead to increasing the construction period and the expense of huge additional costs.

(e) Budgeting of maintenance

When the medium- and long-term repair plans are created, approximate construction costs should be calculated based on the exchange parts in each unit, parts which are GT hot parts and are reused in repairs after removing, the cost of construction which is planned in the periodic inspections such as the replacement of equipment, etc. (purchase cost of equipment + transportation cost + installation cost).

However, there is always a risk that securing workers may become impossible due to price changes and the prolongation of the construction period, so it is necessary have discussions between the workers involved (e.g., staff on duty of the PS, repair department, budget department, construction company) one year before the planned periodic inspection of the relevant unit and establish a detailed implementation plan. Meetings of the last double check should be held three months before the inspection. In addition, there should be additional inspections and investigations of any parts where problems occurred after the creation of the plan.

(Note: In general, contracts of Long Term Service Agreements ("LTSA") and Long Term Parts Management ("LTPM") should be concluded with equipment manufacturers. These contracts include that equipment manufacturers shall provide spares and consumable parts over a long period of time, e.g., GT hot parts, and a large contract deposit is paid for long-term collateral. Under these contract conditions, it may be difficult for GT engineers and repair technicians to gain experience.)

3) Operation management

The base of operation management is to strictly keep the reference standard operation. If any operation status standards deviate from reference standards, engineers of the electricity generation group and repair staff shall investigate the cause and take reform measures.

(a) Standard process

The base for operation management for the reference standard automatic operation is by process computer. During automatic operation, security devices are maintained and protection circuits are normal. The unit trip is the last measure to protect the equipment and the trip circuit should not be removed.

If any inspections of the circuit are required when the unit output is constant, then the inspection range, the personnel to conduct the inspection and the manual trip must be determined. If output changes with a big change possibly affecting other equipment, an operating procedure must be created, with the division of roles and deployment of staff determined and then launched.

(b) Management of security devices and protection circuits

For security devices and protection circuits, the base is the sequence of the completion of test operations (manufacturers submit applications which are then approved by the PS). For any parts in which the alarm device is frequently activated, they should be checked immediately, and if there are any abnormalities then appropriate reform measures should be taken. However, if the sequence is changed or the set standard of each alarm is changed, top-level technical staff of PS shall have discussions and determine the range, and any changes must be approved by PS. In this case, it is important to immediately change the original sequence drawings and the lists of set standards, and inform operation staff on duty and staff in charge of repairs of such changes.

(c) Fuel management

It is important that executives of the PS attend the orifice test at the setting of the gas receiving flow meter (determined by the gas supplier) and examine the data. In addition, both the PS and gas supplier should decide beforehand the time interval and test method of checking for any changes regarding the gas. Gas composition is the main element of the gas which affects heat efficiency. To observe any changes of gas composition due to any changes of the gas supplier (e.g., gas is mined well) etc., the gas chromatography at the outlet side of the flow meter should be set, with continuous checking of gas composition.

(d) Efficiency management

Data required for heat efficiency management should be sent from the process computer to the computer for operation history management, and necessary LAN should be established so that heat efficiency can be controlled at the heat efficiency management workstation. Heat efficiency management, such as the individual operation of GTs, combined cycle operation and heat balance

checks, is assisted by the data from the documentation functions of the heat efficiency workstation, such as daily, monthly, quarterly and yearly reports.

(e) Management of water and lubricating oil which are used in the PS

To operate the PS stably, a large amount of water, lubricating oil, hydrogen gas and nitrogen gas will be used daily. In order to establish a medium- and long-term consumption plan, the amount, etc., of each of the following must be estimated: annual consumption of pure water, rate of HRSG makeup water, product name and amount of injected agent in HRSG feed water, resin amount for the manufacturing equipment of pure water, product name and amount of injected agent in HRSG boiler water, amount of cooling water of accessories, amount of GT/ST lubricating oil, amount of other lubricating oil for accessories, exchange amount of fire extinguisher agents, amount of hydrogen gas for cooling the electric generator/nitrogen gas for substitution, consumption of hydrogen gas during normal operation, and exchange amount of hydrogen gas in periodic inspections and maintenance.

(f) Coordination with Central Load Dispatch Center

PS operation shall basically follow the instructions of the central load dispatching center ("CLDC"). However, in the case of problems, etc., urgent decisions on whether or not to stop operation of the PS shall be made by the PS. Substation facilities within the PS premises shall also be used to transmit the generated power. Considering the above, the following points need to be discussed with CLDC and agreement must be reached in advance:

- Power output instruction procedures
- Types of information to be reported
- Power measurement methods
- Responsibility demarcation points for PS facilities
- Modes of discussion on regular inspection timing

4) Cause Analysis of Unscheduled Outage Trouble

Unplanned stoppage trouble occurs due to some sort of cause. It is important to definitely conduct cause analysis and take measures to remove the actual cause in order to avoid any re-occurrence of the trouble. Therefore, if any unplanned stoppage trouble occurs, even if it is only small-scale, it is important to definitely draft trouble documentation and accumulate the information as a database.

(a) Reference datasheet

As a reference, the following table shows the datasheet for analyzing unscheduled outages.

Table 8.5-2 Datasheet for Analyzing Unscheduled Outages

Item	Reference Data
1. Timing	At start, at stop, during operation (within 3 months after OH, three months passed)
2. Alarm which was generated	Trip alarm, serious trouble
3. Problem	Leak, break, breakage, damage, smoke, vibration, operation trouble, actuation trouble, malfunction, False feeling, removal of parts, ignition, deterioration
4. Direct cause	Improper design, improper quality control, improper skill, improper operation, inspection interval, lack of critical analysis
5. Indirect cause	Improper operating instructions, insufficient manual, insufficient check sheet, newly experienced event
6. Reason why timely response was impossible	Outside patrol range, outside of r inspection and maintenance range, impossible detection due to structural problems, impossible detection with five senses, actuation trouble of security device, delay of emergency stoppage operation
7. Preventive measures of reoccurrence	Emergency measures, permanent measures (repair equipment, reexamination of structure, reexamination of manual)

*If several items are applicable, list all of them.

(Source: JICA Study Team)

Table 8.5-3 Analysis Sheet of Unplanned Stoppage Trouble: Preventive Measures of Reoccurrence

#	Date	Time	Unit No	Operation Load MW	(1) Trips	(2) Alarm which was generated	(3) Problem	(4) Direct cause	(5) Indirect cause	(6) Reason why timely response was impossible	(7) Preventive measures of re-occurrence	Time of recovery work

(Source: JICA Study Team)

8.5.4 Reinforcement of Maintenance Implementation System

For the future implementation of O&M of the PS, it is recommended that EDM form relations with manufacturers, which have detailed know-how of technology, and that there be an optimal implementation system inside EDM.

(1) Evaluation of example case

Independent power Producer (“IPP”) case

In the case of Major Overhaul (“MOH”), in the periodic inspections and maintenance of GT, ST, generators and HRSG equipment, EDM requests the original manufacturer to dispatch instructors and examiners.

(2) Maintenance of combined cycle

The combined cycle consists of a GT which is operated with high-temperature combustion gas, HRSG, ST and a generator. From the viewpoint of the interval of periodic tests, the main part of the cycle is the GT, so it is practical to conduct the periodic tests of the HRSG, ST and generator when the GT is inspected.

In addition, there may be severe cracks, corrosion, oxidation, deformation and detachment of coating in the hot parts of the GT, such as the combustor, stationary blade, moving blade and impeller blade (shroud segment), etc. Therefore, the aging deterioration level is not estimated based on the total operation hours and number of start/stops which are adopted in the ST, but the time of periodic tests is estimated based on the equivalent operation hours ("EOH"). Based on EOH, deformation and high-temperature creep fatigue life in the time of start/stops, the number of load rejections, the number of trips, etc., are estimated and safety levels can be confirmed. Every GT manufacturer adopts this method.

In general, LTSAs are concluded between plant operators and suppliers.

The following schedule pattern has been developed: Minor inspections are repeated after every 8,000 hours of EOH after the commission date, the major inspection is conducted after 25,000 hours of EOH from the commission date, minor inspections repeated after every 8,000 hours thereafter, and an overhaul of the hot gas component is conducted after 50,000 hours of operation from the commission date.

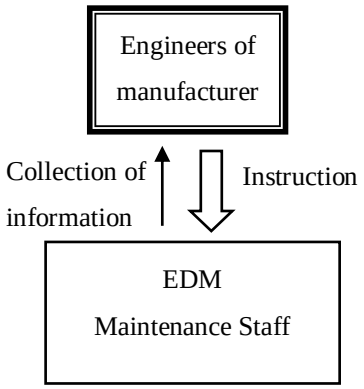
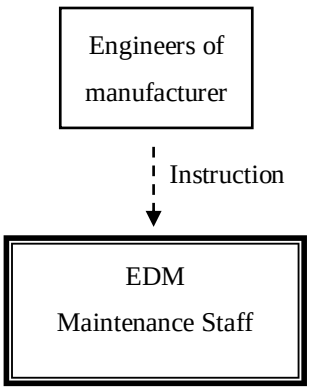
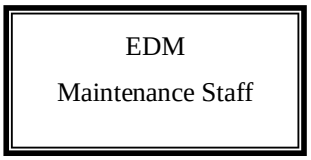
The contract period of LTSA is 6 years (approximately 50,000 hours of operation) because the cycle in which the parts that are removed and repaired in each minor inspection and the high-temperature parts that are replaced in the major inspection (after 25,000 hours operation) are replaced and reused in the overhaul of the hot gas component (after 50,000 hours operation). During the contract period of LTSA, the manufacturer supplies GT high-temperature parts and dispatches instructors for the disassembly, assembly and test operations to the site. In this case, the workers of the power plant conduct the maintenance operations under the supervision of the instructors from the manufacturer onsite.

After the LTSA expires, in general, under an LTPM agreement, the unit-price contract of high-temperature parts is concluded. For the repairs of GT after the 7th year from commissioning, if the workers of the power plant have gained experienced in the disassembly, assembly and test operations for 50,000 hours from the commission date and GT maintenance skills have been confirmed by EDM, then following the expiration of the LTSA, GT maintenance and quality are ensured by purchasing and stocking spare parts under an LTPM. Following this, if there is a request by the PS for the dispatch of an instructor from the manufacturer, the LTSA can be reviewed to include the dispatch of specified instructors.

(3) Direction of the Maintenance Implementation System in EDM

EDM has the management vision of "continuous development", and tries to develop human resources based on a long-term perspective. The direction of the maintenance implementation system in EDM is shown below.

Table 8.5-4 Direction of Maintenance Implementation System

Early Period (For 6 years after Commissioning)	Middle Period (7th to 12th Year)	Long Period (After 13th Year)
		
LTSA contract (6 years) will be concluded and the periodic checks during this period will mainly be conducted by the engineers from the manufacturer. The maintenance staff of EDM will try to improve their technical capabilities by collecting information.	Periodic checks will be mainly conducted by the maintenance staff of EDM. When necessary, the dispatch of engineers from the manufacturer can be requested for guidance.	Maintenance staff of EDM will conduct all periodic checks. The maintenance department of EDM is developed to SBU and periodic checks of other companies can be accepted and conducted, if possible, using the acquired technical ability.

(Source: JICA Study Team)

Although it is inevitable that instructors and inspectors from the manufacturer will be asked to conduct periodic checks in the early period (first and second checks), however the maintenance staff should take part in the checks, etc., and should try to acquire technological experience. The aim should be to establish a system in which periodic checks can be implemented by only the staff of EDM at the earliest possible stage. Technical capability should be improved to the level where periodic checks of other power plants can be undertaken by acquiring technical experience with the aim to receive requests from other power plants. The direction to be taken is the development of the maintenance department of EDM to SBU and the implementation of construction management by a group of professional engineers and technicians, and in this way the maintenance and improvement of equipment quality, elimination of injury and accidents and high levels of personal safety can be expected.

(4) Future Technological Levels Required in the Maintenance Department and How to Acquire Technology

To implement periodic checks using only PS staff, it is necessary to train technicians to have the same levels of technical knowledge as technical instructors, special inspectors (e.g., nondestructive test, remaining life assessment, etc.) and specialist labor (e.g., special processing and welding, low-alloy steel – Steel Use Stainless ("SUS") dissimilar metal joint welding, welding of large diameter pipes, annealing operation of welding area, etc.). The methods to acquire these technologies are as follows.

(a) General information

Basic technical skills should be gained mainly by the staff of the maintenance department who were trained in the assembly and test operation during the construction work, and who have accompanied the manufacturer's instructors during the LTSA period, learning the skills of disassembly, assembly and adjustment.

The set protocols are as follows: Document the source of acquired technology in the manufacturer's instruction book and add photographs if needed to clarify operational methods. At the same time, draft a memo about the technical information acquired onsite, and add it to the manual as needed to complement the manual. At the completion of the periodic checks and maintenance, check equipment, contents of checks, used equipment, check results data, make judgments (good or bad) based on the data, find any differences between planned man-hours and real man-hours and others factors that should be written in the construction report without any omissions. In addition, draft a report which includes the issues that should be reflected in the next periodic check (number of days of operation, used equipment, used measuring instruments and results of the introduced nondestructive test), including maintenance and parts that should be rechecked as soon as possible from the areas from the most recent periodic check. A system should be established by digitizing the report so that it can be searched at anytime by PS workers.

(b) Disassembly and assembly of GTs and STs

During the periodic checks conducted in the early period by the manufacturer's engineers, take videos and photographs of the operation of the disassembly and assembly of GTs and STs, collect necessary information and create a manual of disassembly and assembly procedures. In addition, another method of receiving training of disassembly and assembly of GTs and STs is at the training center of the manufacturer.

(c) Nondestructive test

For nondestructive tests, it is possible to gain engineer's knowledge in a short period by purchasing the inspection equipment and receiving training from foreign experts. During construction work, there are many checks using inspection equipment at the welding site, and thereby many chances to acquire knowledge and expertise. Another effective method for staff to acquire knowledge is by appointing staff who will be in charge of the inspection department in the future, and sending them to the site of the nondestructive tests.

For Ultrasonic Testing ("UT") inspections, besides using simple measuring instruments in which the measured results are displayed digitally, such as instruments for measuring the wall thickness of boiler tubes, angle beam techniques, use of plural sensing terminals in which inside flaws of materials can be evaluated, radiograph examinations, etc., are adopted. Currently, there are no experts in the country that can use this technology, and the country is completely dependent on overseas experts in relation to this technology. As a method used to judge the life of equipment, the photomicrography of metal

structures is also necessary technology to gain. A long- term vision is required for the future about how much diagnosis technology used in electric power facilities in the country will be developed.

(d) Specialist labor

It is not easy to train specialist labor such as special in-house welders. As a temporary measure, workers who have the qualifications and skills of specialist labor (e.g., special processing and welding, low-alloy steel – SUS dissimilar metal joint welding, welding of large diameter pipes, and annealing operations of welding areas, etc.) shall be contracted. If the maintenance department plans to develop to SBU with periodic checks of other companies to be undertaken, it is necessary to train engineers in EDM.

(5) Maintenance Methods in the Middle Period

To aim at effective maintenance management, daily maintenance (e.g., small-scale maintenance conducted during operation, e.g., tightening of leaks of valve glands, tightening of flange leaks, refilling lubricants, calibration of instruments, replacement of automatic control cards, etc.), and urgent responses are required to ensure the reliability of the electric power facilities, and the daily maintenance department of the power station should be able to adapt quickly.

Three months prior to the periodic check, the maintenance department should hold a joint conference with the operation department and the daily maintenance department. The maintenance department should explain the contents of the next periodic check and maintenance construction, obtaining agreement from the operation department and the daily maintenance department. Total agreement should be reflected in the program for the next periodic check and maintenance construction. Then, to avoid any oversights in the contents of construction, e.g., about areas whose standards of operating state deviates from the planned standards and frequent alarms, etc., the staff in charge of each field should report the current situation. In particular, all three departments should confirm the current situation of the following: untreated lapses of daily maintenance which were issued by the operation department of the PS, standards which are close to the limit standards judging from the operating state standards, e.g., vibration standards of rotating equipment, points where the metal temperatures of hot areas are close to the warning standards, and systems in which differential pressures between the front pressure gauges and the rear ones are large, etc.

One month prior to the periodic check, the three departments should hold another conference to conduct the final confirmation on whether there are any additional checks and maintenance required. The maintenance department should recheck ordered spare articles, parts which should be newly ordered, consumable supplies (e.g., general purpose articles such as gasket packing, sheet packing, valve gland packing, packing of pump shaft seal parts, etc., and special components) and confirm whether or not there are any omissions.

Furthermore, the status of the drafting and procedures of the construction schedule, worker deployment schedule, number of outsourced workers for each job, equipment for construction, nondestructive tests, equipment for special welding, etc., for each part, GT, ST, HRSG, generator and Instrumentation & Control ("I&C") should all be confirmed.

8.5.5 Reinforcement of Long-term Human Capital Development

(1) Development of Staff during the Construction Period

Before launching the construction work, the O&M leaders should be selected and trained on the side of the construction work. In that case, it is assumed that the terms of reference ("TOR") for employment in the loan consultant business, should include on the job training ("OJT") for human resources development. During the construction work, the structure of the equipment of the PS cannot be checked and only during the operation of the PS can it be learnt in detail. And, moreover, how to install equipment can be checked.

The O&M leaders shall collect data at each stage, such as the assembly of equipment, opening measuring methods in assembling and acceptable standards, sequence check before the single test after assembly, general security test, load test, etc., and take digital photographs of the areas of which they are in charge. The O&M leaders shall attach such photographs to the manufacturer's instruction books in order to visualize each stage. These instruction books are to be used for the training of O&M staff at the PS and OJT material of junior staff. The documentation and data from the period of the construction work should be stored on an OA server (such data and documentation should also be received in electronic form).

The contract system with the manufacturers has not been decided yet. Even if the full-turnkey system will be adopted, the PS shall prepare an electric generation preparation group, subject to manufacturer start-up, and receive OJT of practical operation. In particular, the sequence test shall provide the chance to check the circuit and functions, and not only the members of the electric generation preparation group but also those of the electricity group and I&C group in the repair department shall attend such sequence test.

In the unit testing of accessories, after conducting the inching test under the condition where coupling is separated, the unit testing after direct coupling shall be conducted. The record shall be stored on the OA server because the centering record in coupling shall become the pace of subsequent maintenance.

To promote automation, in many systems motor valves shall be used, and the records of setting positions of torque switch and limit switch shall be stored. It is necessary to accurately take over the know-how of the manufacturer because the full closed position in cold is different from that in warm.

The staff of the PS should attend all of the following: burning adjustment, start/ stop test, runback test, load control test, load rejection test, general test of the system, AC/ DC power-off test, and other tests which shall be conducted in the stage of the HRSG water pressure test and load test after unit testing of accessories. All data, drawings and other documentation relating to test plans, preparation measures for tests, command structures of tests, responsible persons for stopping of tests and the operation of fuel shutoff valve switches, shall be stored and used as reference in the security tests after subsequent MOH.

(2) Training System

The contents of training shall diff according to the academic background and experience of staff entering the company. For EDM staff, the following training items are required.

(a) Items for all new employees, mid-career workers and experienced persons

- Positioning and responsibility as a power company
- Operation principles of a power company
- System and basic knowledge of equipment of the PS (as all specifications of the plant are different, experienced persons should attend the training)
- Safety precautions of the PS

(b) Concrete training for new employees and mid-career workers

- Training of operation duties (College graduates: 1-3 weeks, Other staff: 3-5 weeks, Clerical staff:1 week)
- Operation duties and transfer duties in shift work, implementation of patrols (staff in charge of training - executive class of operation duties who are not included in the operation duty shifts the staff in charge of actual operations - OJT of staff on duty)
- Maintenance training (College graduates: 1-3 weeks, Other staff: 3-5 weeks)
- General maintenance (1 week)
- Training in each specialized field (3 weeks: New employees and mid-career workers shall be divided according to the department from which they graduated, such as machinery, electricity, and instrumentation, etc. In this training, OJT shall be conducted, and the drawings of manufacturers, instruction manuals and relevant manuals shall be used as text)
- During the training, OJT of equipment check patrols, repair technology and skills in the field of repair construction, handling of measuring instruments, and management of data, etc., shall be conducted.

(c) Training of O&M staff during construction work

As described in the preceding section, training of O&M staff during the construction work period can be established by deploying potential leaders who will become the key personnel of the operation department and maintenance department of the PS, after starting the operation of the PS, in order to learn required special technology. After launching of the operation, these staff will become the key instructors of the operation department and maintenance department of the PS, and shall teach

subordinates in OJT. Moreover, to improve the level of staff that shall play a central role, internships in relevant facilities inside and outside the company shall be carefully planned.

(d) Adoption of recognition system

It is optimal to set certain levels of acquiring technology to be linked to the wage standards. Measures should also be taken to avoid the loss of skilled staff who have acquired the required skills to IPP, whose wage standards are higher, by establishing a system in which staff who acquire the same level of skills as the technical instructors from manufacturers are given titles, like "Meister" in Germany, and an appropriate wage.

8.5.6 Reinforcement of Environment Management Planning and Monitoring

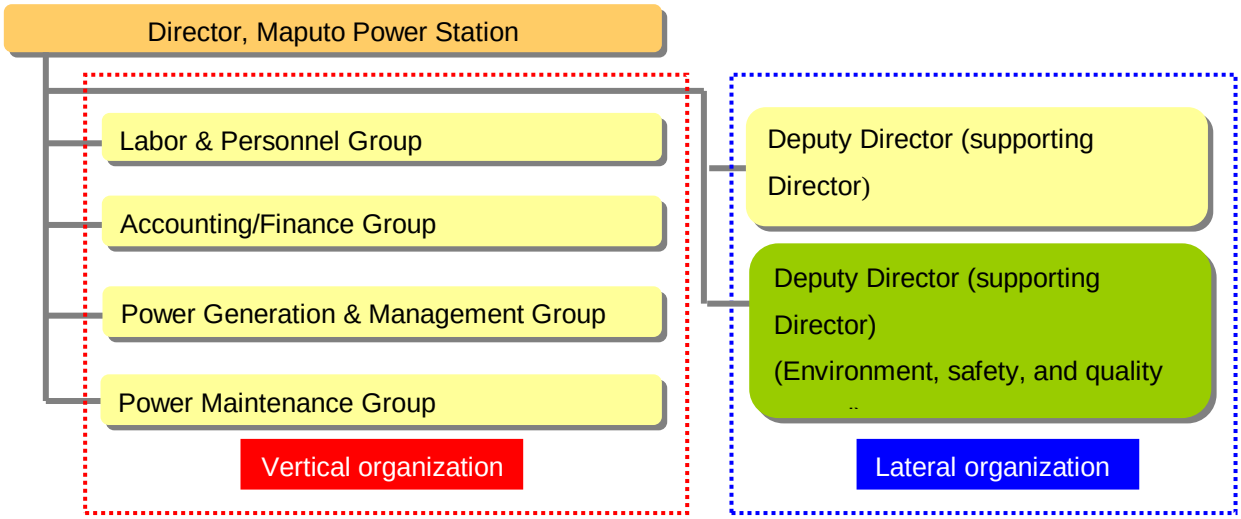
(1) Plant Level

1) Organizational framework

In parallel to the management level, a position of deputy director in charge of environment, safety, and quality control should be introduced within the organizational framework on the plant level, to actually collect and coordinate information in this area that exists in the organization.

2) Management structure

The aforementioned position is critical in playing an important role in gathering and analyzing environmental data through day-to-day operations, such as setting goals of the PS and assessing and reviewing performances. The position of deputy director will have complete responsibility in the immediate provision of information to the director and executive officers of the PS as well as to the Chief Officer in Charge of Environment at HQ.



(Source: JICA Study Team)

Figure 8.5-6 Environmental Management Systems (Plant Level)

3) Support measures

(a) Corporate ethics

The position of Chief Officer in Charge of Environment has acute responsibility in instilling corporate ethics in all employees through organizing training on the proper treatment and submission of all information in the correct manner, including environmental data, so that falsification of data does not occur within the PS's operation.

(b) Management of environmental monitoring

The important points in controlling information are summarized below:

- Operational administrative data on environmental preservation should be saved in the database so that data can always be submitted to outside organizations immediately upon request.
- In addition, measuring equipment for air quality conservation and water quality conservation facilities should be placed under strict control, so that they operates properly offering dependable management value.
- Related measuring equipment must be assessed every month at regular intervals and accurate performance should be confirmed.
- With respect to noise levels on the perimeter of the PS, stationary measurement points before operational start should be decided and noise levels during trial runs must be measured at all points.
- Stationary measurements must be carried out after the full-scale periodic inspection of the PS.
- Daily discharged water requires sample analysis per drain outlet once a month to ensure that management standards are maintained.
- In regards to emergency drainage, acceptable discharge standards must be inspected at the exit of drainage tanks before water discharge is commenced.
- The operational, measurement, and maintenance data of environmental facilities, as well as repair data for related measuring equipment, should be stored in the operational data processing computer system to record maintenance history.

(c) Preservation measures

The specific environmental preservation measures at the plant level are described below.

Table 8.5-5 Specific Environmental Preservation Measures

Issue	Measure
Air quality conservation	Low NOx burning appliances shall be used to prevent nitrogen oxide (denitration equipment will not be installed).

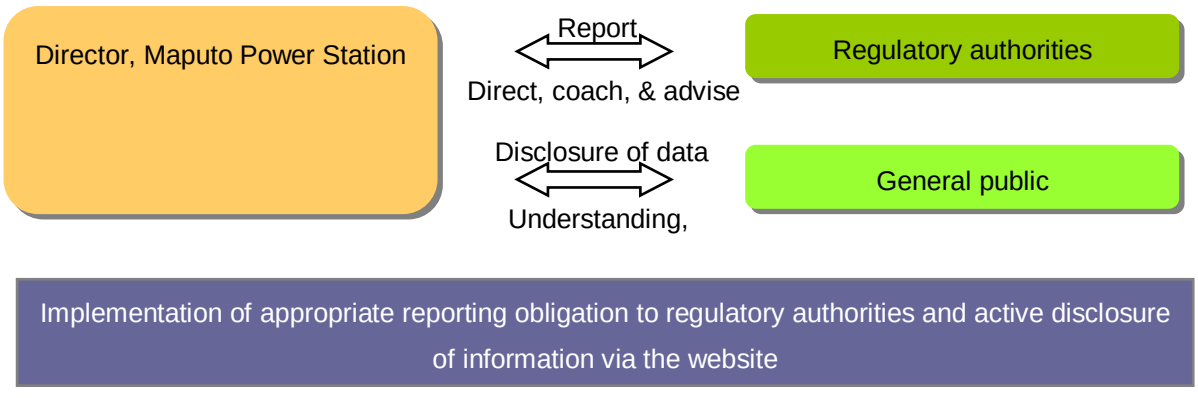
Issue	Measure
Water quality conservation	Environmental changes at points of water intake and discharge (basically, power facilities will be designed so that environmental changes in the rivers at discharge points shall not take place nor shall they occur regardless of the rainy and dry seasons) Compliance with water quality laws and regulations with respect to regular and emergency water discharge when the PS is in operation (periodic water quality inspections shall be implemented). Prevention of leakage of lubricants and fuel oils from the premises (installation of a shutoff valve at the very end of the drainage path).
Prevention of noise and vibration	Avoid installation of machinery and equipment which might be a main source of noise and vibration at the perimeter of the PS (stationary noise measurements shall be implemented continuously). HRSG drum safety valves shall be equipped with silencers.
Harmonious coexistence with local community	Scenic balance and greening (based on local opinions), regional scale activities by volunteer fire fighters

(Source: JICA Study Team)

(2) Public Level

1) Implementation of active information disclosure

Because of the industry characteristics of constructing power facilities in the region and supplying power to local residents, it is extremely important for the power industry to build a relationship of mutual trust with the stakeholders (including shareholders, business partners, and local community, etc.). In addition to implementing appropriate and responsible reporting to regulatory agencies, it is essential to build a relationship of mutual trust with local communities through active information disclosure of daily operations, environmental data, and immediate countermeasures against accidents to the stakeholders, including the general public, in annual reports or via the website.



(Source: JICA Study Team)

Figure 8.5-7 Environmental Management System (Public Level)

2) Harmonious coexistence with the local community

In regards to the site location for the PS, it is recommended to adopt the basic policies for environmental preservation by participating in community support building by constructing a popular

PS, making the PS open to the public, i.e., construction of a usable PS, and harmonizing with the local community with an expansive PS, and implement these policies in all areas of construction and operation.

In the construction of PSs, it is essential to preserve and create the natural environment by conserving the existing green spaces as much as possible and by planting trees onsite to coexist with the local community. The specific measures to achieve these goals are:

- Build a popular PS: By planting many trees onsite and aiming at developing a PS with a lot of greenery to contribute to the expansion of building a healthy and productive environment for the community as a whole, in cooperation with local residents.
- Build a usable PS: By creating green spaces, water features and opening a part of the premises as a community park, aimed at developing the PS to be used by the local community.
- Build a PS with an open atmosphere: Through making the inside of the PS open to the general public on a regular basis, therefore constructing a PS with an open atmosphere.
- In terms of coexistence with the local community, the promotion of positive employment from the local community for logistic works positions such as drivers, cleaners, and cooks, etc., is highly recommended.

Chapter 9

Project Cost

Chapter 9 Project Cost

9.1 Project Cost Estimate

The Project cost is composed of the following items:

- Eligible portion for ODA loan
  - Construction cost of new power plant (EPC cost)
  - Project management cost (cost for consulting service)
  - Cost of LTSA, training and spare parts
  - Interest during construction
- Non-eligible portion for ODA loan
  - Site preparation cost (removal of existing fuel tanks)
  - EDM's administration cost
  - VAT, withholding tax and custom duties

According to the above composition, the total Project cost is estimated based on the Project implementation schedule mentioned in Chapter 8.1.

Table 9.1-1 is the summary sheet of the total Project cost estimate.

As mentioned in other chapters of this report, the following items are considered as "not required for the Project," and are not included in the estimate:

- Landfilling at site against storm surges
- Marine construction of intake and discharge structures for cooling system
- Additional works for transformation and transmission system

The following rates are adopted in this estimate based on the survey results and recent project data in Mozambique:

- Price escalation Foreign portion: 2.1%
  Local portion: 4.6%
- Physical contingency: 5.0%
- Interest during construction: 0.01%
- Commitment charge: 0% (exempted)
- VAT: Conditions of VAT on this project will be finalized in the process of forthcoming consultations between Mozambique government and EDM. In this estimate, it is assumed that VAT (17%) would be imposed on 25% of EPC cost and the cost for removal of existing fuel tanks.
- Customs duty: It was confirmed by EDM that customs duties will be exempted for this project.

- Withholding tax: It was confirmed by EDM that withholding tax (20%) will be imposed on consultant service fees except for their expenses.
- Administration cost: 0.5% of the Project cost (confirmed by EDM)

The exchange rates used in this estimate are as follows:

- 1 USD = 91.04 JPY
- 1 MZN = 2.985 JPY

Table 9.1-1 Project Cost Estimate

No.	Item		Base Case CCGT in Single Phase Total	Foreign	Local
				[1,000 US$]	
	JICA Finance Portion				
A.	Power Plant Construction and Associated Works (EPC Cost)		124,171	90,220	33,951
A1.	Power Block		98,874	80,228	18,646
A2.	B.O.P.		4,698	3,812	886
A3.	Civil & Erection		20,598	6,179	14,419
B.	LTSA, Training and Spare Parts		18,403	18,403	
B1.	6-year LTSA Cost for Gas Turbine		13,040	13,040	
B2.	Training		1,098	1,098	
B3.	Spare Parts		4,265	4,265	
C.	Consulting Service		14,344	11,659	2,685
D.	Contingency		26,242	17,467	8,775
D1.	Price Contingency on A, B & C	F 2.1% / L 4.6%	17,520	10,907	6,612
D2.	Physical Contingency on A, B, C & D1	5.0%	8,722	6,559	2,162
E.	Interest During Construction	0.01%	145	145	
F.	Commitment Charge (exempted)	0.0%			
	Total of JICA Finance Portion (A~F)		183,305	137,894	45,410
	Non Eligible Portion				
G.	Land Preparation		833		833
G1.	Removal of Existing Fuel Tanks		725		725
G2.	Price Contingency	4.6%	68		68
G3.	Physical Contingency	5.0%	40		40
H.	Administration Cost	0.50%	920		920
	* 0.5% of A~D & G				
I.	Custom Duties, VAT and Withholding Tax		9,734		9,734
I1.	VAT on 25% of A, B, D & G (except contingency of C)	17.0%	7,125		7,125
I2.	Custom Duties on Foreign Portion of A, B, D & G (exempted)	0.0%	0		0
I3.	Withholding Tax on Consulting service fee except for expenses	20.0%	2,609		2,609
	Total of Non Eligible Portion (G~I)		11,487		11,487
	Grand Total (A~I)		194,791	137,894	56,897

(Source: JICA Study Team)

9.2 EPC Cost

9.2.1 Basis of EPC Cost Estimate

EPC cost is estimated using the software from the U.S., State of the Art Power Plant ("SOAPP") under the sponsorship of the Electric Power Research Institute ("EPRi") that was made for the conceptual design, costing and project financial analysis based on the latest database of international equipment prices and construction prices in the U.S.

9.2.2 Adjustment of Local Portion of EPC Cost

As mentioned above, the EPC cost is estimated based on the construction prices in the U.S. Therefore, the local portion of EPC cost should be adjusted based on the construction price difference between the U.S. and Mozambique.

According to interviews with construction companies based in Maputo, the construction prices in Mozambique are much higher than those in South Africa due to the following reasons:

- Dependence on Imported Materials
  Production of cement in Mozambique is recently increasing and ready-mixed concrete is locally available especially in Maputo city. However, other major materials for construction such as reinforcement bars, structural steel, finishing materials, mechanical and electrical equipment and temporary machinery and equipment are imported from South Africa and other countries.
- Dependence on Foreign Companies
  Since there are very few major domestic construction companies, large-scale construction works are mostly carried out by foreign construction companies from South Africa, Portugal, Brazil, etc. Furthermore, South African skilled workers are largely employed due to the lack of local skilled workers.
- Low Productivity
  Productivity of construction work is low in Mozambique due to the lack of local skilled workers and the poor work ethics of some workers.

In consideration of the above situation, the local portion of EPC cost will be adjusted by comparing the construction prices of the U.S., South Africa and Mozambique.
Table 9.2-1 shows the building cost rate comparison in African countries, and it corroborates the fact that the construction costs in Mozambique are much higher than those in South Africa. Civil work for power plants, which is one part of the local portion of EPC cost, is composed of more structural work and fewer finishing work, and this table shows that the South African

building cost for factories and car parks that should have similar composition of structural and finishing work is about 70% of the Mozambican cost.

Table 9.2-1 Africa Building Cost Rate Comparison

AFRICA BUILDING COST COMPARISON

Building type	Angola Luanda	Botswana Gaborone	Ghana Accra	Kenya Nairobi	Mozam-bique Maputo	Nigeria Abuja	Nigeria Lagos	Rwanda Kigali	Senegal Dakar	South Africa Johannes-burg	Tanzania Dar Es Salaam	Uganda Kampala	Zambia Lusaka
Residential (rate/m²)													
Average multi-unit high rise	1,490	1,050	900	505	1,100	1,450	1,400	960	790	940	870	820	1,200
Luxury unit high rise	2,430	1,610	1,450	650	1,500	2,250	2,200	1,550	1,240	1,640	1,390	1,290	2,000
Individual prestige houses (Detached houses & bungalows)	4,160	1,610	2,550	780	2,130	4,010	3,900	2,410	1,900	1,650	2,210	2,050	2,300
Commercial/Retail (rate/m²)													
Average standard offices high rise	1,630	1,370	900	460	1,250	1,530	1,490	990	810	1,250	930	850	1,250
Prestige offices high rise	2,810	1,730	1,480	910	1,440	4,790	4,700	1,650	1,320	1,600	1,500	1,390	2,000
Major shopping centre (CBD)	2,360	1,130	1,170	520	1,150	2,850	2,800	1,590	1,060	1,180	1,200	1,120	1,600
Industrial (rate/m²)													
Light duty factory	1,000	490	950	400	770	1,740	1,700	840	730	430	820	780	1,000
Heavy duty factory	1,330	1,640	1,560	540	1,150	2,320	2,280	1,040	1,170	600	1,350	1,260	1,300
Hotel (rate/key)													
3-Star budget	145,590	93,500	80,000	110,000	78,900	135,430	133,300	80,620	72,560	83,500	83,220	77,620	139,260
5-Star luxury (including spa)	580,000	334,100	330,000	170,000	260,000	554,100	552,5					314,470	573,430
Resort style (including spa)	702,190	376,520	390,000	200,000	358,800	789,930	697,000	445,900	367,040	275,000	405,910	404,920	409,590
Other (rate/m²)													
Multi-storey car park	1,390	690	700	400	500	770	750	810	680	460	740	670	640
Exchange rates (1 November 2010)	AOA	BWP	GHS	KES	MZN	NGN	NGN	RWF	XOF	ZAR	TZS	UGX	ZMK
USD – 1	92.27	7.00	1.45	77.28	35.60	149.52	149.52	595.00	479.54	7.00	1481.00	2315.00	4930.00

Prices exclude land, site works, professional fees, tenant fitout, equipment & VAT.
Hotel rates include an allowance for FF&E.

Ave. 67% of Mozambique Price

(Source: Africa Property and Construction Handbook 2011 by Davis Langdon)

Table 9.2-2 and Table 9.2-3 show building costs per square meter in South Africa and the U.S. They show that building costs in South Africa are generally lower than those in the U.S., and the building costs for factories and car parks in South Africa is about 70% of those in the U.S.

Table 9.2-2 Building Costs per square meter in South Africa

South Africa – international building costs per m² of internal area	2008 ZAR	2009 ZAR	2010 ZAR	2011 ZAR	2011 USD
Residential					
Detached house – medium standard	4,500	5,000	5,000	5,300	746
Detached house – prestige	8,000	9,000	9 000	9,500	1,338
Townhouse – medium standard	5,000	6,000	6,000	5,800	817
Apartments – private medium density	4,800	6,000	6,300	6,200	873
Apartments – high rise	7,000	7,500	7,500	7,500	1,056
Aged care/affordable units	5,000	5,500	5,500	5,500	775
Commercial					
Offices – business park	4,500	5,000	5,300	6,500	915
CBD offices up to 20 floors – medium	7,000	8,500	8,500	8,500	1,197
CBD offices – prestige	7,500	10,000	10,000	11,500	1,619
Warehouses					
Warehouse/factory unit – basic	3,700	3,700	3,700	3,800	535
Large warehouse distribution centre	3,900	3,900	3,900	4,000	563
High-tech factory/laboratory	4,500	6,000	6,300	6,000	845
Retail					
Large shopping centre including mall	5,500	7,800	7,800	8,000	1,127
Neighbourhood including supermarket	6,000	6,800	6,800	7,000	986
Prestige car showroom	6,200	7,000	7,000	7,500	1,056
Hotels					
Three-star travellers	5,500	8,000	8,400	8,600	1,211
Five-star luxury	7,000	10,000	10,500	10,500	1,479
Resort style	6,900	9,700	10,185	10,000	1,408
Hospitals					Ave. 69% of U.S. Price
Day centre	4,500	5,500	5,500	6,000	845
Regional hospital	6,000	7,000	7,000	7,500	1,056
General hospital	7,500	8,500	8,500	9,000	1,267
Schools					
Primary and secondary	4,500	5,000	5,000	7,000	986
University	5,000	6,000	6,000	9,000	1,267
Carparks					
Multistorey – above ground	3,200	3,500	4,000	3,800	535
Multistorey – below ground	3,500	4,000	4,800	4,500	634
Airports					
Airport terminal	20,000	20,900	20,900	20,900	2,943

(Source: International Construction Cost Survey 2012 by Turner & Townsend)

Table 9.2-3 Building Cost per square meter in the U.S.

US – international building costs per m² of internal area	2008 USD	2009 USD	2010 USD	2011 USD
Residential				
Detached house – medium standard	1,570	1,475	1,435	1,495
Detached house – prestige	1,925	1,750	1,710	1,800
Townhouse – medium standard	1,475	1,330	1,300	1,350
Apartments – private medium density	1,420	1,590	1,520	1,600
Apartments – high rise	2,075	2,045	2,020	2,100
Aged care/affordable units	1,300	1,400	1,420	1,550
Commercial				
Offices – business park	1,600	1,905	1,850	1,885
CBD offices up to 20 floors – medium	2,215	2,150	2,085	2,140
CBD offices – prestige	2,610	2,505	2,440	2,520
Warehouses				
Warehouse/factory unit – basic	750	850	840	860
Large warehouse distribution centre	915	990	1,100	1,140
High-tech factory/laboratory	1,520	1,615	1,700	1,785
Retail				
Large shopping centre including mall	1,580	1,600	1,500	1,560
Neighbourhood including supermarket	860	900	840	910
Prestige car showroom	1,425	1,390	1,325	1,380
Hotels				
Three-star travellers	1,485	1,580	1,525	1,575
Five-star luxury	2,680	2,720	2,550	2,600
Resort style	2,420	2,630	2,250	2,300
Hospitals				
Day centre	1,645	1,765	2,045	2,055
Regional hospital	3,100	3,210	3,290	3,340
General hospital	3,000	3,110	3,260	3,300
Schools				
Primary and secondary	1,450	1,510	1,495	1,570
University	2,160	2,240	2,150	2,200
Carparks				
Multistorey – above ground	700	730	690	700
Multistorey – below ground	1,325	1,395	1,295	1,315
Airports				
Airport terminal	3,650	3,525	3,425	3,550

(Source: International Construction Cost Survey 2012 by Turner & Townsend)

In consideration of the above, it is assumed that,

Mozambican Construction Cost ("C.C") x 70 ≒ South African C.C ≒ U.S. C.C. x 70%
∴Mozambican C.C ≒ U.S. C.C.

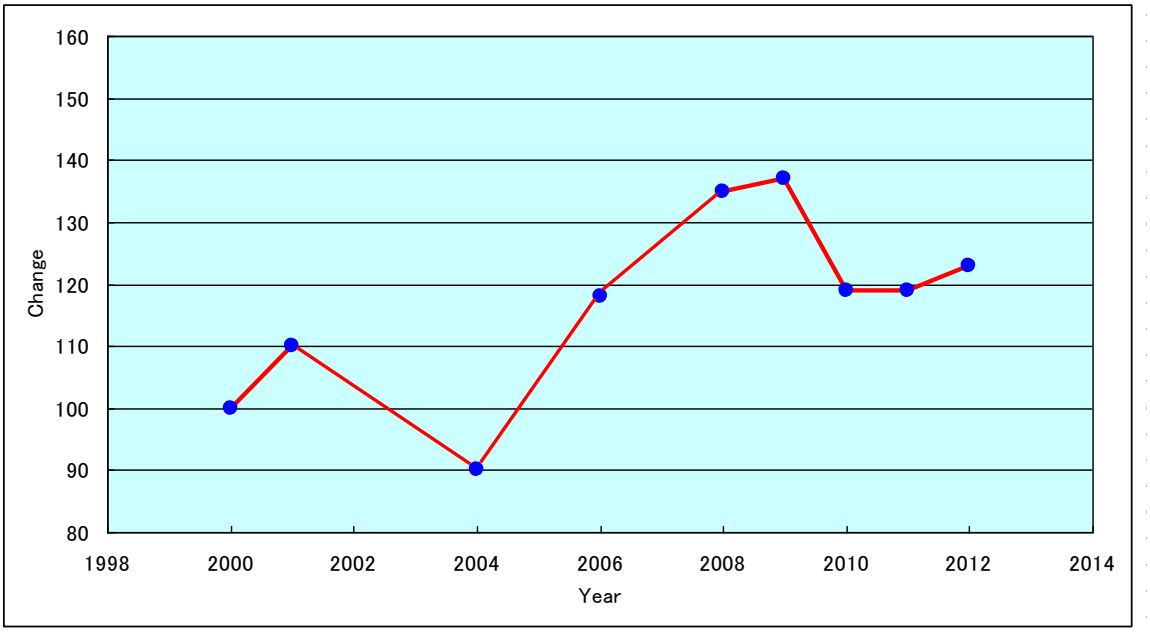
Therefore, the local portion of EPC cost estimated based on the construction prices in the U.S. need not be adjusted for the Project in Mozambique.

9.3 Validity of the Project Cost

9.3.1 Price Trends of Combined Cycle Power Facilities

Since a GT, which is the main equipment of this project, is produced by using rare metals such as nickel, chrome, and cobalt as its main materials, the production costs of GT have substantially increased due to the price rise of these rare metals and other steel materials. In addition, demand for the high-efficiency CCGT was at a level higher than supply because of ballooning energy prices, which was one of the causes that is pushing up the price of the CCGT. This price hike continued until the financial crisis triggered by the Lehman Brothers bankruptcy in 2008. After that, however, the price of GTs fell. Nevertheless, it has been moderately increasing as demand for power is increasing in emerging and developing nations, and the CCGT price has also been going up in concert with the GT price.

The following chart illustrates the movements of the combined cycle power facility price. The price sharply rose from 2004 to about 1.66 times over the next 3 years or an annual rate of about 18%. It fell once in 2009 after the economic crisis in 2008 and has been gradually increasing ever since.



(Source: Gas Turbine World 2012 GTW Handbook)

Figure 9.3-1 Price Trends of Combined Cycle Power Facilities

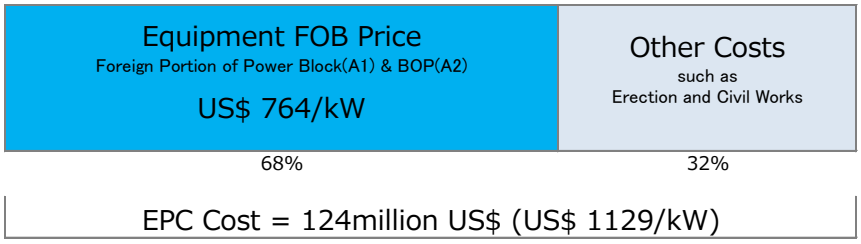
In this survey, it is estimated that the environment surrounding the CCGT market may change according to the world situation, however the CCGT price has regained its stability.

9.3.2 Appropriateness of Project Cost

To ascertain the appropriateness of the power plant construction cost of this project, the working budget of project A (total output: 80 MW, 2 blocks of multi-shaft 1-on-1 CCGT), which was supplied with a yen loan in 2005 and was in a scale equivalent to this project, and the contracted amount of EPC construction, were compared for this study. Project A was to add two blocks of multi-shaft 1-on-1CCGT, which employed a CCGT (H25) of Hitachi, Ltd. Hitachi tendered for this project in 2008 and concluded an EPC construction contract in November 2011.

According to the GTW Handbook, the higher the capacity of the CCGT, the lower the construction price per kW. However, the construction cost per kW of Project A (USD 1,250/kW) was about the same as other large-scale CCGTs. On the other hand, the estimated construction cost per kW of this Project is calculated at USD 1,129/kW (≒124.171 million US$ ÷ 110MW). This value is within the range of the project cost of Project A as well as other CCGT projects, and it is considered that the cost estimate of this Project is appropriate.

Further, the proportion of equipment free on board ("FOB") price in the EPC cost is estimated as below, and this proportion is considered as appropriate according to the previous experiences of the JICA Study Team.



(Source: JICA Study Team)

Figure 9.3-2 Proportion of Equipment FOB Price in EPC Cost

Table 9.3-1 List of Contracted Amount of EPC Construction

Plant Name	Location	Owner	EPC Contractor	Nominal Rating (MW)	Type of GT	Configuration	Number of Unit	Month/Year of News	Contract Price (Estimated Cost)	Price per kW	Remarks
	Sigapore Jurong Island	GMR Energy	Siemens-Samsung Consortium	800	SGT5-4000F	1- on - 1	2	Sept-Oct/2011	1,000 MMUS$	1,250 US$	Re-gasified LNG plant
Moxie Liberty Generation Plant	Bradford County Pennsylvania	Moxie Energy		700			1	Sept-Oct/2011	800 MMUS$	1,143 US$	
Moxie Patriot Generation Plant	Lycoming County Pennsylvania	Moxie Energy		700			1	Sept-Oct/2011	800 MMUS$	1,143 US$	
Cane Island Unit 4	Intercession City Florida	Florida Municipal power and Kissimmee Utility Authority		300	PG7241FA	1- on - 1	1	Sept-Oct/2011	479 MMUS$	1,597 US$	Evaporative cooler SCR
Bear Garden CCS	Buckingham Coutry Virginia	Dominion Virginia Power		580	7FA	2 - on - 1	1	Sept-Oct/2011	619 MMUS$	1,067 US$	Duct fired HRSG ST 220MW
	Cairo Egypt	Cairo Electricity Production	Ansald Energia	600	AE94.2	Simple cycle	4	May-June/2011	245 MMEuro	408 €	
L.V. Sutton Energy Complex	Wilmington, North Carolina	Progress Energy		620			1	May-June/2011	600 MMUS$	968 US$	
	Central Iraq	Iraq Electricity	Hyundai Heavy Industry	500		Simple cycle		May-June/2012	158.9 MMUS$	318 US$	
	Dangjin, South Korea		GS Electric and Power Services	410	SGT6-8000H	1 - on - 1	1	May-June/2013	420 MMUS$	1,024 US$	
Keramasan Thermal Power Station	Keramasan Indonesia	PLN	Marubeni	80	H-25	1- on - 1	2	Nov. /2011	100 MMUS$	1,250 US$	

(Source: JICA Study Team)

9.4 Engineering Services

After the signing of the engineering service contract with EDM, the consultant will carry out the following work in coordination with EDM.

- Selection of EPC Contractor
- Supervision of EPC Contractor's activities such as design, manufacturing, transportation, installation, construction, commissioning and testing
- Supervision during Defect Liability Period ("DLP")

The following experts are needed to execute the work mentioned above.

9.4.1 Foreign Consultant

1. Project Manager
2. Plant Design Engineer
3. Mechanical Engineer (Gas Turbine)
4. Mechanical Engineer (Steam Turbine)
5. Mechanical Engineer (HRSG)
6. Mechanical Engineer (BOP)
7. Electrical Engineer
8. I & C Engineer
9. Civil Engineer
10. Contract Engineer
11. Environmental Engineer
12. HIV/AIDS Consultant

9.4.2 Local Consultant

1. Deputy Project Manager
2. Plant Design Engineer
3. Mechanical Engineer (Gas Turbine)
4. Mechanical Engineer (Steam Turbine)
5. Mechanical Engineer (HRSG)
6. Mechanical Engineer (BOP)
7. Electrical Engineer
8. I & C Engineer
9. Civil Engineer
10. Environmental Engineer
11. HIV/AIDS Consultant

Terms of Reference for Engineering Consultancy Services and Project Management

Cost (PMC) are attached in Appendix.

9.5 Operation and Maintenance Costs

9.5.1 Operation and Maintenance

A combined cycle consists of a GT operating with high-temperature combustion gas, HRSG, and a ST power generator, and the GT is essential from the viewpoint of regular inspection intervals;, i.e., when the GT is inspected, regular inspections for the ST power generator and HRSG are realistically combined together. In addition, since cracks, corrosion, oxidation, deformation, or coating exfoliation of high-temperature parts (e.g., combustor, stationary blade, dynamic blade, blade ring (shroud segment)) for the GT can be severe, the EOH is used to recommend inspection times (total number of operation hours and total number of stops (which are used by the ST) are not used to presume the aged deterioration level). Costs used for operation and maintenance considered for this project are as follows:

- LTSA: Expense and assumption before operation start of each period (included in loan)
- Maintenance fixed cost (e.g., labor costs and regular inspection costs)
- Fluctuating maintenance costs (e.g., oils and fats, chemicals)
- Training costs
- Spare costs

9.5.2 Examination of LTSA

The main facilities of CCGT are the GT, HRSG, and ST. In general, the failure ratio of the GT is the highest and maintenance levels of the GT have a great influence on the operation ratio of the entire plant.

The high-temperature parts of the GT, such as the combustor and turbine blades, operate while being exposed to high-temperature gas of 1,000 degrees or more. Therefore, deterioration and damage of the GT are more severe than the blades of the ST, i.e., inspection, repair, and replacement are required at short intervals. Therefore, the expected life of these high-temperature parts is set by manufacturers for each type. Normally, inspection, repair, and replacement are required at proper maintenance intervals until the life expectancy is reached. Three types of inspections for the GT are generally done at the equivalent operating hour as shown in Table 9.5-2.

Table 9.5-1 Inspection Interval by Type (Example)

Type of Inspection	Inspection Interval/ EOH
Combustor Inspection	8,000 hr
Turbine Inspection	16,000 hr
Major Inspection	48,000 hr

(Source: JICA Study Team)

Since the high-temperature parts are a superalloy using nickel and cobalt as the base, special technology, such as welding and coating, and special facilities are required to repair these parts. Therefore, most users request the GT manufacturer or other repair company to repair them.

(1) Characteristics of GT long-term maintenance contract

Since high-temperature parts require regular inspections, repairs, and replacements at relatively short intervals as described above, GE and other GT manufacturers have contracts (i.e., LTSAs) which supply such regular inspections, repairs and replacements in a lump for a certain period, which has become mainstream. Since the contract period up to a major inspection is generally considered to be one cycle, contracts for 6 or 12 years are common.

The table below summarizes the characteristics of LTSAs. For technical characteristics, a user understands operation time, number of starts/ stops, and number of emergency stops and manages the necessary range and times for inspections, repairs, and replacements of high-temperature parts, and under the LTSA the supplier is allowed to do so. In addition, since the remote monitoring system is planned to be introduced to realize the services, the operation status of the PS can be monitored in real time at the supplier's remote monitoring center. Therefore, a combination of dispatching the stationed engineer and using the remote monitoring system allows any trouble to be monitored and countermeasures to be taken rapidly, i.e., contributing to improvement of the operation ratio. Therefore, under the LTSA the supplier optionally executes the business concerning monitoring and maintenance of the GT operation status, therefore the operation ratio can be additionally ensured.

Another large characteristic is the package price for inspections, repairs, and replacements of the high-temperature parts. Under the LTSA the package price is equal to or less than the total costs when a user individually executes inspections, repairs, and replacements, and it is therefore attractive when additional services are considered. In addition, since the cost of the LTSA is decided at the time of the contract, users can avoid unexpected risks for repairs and replacements of high-temperature parts.

In addition, if a user individually repairs or replaces high-temperature parts, over the years there is great fluctuation of the costs regarding whether or not a large amount of high-temperature parts should be replaced (e.g., approximately USD 1 million for one LM6000GT), i.e., management of a small-scaled company such as IPP would be greatly affected. In contrast, an LTSA allows the cost payments to be leveled because of paying a set price each month, therefore management can be stabilized.

Table 9.5-2 Characteristics of LTSAs

	LTSA	Individual Order
Management of inspections, repairs, replacements for high-temperature parts	Package management by supplier	Management by user
Operation status monitoring for GTs	Remote monitoring by supplier Contributing to improved operation ratio	Monitoring only by user
Stationed engineer	Yes	No
Ensured operation ratio	Yes (option)	No
Payment of inspections, repairs, replacement costs for high-temperature parts	Package price and payment of a set price each month The same level or less than total price of individual ordering Supplier is charged for unexpected repairs and replacements (excluding the case of user responsibility)	Payment of price corresponding to repairs and replacements for each inspection User is charged for unexpected repairs and replacements

(Source: JICA Study Team)

(2) Introduction of an LTSA into this Project

CTM Maputo CCGT will be the first CCGT using GT in Mozambique. Therefore, an LTSA is considered to be a necessary service for CCGT stable operation in technical support. In addition, an LTSA is economically advantageous compared to individual orders and therefore management can be stabilized by leveling cost payments, greatly contributing to ensuring stable profit of EDM.

As described above, since an LTSA would greatly contribute to the stabilization of the PS operation and company management, it is a welcomed process from the viewpoint of fund supply. Therefore, this investigation recommends that an LTSA to be a target of this project.

Chapter 10

Financial and Economic Analyses

Chapter 10 Financial and Economic Analyses

10.1 Effectiveness of the Project

Recent discoveries of gas and coal in the central and northern areas have significantly increased the level of economic activity in the country. In particular, the capital city of Maputo, where the Project is located, has been economically booming because it is the major gateway of foreign investments to the country. As a result, the power demand of the Southern System, where Maputo is situated, has been increasing considerably. There are ceaseless requests for new connections by both businesses and households. Power demand of the Southern System dominates two-thirds of the country and there are a number of proposals for both industrial and housing developments outside Maputo, the implementation of which are subject to the availability of power for new connections. Therefore, sustainable power supply is the key to the sustainable economic growth of Mozambique.

As mentioned in Chapter 2.3, power supply in the Southern System is in a critical state and will remain insufficient until the completion of the STE project that will connect the Southern System and Mid/Northern System. The project is scheduled to begin operation in the early 2020s; however, it might be delayed because the scale of the project is very large and multiple stakeholders are involved. Therefore, this new power plant Project located in the CTM site to be implemented within several years will be quite effective in overcoming this critical situation.

On the other hand, according to the master plan for power source development, EDM has another scenario for purchasing power from Aggreko to reduce the gaps in power supply.

In the case of "Without the Project," it is assumed that EDM needs an alternative power supply as follows:

- From SASOL/EDM and Gigawatt for base and middle load
- From Aggreko for peak and middle load

All these capacities are based on gas engines because no water is available at Ressano Garcia. Aggreko uses mobile-type gas engines that are known to be expensive. Thus, they will be merely a temporary solution. Any further shortage of power supply will need to be met by purchase from ESKOM of the South African Power Pool (SAPP), which is already a current practice. Conversely, the Project, which is based on CCGT, is expected to supply power at a much lower cost than the other alternatives.

The Project also has a few advantages derived from its location. Firstly, it is located at an old power plant site; therefore, no major additional cost will be basically required for the

transmission system. Secondly, because it is located just outside of Maputo, the demand center of the Southern System, the transmission loss of the Project is projected to be much lower than that of other existing and planned power sources. The Project is desirable in terms of lowering the overall transmission loss and increasing the system stability. Thirdly, in the case of "With the Project," investment in a part of the transmission system around Maputo could be postponed by at least one year.

In consideration of the above, the effectiveness of the Project is to be as follows:

- Contribution to the sustainable economic growth
- Lower power generation cost
- More power supply due to less transmission loss
- Saving by postponement of investment to transmission system

10.2 Financial Situation of EDM

We examine and analyze the financial soundness of EDM on the basis of their financial statements. As indicated in Table 10.2-1, sales of EDM have doubled from 3.2 billion MZN in 2006 to 6.4 billion MZN in 2010. Accordingly, the balance sheet had rapidly expanded.

Table 10.2-1 Financial Statements and Indicators

(Unit: 1,000 MZN)

Profit & Loss					
	2010	**2009**	**2008**	**2007**	**2006**
Sales	6,414,321	5,295,179	4,596,005	3,933,644	3,228,556
Profit before Tax	105,924	72,829	27,776	139,970	-34,714
Net Profit	-64,156	13,762	27,776	4,388	-70,182
Balance Sheet					
Total Fixed Assets	18,834,825	15,183,370	13,034,113	11,352,355	9,479,121
Equity	7,457,035	7,257,328	5,830,847	4,401,194	4,393,897
Capital Employed	16,364,841	14,007,460	10,747,539	9,205,345	8,274,968

Financial Indicators					
Profitability Ratios	**2010**	**2009**	**2008**	**2007**	**2006**
Pre-tax Profit Margin (%)	1.65%	1.38%	0.60%	3.56%	-1.08%
Return on Sales (%)	-1.00%	0.26%	0.60%	0.11%	-2.17%
Return on Total Assets (%)	-0.86%	0.19%	0.48%	0.10%	-1.60%
Return on Capital (%)	-1.04%	0.24%	0.92%	0.15%	-2.33%
Return on Investment (%)	2.38%	0.34%	1.47%	1.24%	1.55%
Liquidity Ratios					
Quick Ratio (Acid Test) (%)	120%	166%	105%	93%	110%
Current Ratio (%)	140%	196%	127%	116%	135%
Return on Equity (%)	1.40%	-4.00%			
Collection Rate (%)	97%	97%	96%	95%	95%

(Source JICA Study Team)

10.2.1 Profitability

The pre-tax profit margins were negative in 2006. After that, they showed a slightly positive percentage during the period from 2007 to 2010. The ratios of return on assets and return on capital during the period from 2006 to 2010 were negative or close to zero in value. Hence, it can be said that the profitability of EMD is not high. The profitability is expected to improve by a review and increase in electricity sales price or a reduction in operation cost in the future.

10.2.2 Debt Service Capacity

The quick ratio during the period of 2006 to 2010 except for 2007 had basically surpassed 100%. In this instance, EDM is capable of securing the funds on hand, even if EDM services all the current liability by utilizing quick assets. Accordingly, the debt service capacity for the short-term of EDM is not significantly worrying. The collection rates of receivables have been improved and such rates in 2009 and 2010 reached 97%. As a payment method, a prepaid system has been introduced. Consumers choosing the prepaid system account for 81% (2011) of the total number of consumers. The difficulty in financial situation of EDM is that the debt payable on the borrowed capital is rapidly expanding, while there are almost no profits. Given that this situation will continue in the future, it is a possibility that EDM's financial situation and the debt service capacity will deteriorate. EDM has carried out a study to revise and possibly raise current electricity prices. The profitability is expected to improve through this review and an increase in electricity sales price or the reduction in operation cost in the future.

10.3 Financial Analysis of the Project

In this section, we project the cash flow and examine the financial viability of the Project.

10.3.1 Key Assumptions Used for Financial Analysis

Key assumptions employed in the financial assessment of the Project are as follows:

(1) Major Economic Indices

Mozambique has achieved remarkable growth in its economy over the last decade at an average annual rate of 7.2 percent. The economy is expected to grow steadily at 7.5 percent and 7.9 percent in 2012 and 2013 respectively due to continuous inflows of foreign direct investment as well as strong growth of the agriculture sector and infrastructure investment[1].

Since December 2010, the inflation rate measured by the consumer price index steadily declined from over 16 percent to less than 2 percent in May 2012, as exhibited in Table 10.3-1.

[1] 2012 African Economic Outlook, available at http://www.africaneconomicoutlook.org/en/countries/southern-africa/mozambique/

Table 10.3-1 Changes in Consumer-Price Inflation (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Moving average
2009	6.53	4.36	5.15	4.38	3.05	2.65	2.42	1.12	1.37	1.43	2.55	4.22	3.27
2010	5.06	6.84	7.13	9.09	12.70	14.51	16.11	17.07	16.80	15.52	15.06	16.62	12.71
2011	16.51	16.00	14.73	13.04	11.36	9.28	7.67	7.86	7.80	8.34	7.74	5.46	10.48
2012	4.26	2.48	2.71	2.54	1.62	1.63	1.47	1.07	1.23	na	na	na	3.31

(Source: Central Bank of Mozambique)

Note: na: not available.

As Table 10.3-2 indicates, the exchange rate between the Mozambican Metrical and US dollar is relatively stable, while the Metrical has lost its value against the US dollar by 18 percent in the last six years or 2.8 percent per annum.

Table 10.3-2 Changes in the Average Annual Exchange Rate between Metical and USD

Year	2006	2007	2008	2009	2010	2011	2012
Metical/USD	24.99	25.56	24.17	26.71	32.98	29.06	29.50

Note: The figure for 2012 is the rate as of 3 November 2012.
(Source: Central Bank of Mozambique (except 2012))

In our analysis, we assume the following inflation and exchange rates, which will be applied to the-end-of-2012-price base costs of the Project:

- Price escalation for the foreign currency components: 2.1 percent per annum
- Price escalation for the domestic currency components: 4.6 percent per annum
- Exchange rate: 30.5 MTn (constant until and during the initial investment period)

(2) Project Configuration

Under the Project, the country's first combined cycle gas turbine (CCGT) power station will be built and operated. The Project will be implemented, installing two gas turbine units and one steam turbine unit. The total installed generation capacity will be in the range of 70 MW to 110 MW.

In this feasibility study, we assume that the total installed generation capacity will be 110 MW (40 MW x 2 & 30 MW x 1). These three units will become fully operational in June 2018.

(3) Initial Investment Costs

As described earlier in this report, the total base cost of the Project (in 2012 year-end prices) is estimated at approximately US$ 159 million. With physical and price contingencies, VAT and withholding tax, the total initial investment cost (excluding IDC) is estimated at approximately US$ 194 million. The Project is expected to be exempted from import duties. Table 10.3-5 shows the estimate of initial investment costs. The disbursement schedule of the EPC cost

(excluding O&M training, initial stock of spare parts and LTSA (long-term service agreement)) is assumed as follows:

Table 10.3-3 Cost among the Years of Construction

	1st year of construction	2nd year of construction	3rd year of construction	4th year of construction
	3%	36%	48%	13%

(Source JICA Study Team)

Table 10.3-4 Cost among Foreign and Local Currency Components:

	Foreign currency components	Local currency components
Power block	80%	20%
Balance of plant	80%	20%
Civil and erection	30%	70%

(Source JICA Study Team)

Table 10.3-5 Initial Investment Costs

No.	Item		Base Case CCGT in Single Phase			Base Case CCGT in Single Phase			
			Total	Foreign	Local	Total	Foreign	Local	
			[1,000 US$]			[MJPY]			[MMZN]
	JICA Finance Portion								
A.	Power Plant Construction and Associated Works (EPC Cost)		124,171	90,220	33,951	11,305	8,214	3,091	1,035
A1.	Power Block		98,874	80,228	18,646	9,002	7,304	1,698	569
A2.	B.O.P.		4,698	3,812	886	428	347	81	27
A3.	Civil & Erection		20,598	6,179	14,419	1,875	563	1,313	440
B.	LTSA, Training and Spare Parts		18,403	18,403		1,675	1,675		
B1.	6-year LTSA Cost for Gas Turbine		13,040	13,040		1,187	1,187		
B2.	Training		1,098	1,098		100	100		
B3.	Spare Parts		4,265	4,265		388	388		
C.	Consulting Service		14,344	11,659	2,685	1,306	1,061	244	82
D.	Contingency		26,242	17,467	8,775	2,389	1,590	799	268
D1.	Price Contingency on A, B & C	F 2.1% / L 4.6%	17,520	10,907	6,612	1,595	993	602	202
D2.	Physical Contingency on A, B, C & D1	5.0%	8,722	6,559	2,162	794	597	197	66
E.	Interest During Construction	0.01%	145	145		13	13		
F.	Commitment Charge (exempted)	0.0%							
	Total of JICA Finance Portion (A~F)		183,305	137,894	45,410	16,688	12,554	4,134	1,385
	Non Eligible Portion								
G.	Land Preparation		833		833	76		76	25
G1.	Removal of Existing Fuel Tanks		725		725	66		66	22
G2.	Price Contingency	4.6%	68		68	6		6	2
G3.	Physical Contingency	5.0%	40		40	4		4	1
H.	Administration Cost	0.50%	920		920	84		84	28
	* 0.5% of A~D & G								
I.	Custom Duties, VAT and Withholding Tax		9,734		9,734	886		886	297
I1.	VAT on 25% of A, B, D & G (except contingency of C)	17.0%	7,125		7,125	649		649	217
I2.	Custom Duties on Foreign Portion of A, B, D & G (exempted)	0.0%	0		0	0		0	0
I3.	Withholding Tax on Consulting service fee except for expenses	20.0%	2,609		2,609	237		237	80
	Total of Non Eligible Portion (G~I)		11,487		11,487	1,046		1,046	350
	Grand Total (A~I)		194,791	137,894	56,897	17,734	12,554	5,180	1,735

(Source: JICA Study Team)

(4) Financing

It is assumed that 10 percent of the total initial investment cost including IDC will be financed with equity from EDM and the remaining 90 percent, with a yen-denominated soft loan[2] from JICA with the conditions given below:

(a) Yen-denominated soft loan

- Interest rate: 0.01 percent per annum
- Repayment period: 40 years including 10-year grace period

  (The grace period starts in the year of the first disbursement of the loan.)

(b) Loan to EDM from a local commercial bank

- Interest rate: 12 percent per annum
- Repayment period: 9 years

(5) Electricity Price

(a) Average sales price

The average sales price of electricity increased from 2.44 MTn/kWh in 2009 to 2.76 MTn/kWh in 2011. However, because of high inflation rates during the same period, the real sales price of electricity in fact decreased. As the inflationary pressure decreases, the price of electricity, which incidentally has become increasingly lower than that in South Africa for the last few years, could be raised more than currently planned. Table 10.3-6 exhibits recent and planned average sales prices in MTn and USD. In our study, we assume that 3.30 MTn/kWh or 11.8 US cents/kWh for the projected price for 2014 is assumed for the entire duration of the Project.

Table 10.3-6 Average Electricity Sales Price Analysis

Year	2009	2010	2011	2012	2013	2014
1. Average sales price (MTn/kWh)	2.44	2.53	2.76	2.84	3.11	3.30
2. Change from previous year (MTn)		0.09	0.23	0.08	0.27	0.19
3. Change in percentage		3.7%	9.1%	2.9%	9.5%	6.1%
4. Inflation	3.3%	12.7%	10.5%	3.3%	4.6%	4.6%
5. Real change		-9.0%	-1.4%	-0.4%	4.9%	1.5%
6. USD exchange rate (MTn)	26.71	32.98	29.06	29.50	27.90	27.90
7. Average Sales Price (USD/kWh)		0.077	0.095	0.096	0.111	0.118

(Source: Average sales prices are from EDM. The inflation and exchange rates for 2013 and 2014 are discussed earlier in this section.)

(b) Income from electricity generation

[2] The exchange rate between yen and USD assumed is 91.04 JPY/USD.

It is assumed that the above-mentioned sales price is composed of the costs for electricity generation, transmission and distribution, consumers' related costs and margins. Therefore, the income of the Project is basically a value multiplying the volume of electricity supplying to grids by the following unit value.

The unit of income from generation = (average sales price) – (long-run marginal cost of the costs for electricity generation, transmission and distribution and consumers' related costs) – (margin).

A total of the long-run marginal cost including the costs for electricity generation, transmission and distribution, consumers' related costs and margin is assumed at 20 percent of the average sales price in this study. Hence, it is assumed that the income price from electricity generation is 2.64 MTn/kWh or 9.44 USc/kWh.

(6) O&M Costs

Operating expenditures include the cost of fuels (gas), operation and maintenance costs and insurance. The following assumptions are used:

(a) Cost of fuels (gas): 5.60 USD/GJ at the Project site (This price has been agreed on between EDM and ENH, the integrated gas supplier of the country.

(b) Annual O&M costs of the power plant: (USD thousand) are as follows:

Table 10.3-7 Annual O&M Costs

(Unit: 1,000 USD)

Year	2018	2019	2020	2021	2022	2023	2024-
O & M cost	2,406	4,126	4,126	4,126	4,126	4,126	5,031

(Source: JICA Study Team)

(c) Insurance: one percent of the total capital cost of the power plant per annum.
(d) Interest paid on loan: As discussed earlier in this section.

(7) Others

Other key assumptions used in our analysis are as follows:

(a) Depreciation: 20-year straight line
(b) Corporate income tax: 32 percent

Property taxes or working capital requirements are not considered in projecting the cash outflow stream. Potential revenues other than sales revenue, such as interest earnings, are not taken into account either, since they will be comparatively small.

Table 10.3-8 and Table 10.3-9 exhibit the financing plan and the before-debt-service cash flow projection of the Project.

Table 10.3-8 Disbursement of Investment Costs and Flow of Financial Resources

USD Thousand (MZN Thousand)

Item	Project year	1			2			3			4			5			6		
	Calendar year	2014			2015			2016			2017			2018			2019		
		F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
1 Total initial investment																			
(1) Initial investment costs excluding IDC		1,370	549	1,919	6,378	3,790	10,168	38,220	18,543	56,763	55,234	26,096	77,558	20,284	8,195	27,014	2,999	339	3,158
(2) Interest on foreign loan accrued		0	0	0	1	0	1	4	0	4	10	0	10	14	0	14	16	0	16
(3) Interest on domestic loan accrued		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDC total (Items (2) and (3))		0	0	0	1	0	1	4	0	4	10	0	10	14	0	14	16	0	16
Total (Items (1) to (3))		1,370	549	1,919	6,379	3,790	10,168	38,224	18,543	56,767	55,244	26,096	77,567	20,298	8,195	27,029	3,015	339	3,174
		(41,783)	(16,744)	(58,528)	(194,552)	(115,586)	(310,138)	(1,165,835)	(565,547)	(1,731,382)	(1,684,934)	(795,930)	(2,365,805)	(619,099)	(249,941)	(824,380)	(91,949)	(10,343)	(96,805)
2 Total finance required		1,370	549	1,919	6,379	3,790	10,168	38,224	18,543	56,767	55,244	26,096	77,567	20,298	8,195	27,029	3,015	339	3,174
(Financial resources)																			
3 Foreign bank loan		1,727	0	1,727	9,151	0	9,151	51,087	0	51,087	69,802	0	69,802	24,313	0	24,313	2,842	0	2,842
		(52,672)	(0)	(52,672)	(279,107)	(0)	(279,107)	(1,558,144)	(0)	(1,558,144)	(2,128,959)	(0)	(2,128,959)	(741,547)	(0)	(741,547)	(86,692)	(0)	(86,692)
Cumulative		1,727	0	1,727	10,878	0	10,878	61,965	0	61,965	131,767	0	131,767	156,080	0	156,080	158,922	0	158,922
		(52,672)	(0)	(52,672)	(331,780)	(0)	(331,780)	(1,889,923)	(0)	(1,889,923)	(4,018,882)	(0)	(4,018,882)	(4,760,429)	(0)	(4,760,429)	(4,847,121)	(0)	(4,847,121)
4 Domestic bank loan		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Cumulative		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
5 EDM equity			192	192		1,017	1,017		5,680	5,680		7,765	7,765		2,716	2,716		332	332
		(0)	(5,855)	(5,855)	(0)	(31,031)	(31,031)	(0)	(173,238)	(173,238)	(0)	(236,846)	(236,846)	(0)	(82,833)	(82,833)	(0)	(10,113)	(10,113)
Cumulative																			
		(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
6 Total finance		1,727	0	1,727	9,151	0	9,151	51,087	0	51,087	69,802	0	69,802	24,313	0	24,313	2,842	0	2,842
		(52,672)	(0)	(52,672)	(279,107)	(0)	(279,107)	(1,558,144)	(0)	(1,558,144)	(2,128,959)	(0)	(2,128,959)	(741,547)	(0)	(741,547)	(86,692)	(0)	(86,692)
Cumulative		1,727	0	1,727	10,878	0	10,878	61,965	0	61,965	131,767	0	131,767	156,080	0	156,080	158,922	0	158,922
		(52,672)	(0)	(52,672)	(331,780)	(0)	(331,780)	(1,889,923)	(0)	(1,889,923)	(4,018,882)	(0)	(4,018,882)	(4,760,429)	(0)	(4,760,429)	(4,847,121)	(0)	(4,847,121)

Item	Project year	7			8			9			10			11					
	Calendar year	2020			2021			2022			2023			2024			Total		
		F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
1 Total initial investment																			
(1) Initial investment costs excluding IDC		2,634	14	2,648	2,702	14	2,715	2,756	14	2,770	2,822	14	2,835	1,168	0	1,168	136,567	57,566	194,133
(2) Interest on foreign loan accrued		16	0	16	16	0	16	16	0	16	17	0	17	17	0	17	127	0	127
(3) Interest on domestic loan accrued		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDC total (Items (2) and (3))		16	0	16	16	0	16	16	0	16	17	0	17	17	0	17	127	0	127
Total (Items (1) to (3))		2,650	14	2,664	2,718	14	2,732	2,773	14	2,786	2,838	14	2,852	1,185	0	1,185	136,693	57,566	194,260
		(80,822)	(421)	(81,243)	(82,893)	(421)	(83,314)	(84,564)	(421)	(84,984)	(86,567)	(421)	(86,988)	(36,148)	(0)	(36,148)	(4,169,147)	(1,755,774)	(5,924,921)
2 Total finance required		2,650	14	2,664	2,718	14	2,732	2,773	14	2,786	2,838	14	2,852	1,185	0	1,185	136,693	57,566	194,260
																	0	0	0
(Financial resources)																	0	0	0
3 Foreign bank loan		2,383	0	2,383	2,444	0	2,444	2,493	0	2,493	2,552	0	2,552	1,051	0	1,051	169,845	0	169,845
		(72,679)	(0)	(72,679)	(74,536)	(0)	(74,536)	(76,033)	(0)	(76,033)	(77,830)	(0)	(77,830)	(32,069)	(0)	(32,069)	(5,180,267)	(0)	(5,180,267)
Cumulative		161,305	0	161,305	163,749	0	163,749	166,242	0	166,242	168,793	0	168,793	169,845	0	169,845			
		(4,919,800)	(0)	(4,919,800)	(4,994,336)	(0)	(4,994,336)	(5,070,369)	(0)	(5,070,369)	(5,148,199)	(0)	(5,148,199)	(5,180,267)	(0)	(5,180,267)			
4 Domestic bank loan		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Cumulative		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
		(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)			
5 EDM equity			281	281		288	288		293	293		300	300		134	134	0	18,998	18,998
		(0)	(8,564)	(8,564)	(0)	(8,777)	(8,777)	(0)	(8,951)	(8,951)	(0)	(9,159)	(9,159)	(0)	(4,080)	(4,080)	(0)	(579,448)	(579,448)
Cumulative																			
		(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)			
6 Total finance		2,383	0	2,383	2,444	0	2,444	2,493	0	2,493	2,552	0	2,552	1,051	0	1,051	169,845	0	169,845
		(72,679)	(0)	(72,679)	(74,536)	(0)	(74,536)	(76,033)	(0)	(76,033)	(77,830)	(0)	(77,830)	(32,069)	(0)	(32,069)	(5,180,267)	(0)	(5,180,267)
Cumulative		161,305	0	161,305	163,749	0	163,749	166,242	0	166,242	168,793	0	168,793	169,845	0	169,845			
		(4,919,800)	(0)	(4,919,800)	(4,994,336)	(0)	(4,994,336)	(5,070,369)	(0)	(5,070,369)	(5,148,199)	(0)	(5,148,199)	(5,180,267)	(0)	(5,180,267)			

(Source: JICA Study Team)

Table 10.3-9 Projected Cash Flow before Debt Service (operation period) 2018-2042

US Thousand

Item	Operation year / Calendar year	1 / 2018	2 / 2019	3 / 2020	4 / 2021	5 / 2022	6 / 2023	7 / 2024	8 / 2025	9 / 2026	10 / 2027	11 / 2028	12 / 2029	13 / 2030	14 / 2031	15 / 2032	16 / 2033	17 / 2034	18 / 2035	19 / 2036	20 / 2037	21 / 2038	22 / 2039	23 / 2040	24 / 2041	25 / 2042	Total
1 Operational parameters																											
1 Capacity (MW)		110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	
1 Electricity generation (GWh)		376	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	18,414
1 Electricity supply (GWh)		368	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	18,046
1 Technical loss		7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	
2 Non-technical loss		8%	8%	8%	8%	7%	7%	7%	7%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	
2 Electricity sale (GWh)		315	630	630	630	637	637	637	637	644	644	644	644	644	644	644	644	644	644	644	644	644	644	644	644	644	15,700
2 Average sales price (USD/kWh)		0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	
2 Average wholesale price (USD/kV		0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	
2 Sales revenue		29,745	59,491	59,491	59,491	60,137	60,137	60,137	60,137	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	1,482,093
3 Operating cost		20,177	39,667	39,667	39,667	39,667	39,667	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	989,388
1 O&M		2,406	4,126	4,126	4,126	4,126	4,126	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	118,625
2 Fuel		16,800	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	823,200
3 Insurance for Economic Analysis		925	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849	45,304
3 Insurance		971	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	47,563
4 Net operating income (Item 2 - 3)		9,569	19,823	19,823	19,823	20,470	20,470	19,565	19,565	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	492,706

(Source: JICA Study Team)

10.3.2 The Unit Cost of Generation of Electricity

In this section, the unit cost of generation of electricity (hereinafter called "generation cost") at the bus bar of the power station for the Project is calculated in order to compare it with relevant figures of alternative projects that have different technologies and to examine the Project viability.

(1) Calculation of Generation Cost

The generation cost shall be calculated by using the method presented by the International Energy Agency (IEA), called the Levelized Cost of Electricity (LCOE). The LCOE is derived from the following formula.

$$LCOE = \frac{\sum NPV(Cost)}{\sum NPV(Electricity)}$$

The details on Σ NPV (Cost) and Σ NPV (Electricity) are as follows:

- Σ NPV (Cost): Sum of discounted[3] future cost (construction cost, O&M cost and fuel cost)
- Σ NPV (Electricity): Sum of discounted future electricity to be produced at sending-out

The corporate income tax (32%) is considered in this analysis from the viewpoint of EMD.

(2) Generation Cost

As shown in Table 10.3-10, the generation cost at the bus bar of the power station of the Project is estimated at 8.84 USc/kWh.

(3) Evaluation of Calculation Result

This value, the abovementioned generation cost (8.84 USc/kWh) of the Project, is much lower than the current purchase price from ESKOM on a spot basis during the on-peak hours (25～30 USc/kWh) and lower than the purchase price from Aggreko's peaking power plant (9.0 USc/kWh). Thus, it can be said that if the Project is operated as a peaking power plant (although the proposed plant is assumed to operate in base-load mode), it can generate electricity at a competitive price in the market.

[3] The discount rate is assumed to be 10%.

Table 10.3-10 Generation Cost

US Thousand

Item	Operation year	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
	Calendar year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	Total
Discount factor for year		1.33	1.21	1.10	1.00	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35	0.32	0.29	0.26	0.24	0.22	0.20	0.18	0.16	0.15	0.14	0.12	0.11	0.10	0.09	
1 Operational parameters																															
1 Capacity (MW)		0	0	0	0	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	
1 Electricity generation (GWh)						376	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	18,414
1 Electricity supply (GWh)						368	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	18,046
NPV of electricity produced produced (GWh)		0	0	0	0	342	621	565	513	467	424	386	351	319	290	263	239	218	198	180	164	149	135	123	112	102	92	84	76	69	
2 Cost		1,919	10,168	56,763	77,558	49,471	47,829	47,147	47,042	47,131	47,025	45,812	44,471	44,506	44,333	44,333	44,333	44,332	44,332	44,332	44,331	44,331	44,331	44,331	44,330	44,330	44,330	44,329	44,329	44,329	
1 Investment cost		1,919	10,168	56,763	77,558	27,014	3,158	2,648	2,715	2,770	2,835	1,168																			119,867
2 Operating cost						22,456	44,671	44,499	44,327	44,361	44,189	44,644	44,471	44,506	44,333	44,333	44,333	44,332	44,332	44,332	44,331	44,331	44,331	44,331	44,330	44,330	44,330	44,329	44,329	44,329	1,087,422
3 O&M						2,406	4,126	4,126	4,126	4,126	4,126	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	5,031	118,625
4 Fuel						16,800	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	33,600	823,200
5 Insurance						971	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	1,941	47,563
6 Income tax paid						0	2,977	3,059	3,140	3,428	3,509	3,295	3,376	3,664	3,745	3,745	3,745	3,746	3,746	3,746	3,746	3,746	3,746	3,746	3,747	3,747	3,747	3,747	3,747	3,747	
7 Interest paid on debt						2,280	2,026	1,773	1,520	1,267	1,013	777	523	269	16	15	15	14	14	14	13	13	12	12	11	11	11	10	10	9	
NPV of Cost		2,554	12,303	62,439	77,558	44,974	39,528	35,422	32,130	29,265	26,544	23,509	20,746	18,875	17,092	15,538	14,126	12,842	11,674	10,613	9,648	8,771	7,973	7,248	6,589	5,990	5,446	4,951	4,501	4,091	
Unit gen. cost (LCOE)		**8.84 USc/kWh**																													

(Source: JICA Study Team)

10.3.3 FIRR on the Total Investment Cost (Project FIRR)

To confirm the underlying financial viability or the true soundness of the Project, the financial internal rate of return (FIRR) on the total investment cost was calculated. In this calculation, no considerations were made regarding financing costs, whereas other assumptions stated above were applied. The result of the calculation is as follows: (See also Table 10.3-11)

Project FIRR: 6.7 percent

The Project FIRR is at 6.7 percent, which exceeds 6.47 percent, the short-term cutoff rate of national loan interest rates. Therefore the Project is regarded as financially viable.

Table 10.3-11 Project FIRR (2014-2042)

USD Thousand

Project year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
Calendar Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	Total
1 Cash inflow																														
Sales revenue	0	0	0	0	29,745	59,491	59,491	59,491	60,137	60,137	60,137	60,137	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	60,784	1,482,093
2 Cash outflow	1,919	10,168	56,763	77,558	47,536	46,451	45,941	46,009	46,270	46,336	45,284	44,116	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	44,323	1,267,832
(1) Capital paid-in	1,919	10,168	56,763	77,558	27,014	3,158	2,648	2,715	2,770	2,835	1,168																			188,716
(2) Operation	0	0	0	0	20,177	39,667	39,667	39,667	39,667	39,667	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	40,572	989,388
(3) Net working capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(4) Interest paid on debt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(5) Income (corporate) tax	0	0	0	0	344	3,626	3,626	3,626	3,833	3,833	3,543	3,543	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	89,728
(6) Loan repayments	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Net cash flow (Item 1 - 2)	-1,919	-10,168	-56,763	-77,558	-17,790	13,039	13,550	13,482	13,867	13,802	14,853	16,022	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	16,461	214,261
4 Cumulative net CF	-1,919	-10,168	-58,682	-87,726	-76,472	-74,686	-62,922	-61,204	-49,055	-47,403	-34,202	-31,381	-17,740	-14,919	-1,279	1,542	15,182	18,003	31,644	34,465	48,105	50,926	64,567	67,388	81,028	83,849	97,490	100,310	113,951	178,692
5 Net present value	-1,919	-9,550	-51,767	-72,685	-59,511	-54,589	-43,196	-39,463	-29,708	-26,962	-18,272	-15,746	-8,361	-6,604	-532	602	5,568	6,201	10,238	10,473	13,729	13,651	16,256	15,935	17,996	17,491	19,101	18,459	19,695	-253,467
discount factor	1	0.94	0.88	0.83	0.78	0.73	0.69	0.64	0.61	0.57	0.53	0.50	0.47	0.44	0.42	0.39	0.37	0.34	0.32	0.30	0.29	0.27	0.25	0.24	0.22	0.21	0.20	0.18	0.17	
6 Cumulative NPV	-1,919	-11,469	-63,235	-135,920	-195,431	-250,020	-293,216	-332,679	-362,386	-389,348	-407,620	-423,366	-431,726	-438,330	-438,862	-438,260	-432,692	-426,490	-416,253	-405,780	-392,051	-378,400	-362,144	-346,209	-328,212	-310,721	-291,621	-273,162	-253,467	
7 FIRR on the Project **6.7%**																														

(Source: JICA Study Team)

10.3.4 Financial Analysis on the Equity

Table 10.3-12 exhibits the cash flow for the financial planning, considering debt loans. Calculations were made for the debt service coverage ratio (DSCR), which shows the sovereign debt payment below.

DSCR: 4.6 (average), 2.2 (minimum) and 6.6 (maximum)

The DSCR is an important indicator of financial viability of a project not only for the project owner, but also for a lending institution, as it indicates the project's ability to pay its debt. The ratio is normally required to be 1.3 to 1.5 at minimum. If the DSCR of the project is over 2.2, it will meet this criterion and improve EDM's overall DSCR. Hence, the Project is considered to be a sound investment.

Table 10.3-12 Cash Flow Table for Financial Planning (operation period) 2017-2042

USD Thousand

	Operation year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
	Calendar year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	Total
1	Net cash flow from operation	9,569	19,823	19,823	19,823	20,470	20,470	19,565	19,565	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	20,212	492,706
2	Interest earned	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Working capital (net increase)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Interest paid on debt	2,280	2,026	1,773	1,520	1,267	1,013	777	523	269	16	15	15	14	14	14	13	13	12	12	11	11	11	10	10	9	11,649
	Interest of foreing Loan	0	0	0	0	0	0	17	17	16	16	15	15	14	14	14	13	13	12	12	11	11	11	10	10	9	250
	Interest of domestic Loan	2,280	2,026	1,773	1,520	1,267	1,013	760	507	253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,399
5	Net income before depreciation	7,289	17,797	18,050	18,303	19,203	19,457	18,788	19,042	19,942	20,196	20,196	20,197	20,197	20,198	20,198	20,198	20,199	20,199	20,200	20,200	20,201	20,201	20,201	20,202	20,202	481,057
6	Income tax paid	0	2,977	3,059	3,140	3,428	3,509	3,295	3,376	3,664	3,745	3,745	3,745	3,746	3,746	3,746	3,746	3,746	3,746	3,746	3,747	3,747	3,747	3,747	3,747	3,747	86,385
7	After-tax cash flow	7,289	14,819	14,992	15,164	15,776	15,948	15,493	15,666	16,278	16,451	16,451	16,451	16,452	16,452	16,452	16,452	16,453	16,453	16,453	16,454	16,454	16,454	16,454	16,455	16,455	394,671
8	Loan repayments	2,111	2,111	2,111	2,111	2,111	2,111	6,357	6,357	6,357	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	99,675
	Foreign loan repayments	0	0	0	0	0	0	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246	80,676
	Foreign outstanding principal	169,845	169,845	169,845	169,845	169,845	169,845	165,599	161,353	157,106	152,860	148,614	144,368	140,122	135,876	131,630	127,384	123,138	118,891	114,645	110,399	106,153	101,907	97,661	93,415	89,169	
	Domestic loan repayments	2,111	2,111	2,111	2,111	2,111	2,111	2,111	2,111	2,111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18,998
	Domestic outstanding principal	16,887	14,776	12,666	10,555	8,444	6,333	4,222	2,111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9	After-debt service cash flow	5,178	12,708	12,881	13,053	13,665	13,837	9,136	9,309	9,921	12,205	12,205	12,205	12,205	12,206	12,206	12,206	12,207	12,207	12,207	12,207	12,208	12,208	12,208	12,209	12,209	294,997
	Cummulative	5,178	17,886	30,767	43,820	57,485	71,322	80,458	89,767	99,689	111,893	124,098	136,303	148,509	160,714	172,920	185,127	197,333	209,540	221,748	233,955	246,163	258,371	270,579	282,788	294,997	
10	Debt service coverage (Items 5 + 4) / (items 4 + 8)	2.2	4.8	5.1	5.5	6.1	6.6	2.7	2.8	3.1	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	Ave. 4.6

(Source: JICA Study Team)

10.3.5 Sensitivity to FIRRs

The biggest risk involved in the Project in terms of financial viability is the future uncertainty of the exchange rate between the local currency and the US dollar. If the former declines against the latter, the US dollar-denominated revenue of the Project will decline. Since the electricity tariff is denominated in the local currency and a drastic increase in the tariff will be politically difficult, the currency exchange poses a risk. Our exchange forecast is 28.50 MTn/USD; however, the rate was once down to 32.98 MTn/USD in 2010.

Other major risks are associated with the EPC cost and the gas price. The Project will be the first combined cycle power project in the country and thus there are no comparable cost data available. The gas price has been agreed between EDM and ENH; however, there still remains a chance the agreement will be modified. We therefore performed a sensitivity analysis for the following six scenarios:

(1) 10 percent lower exchange rate than assumed, i.e., 30.69 MTn/USD and thus 0.086 USD/kWh of the income price from electricity generation
(2) 15 percent lower exchange rate than assumed, i.e., 32.01 MTn/USD and thus 0.082 USD/kWh of the income price from electricity generation
(3) 10 percent higher EPC cost
(4) 20 percent higher EPC cost
(5) 10 percent higher gas price
(6) 20 percent higher gas price

The results of the above sensitivity test are summarized below:

Table 10.3-13 Results of Sensitivity Analysis on FIRR

	Item	Project FIRR
1	10% lower exchange rate	2.9%
2	15% lower exchange rate	0.8%
3	10% higher EPC cost	6.1%
4	20% higher EPC cost	5.6%
5	10% higher gas price	5.2%
6	20% higher gas price	3.5%

(Source: JICA Study Team)

The above sensitivity analysis indicates that the Project FIRR in case of a 10% higher EPC cost, a 20% higher EPC cost and 10% higher gas price shows over 5.2%, which is close to the cutoff rate. When the exchange rate is 10% and 15% lower than the assumed rate, the Project FIRRs show 2.9% and 0.8% respectively. Therefore, there are some cases in which the Project FIRRs

are close to the cutoff rate, whereas the financial feasibility of the Project is deemed to be lower in case of alteration of the exchange rate or gas price.

10.3.6 Conclusion on Financial Feasibility

The Project FIRR of the base case is at 6.7 percent, which exceeds 6.47 percent, the short-term cutoff rate of national loan interest. Therefore, the Project is regarded as financially viable. The DSCR of the Project is over 2.2 and exceeds the ratio normally required to be 1.3 to 1.5; so, the Project is considered to be a sound investment. With regards to the sensitivity to FIRRs, there are some cases in which the Project FIRRs are close to the cutoff rate, whereas the financial feasibility of the Project is deemed to be lower in case of alteration of the exchange rate or gas price. The main reason for this is that the current EDM electricity price is set quite low. However, as mentioned before, EDM has carried out a study to revise and possibly raise the current electricity price. It is expected that the Project FIRR will be higher and improved, provided that the revision and increase of electricity price are carried out in the near future, which would contribute to higher financial viability of the Project. To sum up, it is deemed that the Project is financially feasible as long as there are no changes in the overall framework of the Project.

10.4 Economic Analysis of the Project

The economic analysis of a project is concerned with all the costs and benefits incurred or generated by the project to the society as a whole, while the financial analysis is concerned with those to the project owner only. In order to assess the economic feasibility of the Project, i.e., whether or not the Project generates a sufficient net benefit to the country so that investment for its implementation can be justified, we estimate what is called the economic internal rate of return (EIRR) of the Project, as discussed below.

10.4.1 Key Assumptions Used for Economic Analysis

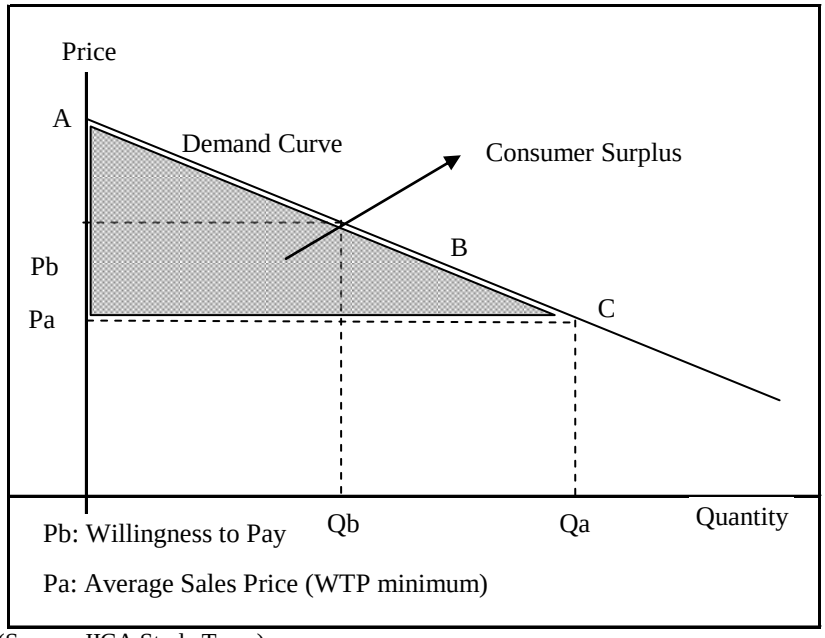
(1) Economic benefits

There are mainly two methods of evaluating the economic benefits. One method is used to define, directly quantify in monetary terms and evaluate the benefits arising from the project, which are compared against the economic cost of the project in obtaining the economic internal rate of return. On the other hand, the other method is used when the measurement and quantification of benefits are difficult, and the analysis assumes an alternative project that might generate the same quality and amount of the benefit but could be constructed at the least cost next to the project for appraisal. The economic analysis compares the cost of this least-cost

alternative project against the project to quantify the saving of cost as the benefit of the project.

It is generally acknowledged that in cases where domestic total quantity of electricity supply increases, the former method above is utilized for calculating economic benefit. Meanwhile, in cases where domestic total quantity of electricity supply is stabilized or does not increase, the latter method is utilized. In Mozambique, power supply is unable to keep up with the power demand so it is necessary to create a new additional power source. The Project makes it possible to supply additional power to the domestic market and increase the total domestic quantity of electricity supply. Therefore, the income generated by the assumed average electricity sales price of the project mentioned earlier (consumers' and producers' electricity purchase price), which is regarded as a net economic benefit, is used for the economic analysis. The total of this income is regarded as the willingness-to-pay (WTP) minimum and will not exceed consumers' and producers' willingness-to-pay level for electricity, which can be represented by the cost of supply by a captive power, which is likely to be an oil-based diesel generator or any alternative source of energy, such as kerosene.

In the figure below, Pa indicates assumed average electricity sales price, the WTP minimum. Pb shows the consumers' and producers' average WTP. The area depicted by the points A, Pa, and C below the demand curve represents the range that consumers are willing to pay in excess of the prevailing tariff and is called "consumer surplus." Regarding the calculation of the economic analysis, since it is a principle to carry out conservative evaluation, rather than a willingness-to-pay including consumer surplus, the income generated by the assumed average electricity sales price of the Project is utilized for the economic analysis in order to overestimate economic benefit of the Project. In the graph below, the quadrangle area depicted by the points Pa, C, Qa, and 0 shows the total amount of electricity tariffs that consumers and producers pay.



(Source: JICA Study Team)

Figure 10.4-1 Average Sales Price of Electricity and Willingness to Pay

Using the figure (average sales price of electricity) obtained as the unit price of the economic benefit and multiplying the total volume of generation can quantify the value of the generated electricity.

For reference, the benefit stemming from the saving cost comparing the Project to the least-cost alternative project and other benefits that are not able to be monetized, as described in 10.1 Effectiveness of the Project, are as follows, although they are not calculated for economic benefit.

(a) Cheaper electricity (because of lower generation/supply cost)

"Without the Project," EDM will need to find an alternative power source. The difference in the power production (or procurement) cost between the Project and the alternative power source is regarded as a saving realized by the Project in supplying the same amount of electricity to the grid and thus is an economic benefit of the Project.

Potential alternative power sources are limited to: (1) purchase from the Power Pool of South Africa, (2) purchase from Aggreko, who has an additional 85 MW of capacity that can be mobilized instead of being relocated somewhere else, and (3) a new IPP project (or expansion of a planned IPP project) using the gas that has been allocated to the Project, which is likely to be a gas-engine project located in Ressano Garcia.

The first two options are grossly expensive compared with the Project, costing over 20 US cents/kWh. The third one is considered to be the least-cost alternative option, and there is a

method of measuring the economic benefit or savings incurred by the difference between the Project and the alternative option in terms of estimating the generation cost for the option based on the information for the Sasol project, which includes 18 gas-engine generator sets each with an open cycle capacity of approximately 9.73 MW.

(b) Contribution to sustainable economic development

"Without the Project," because of insufficient electricity supply, EDM operation will be further restricted and the number of new connections will be limited. New connections are associated with investments. If we can identify the exact relationship between those two, we may be able to estimate the amount of investment realized by an additional 110 MW of power the Project can provide. However, it is very difficult, if not impossible, to undertake such an exercise.

(c) More electricity to be delivered (because of a lower transmission loss)

Because the Project is located closer to the demand center of Maputo than the least-cost alternative options discussed above, there is a benefit resulting from the lower transmission loss. We assume the difference in the transmission loss within the Southern System as follows:

- The difference of transmission loss between the Project and a comparable project located at Ressano Garcia: 1.1 MW
- The difference of transmission loss between the Project and power supplied though the STE project: Not considered as the capacity difference between the two (i.e., over 2,000 MW for the latter) is too large for this exercise.

(d) Saving from delay of investment in transmission system

As the demand of Maputo continues to increase, the transmission system around Maputo needs to be enhanced. The Project, being located in Maputo, can delay some parts of the enhancement needs, compared with the alternative power sources identified earlier. However, because of a lack of data, it is difficult, if not impossible to identify the exact difference and thus monetize this benefit.

(2) Economic costs

In the economic analysis, we use true economic prices instead of often-distorted financial or market prices. For this purpose, we disregard all transfer payments within the country, such as taxes and duties. Then, we convert distorted market prices into economic prices by multiplying them with conversion factors. As far as the Project is concerned, while no "border distortion" is assumed, domestic currency components of initial capital investment are expected to be subject to domestic distortion. In particular, wage rates of unskilled labor tend to exceed "opportunity-cost" wages. For simplicity, we use an average conversion factor in our

calculations, to be applied to market prices of all domestic currency components. This average conversion factor is estimated at 0.97, as shown below:

Table 10.4-1 Conversion Factor for Economic Costs

Item	Portion of Total LC Input	CF	Weighed Value
Domestic material/land	80%	1.0	0.8
Skilled labor	10%	1.0	0.1
Unskilled labor	10%	0.7	0.07
		Average CF	0.97

(Source: JICA Study Team)

We assume that the price of the gas to be supplied to the Project reflects its true economic value. The gas could be sold to South Africa for higher prices. However, the gas for the Project comes from the portion designated for domestic use.

10.4.2 EIRR

Table 10.4-2 exhibits the calculation of the EIRR of the Project based on the economic benefits and costs discussed earlier. The EIRR is calculated at 17.1 percent, which clearly supports economic viability of the Project. Because of some economic benefits that are not included in the financial benefits, the EIRR is higher than the FIRR on the total investments.

Table 10.4-2 EIRR of the Project (2014-2042)

USD Thousand

	Item	Project year / Calendar Year	1 / 2014	2 / 2015	3 / 2016	4 / 2017	5 / 2018	6 / 2019	7 / 2020	8 / 2021	9 / 2022	10 / 2023	11 / 2024	12 / 2025	13 / 2026	14 / 2027	15 / 2028	16 / 2029	17 / 2030	18 / 2031	19 / 2032	20 / 2033	21 / 2034	22 / 2035	23 / 2036	24 / 2037	25 / 2038	26 / 2039	27 / 2040	28 / 2041	29 / 2042	Total
1	Technical parameters																														
	(1) Electricity generation (GWh)						376	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	752	
	(2) Electricity supply (GWh)						368	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	737	
2	Benefits						37,182	74,363	74,363	74,363	75,172	75,172	75,172	75,172	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	
	(1) Electricity sales						37,182	74,363	74,363	74,363	75,172	75,172	75,172	75,172	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	75,980	1,852,617
3	Costs		1,639	9,176	53,658	76,888	46,943	42,729	42,222	42,290	42,345	42,410	41,648	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	1,168,951
	(1) Initial investment costs		1,639	9,176	53,658	76,888	26,813	3,153	2,647	2,715	2,769	2,835	1,168																		181,823
	(2) Operation						20,131	39,575	39,575	39,575	39,575	39,575	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	40,480	987,129
4	Net benefits (Item 2 - 3)		-1,639	-9,176	-53,658	-76,888	-9,761	31,635	32,141	32,073	32,827	32,762	33,523	34,691	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	35,500	683,665
5	Cumulative net benefits		-1,639	-9,176	-62,834	-139,722	-149,484	-117,849	-85,708	-53,635	-20,807	11,954	45,477	80,169	115,669	151,168	186,668	222,168	257,668	293,168	328,667	364,167	399,667	435,167	470,667	506,166	541,666	577,166	612,666	648,165	683,665	6,292,724
6	Net present value		-1,639	-8,342	-51,929	-104,975	-102,099	-73,175	-48,380	-27,523	-9,707	5,070	17,533	28,099	36,856	43,788	49,156	53,185	56,076	58,002	59,114	59,544	59,408	58,804	57,819	56,528	54,993	53,270	51,406	49,441	47,408	529,369
	discount factor		1.00	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35	0.32	0.29	0.26	0.24	0.22	0.20	0.18	0.16	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.08	0.07	
7	Cumulative NPV		-1,639	-9,981	-61,910	-166,885	-268,985	-342,160	-390,539	-418,062	-427,769	-422,699	-405,166	-377,067	-340,212	-296,424	-247,268	-194,083	-138,007	-80,005	-20,891	38,653	98,061	156,865	214,685	271,212	326,205	379,475	430,881	480,322	527,730	
8	**EIRR of the Project**	**17.1%**																													

(Source: JICA Study Team)

10.4.3 Sensitivity Analysis

A sensitivity test was performed on the EIRR for the initial investment cost only, which is the largest foreign cost component. The results of the test are as follows:

Table 10.4-3 The Results of EIRR Sensitivity Analysis

	Scenario	EIRR of the Project
1	10% higher initial investment cost	15.6%
2	20% higher initial investment cost	14.3%

(Source: JICA Study Team)

Generally, higher EIRRs are expected for energy projects, whereas a substantial cost overrun of the initial investment cost could undermine the Project's viability. As a result of this sensitivity analysis, the EIRRs are over 10 percent in cases of a 10 percent and 20 percent higher initial investment. Thus, it can be said that the Project is economically feasible.

10.4.4 Conclusion on Economic Feasibility

We can conclude that the Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

10.5 Operation and Effect Indicators

The following operational and effect indicators shall be set for monitoring power plant performance, supervising the management of operation and maintenance and confirming the effect of the CCPP.

Operational Indicators

- Maximum Output
- Plant Load Factor
- Availability Factor
- Gross Thermal Efficiency
- Outage Hours by Human Errors
- Outage Hours by Machine Errors
- Planned Outage Hours

Effect Indicators

- Maximum Output
- Net Electric Power Production
- Number of Beneficiaries

The target of each indicator is set based on international experience of this JICA Team. The targets shall be initially set at the lowest levels possible. They will be checked periodically and reviewed yearly for setting and achieving higher targets toward final targets.

Each target shall be checked and reviewed based on Table 10.5-1. The indicators above are set based on "Operational and Effect Indicators Reference, 2nd Edition, established by JBIC, October 2002."

Table 10.5-1 Operation and Effect Indicators

Indicator	Target	Check *1	Evaluate *1	Remarks
Operation Indicator				
Maximum Output*2	110 MW	Monthly	Annually	The Maximum Output shall be evaluated on the terms and conditions, based on manufacturer's evaluation guidelines, taking the result of the commissioning into consideration.
Plant Load Factor*3	83%	Monthly	Annually	= Annual Amount of Gross Generated Output / (Rated Output x 24 x 365) x 100 Assumed base load operation case. This might be reduced in the case of partial load operation. The maintenance period greatly influences the plant load factor. Its period shall be carefully considered when setting the target.
Availability Factor*3	90%	Monthly	Annually	= Annual Operation Hours / (24 x 365) x 100 Assumed base load operation case. This might be reduced in the case of partial load operation. The maintenance period greatly influences the availability factor. Its period shall be carefully considered when setting the target.
Gross Thermal Efficiency*2	Approx. 50%	Monthly	Annually	= (Annual Amount of Gross Generated Output x 860) / (Annual Amount of Fuel Consumption x Fuel Lower Heating Value) x 100 The gross thermal efficiency shall be evaluated on the terms and conditions, based on manufacturer's evaluation guidelines, taking the result of the commissioning into consideration.
Outage Hours by Human Errors	0 hours	Annually	Annually	Outage Hours by Human Errors is to be nearly zero.

Indicator	Target	Check *1	Evaluate *1	Remarks
Outage Hours by Machine Errors	438 hours	Annually	Annually	Unforeseen outage by machine errors is unavoidable due to the operation records of CCPP. 5% per cent per year is set for outage days by machine errors for the CCPP.
Planned Outage Hours	192 hours	Annually	Annually	Assumed Combustor Inspection year. Combustor Inspection: 192 hour x 4 time / 6 year, Hot Gas Path Inspection: 360 hour / year, Major Inspection: 720 hour / year
Effect Indicator				
Maximum Output*2	110 MW	Monthly	Annually	The Maximum Output shall be evaluated on the terms and conditions, based on manufacturer's evaluation guideline, taking the result of the commissioning into consideration.
Net Electric Power Production*2	GWh	Monthly	Annually	The maintenance period greatly influences the net electric energy production. Its period shall be carefully considered when setting the target. The target of net electric energy production is calculated as follows. 110MW x 8,760 hour x 0.83 x (1 – Auxiliary power ratio: 0.02)
Number of Beneficiaries	441,000 persons	Annually	Annually	Population of Maputo City is 1,178,116 according to the INE2011. Power demand in the region is 2,095GWh by EDM 2011. Hence, electricity consumption per capita is obtained by 2,095GWh/1,178,116= 1,778kWh per capita. Net Electric Power Production by the project is estimated at 784 GWh. Therefore, number of beneficiaries is estimated by the net power production / electricity consumption per capita = 441,000 persons, which corresponds to 37 per cent of the whole population of Maputo city.

1) The target of each indicator shall be checked based on the "check interval" above, and reviewed based on the "review interval" above.
2) The target of the "maximum output," "gross thermal efficiency" and "net electric power production" specified above shall be set based on the guaranteed specifications of an EPC contractor.
3) The "plant load factor" and "availability factor" specified above are subject to operation order from the EDM's dispatch center.
4) Instituto Nacional de Estatística (INE)

(Source: JICA Study Team)

Chapter 11

Environmental and Social Considerations

Chapter 11 Environmental and Social Considerations

11.1 Outline of Project Components Subject to Environmental and Social Considerations

11.1.1 Selection of Proposed Project Site

The proposed site is located in the existing Maputo Thermal Power Station (CTM), which is approximately 3 km west of the center of Maputo city, close to the border of Matola city. The site is situated west of Maputo cargo terminal, immediately south of the EN2 Highway and the northeastern fence line borders the railway lines to the Maputo Cargo Terminal. The closest community is Bairro Luis Cabral, northeast of the site between the railway lines and the EN2 highway.

There are existing facilities in the site, including three sets of GTs that are rarely used, oil tanks, and three substations, as well as remnants of the former coal-fired power station, such as a partially demolished power house, the CW pipe bridge, which is seriously damaged, and an open space that used to be the coal stockyard.

Please refer to Chapters 3 and 5 of this Report for detailed information on the proposed Project site.

11.1.2 Proposed CCGT Technology

The combined cycle gas turbine (CCGT) with a multi-shaft 2 on 1 configuration is proposed for adoption in this Project. A CCGT is a power generation system that utilizes a combination of GT(s) and a ST to achieve greater efficiency than would be possible independently. The gas turbine drives an electrical generator. The GT exhaust is then used to produce steam in a heat recovery steam generator (HRSG). Then the generated steam is fed to a ST whose output provides the means to generate more electricity. This technology is known for its effectiveness in terms of natural gas resource use, higher efficiency, shorter construction period, lower initial investment cost, compact configuration and most importantly, few environmental impacts.

Please refer to Chapters 4 and 6 of this Report for a comprehensive overview of the technical specifications and basic design of the proposed power plant.

11.1.3 Type of Cooling System

An air-cooled condenser (ACC) is proposed as the most preferred steam condenser for this Project. The ACC technology does not need water to condense the process fluid. In this system, exhaust steam from the turbine flows through the tube bundles and is condensed in parallel flow tube bundles using air flow induced by properly designed axial fans. This system has the following observable benefits:

- Elimination of additional water usage from the condensing power cycle
- Flexibility in power plant site selection
- Reduced time required for issuing plant permits because its environmental impact is less.

Refer to Chapters 4 and 6 of this Report for the comprehensive information on the technical specifications of the proposed air-cooled condenser.

11.2 Baseline Environmental Condition

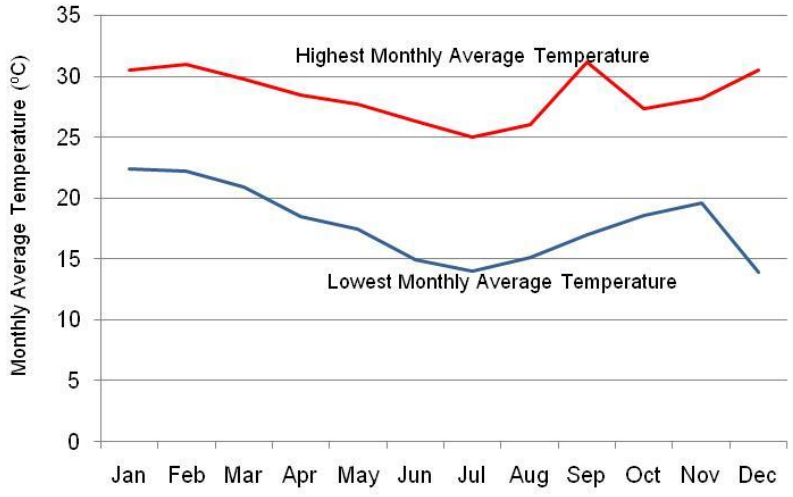
11.2.1 Natural Environment Conditions

(1) Meteorology

The meteorological data was collected from the nearest meteorological station to the Project site (Weather Station #64 – Maputo International Airport). Presented below are significant climate data generated from 2009–2011.

(a) Temperature

As shown in Figure 11.2-1, the highest value in the monthly average of highest temperature is approximately 30℃ from December to March, and the lowest value in the monthly average of highest temperature is between 25–26℃ from June to August. The monthly average of lowest temperature is parallel to the average of highest temperature, but is 7℃to 10℃ cooler. The highest value in the monthly average of lowest temperature is approximately 22℃in January and February.

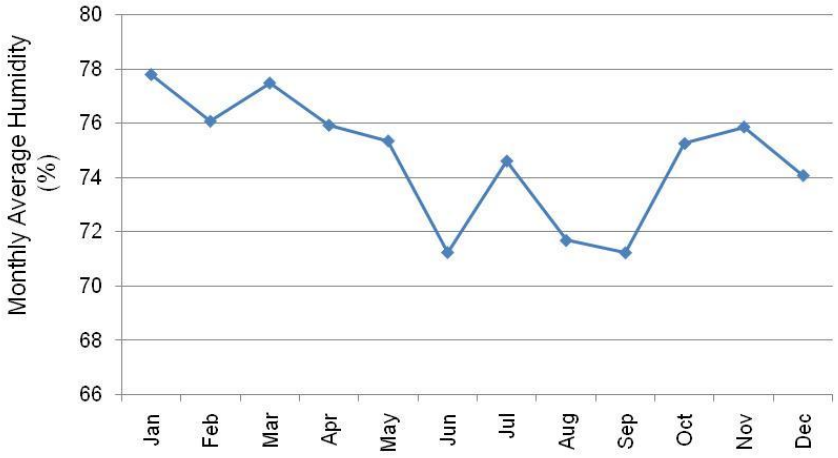


(Source: Instituto Nacional de Meteorologia - INAM)

Figure 11.2-1 Average monthly highest and lowest temperatures at Station No. 64 (2009–2011)

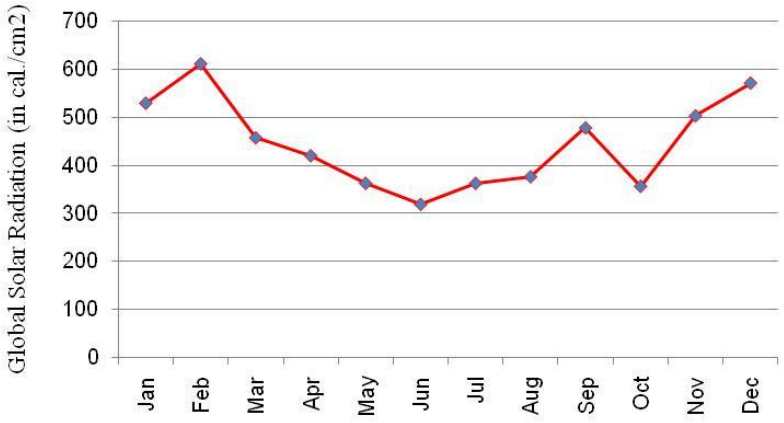
(b) Relative humidity

The relative humidity at the nearest point to the Project site suggests a small fluctuating range between 71 and 78 percent as shown in Figure 11.2-2 below. The fluctuation of the relative humidity results from the seasonal change of rainfall. It can also be attributed to the pattern of solar radiation as shown in Figure 11.2-3.



(Source: Instituto Nacional de Meteorologia - INAM)

Figure 11.2-2 Average monthly humidity at station No. 64 (2009–2011)



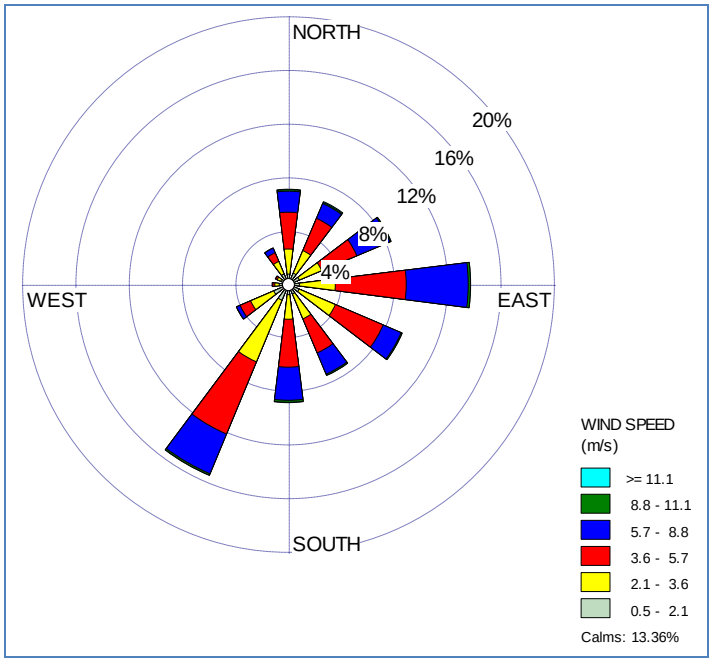
(Source: Instituto Nacional de Meteorologia - INAM)

Figure 11.2-3 Average monthly solar radiation at Station No. 64 (2009–2011)

(c) Wind Direction and Speed

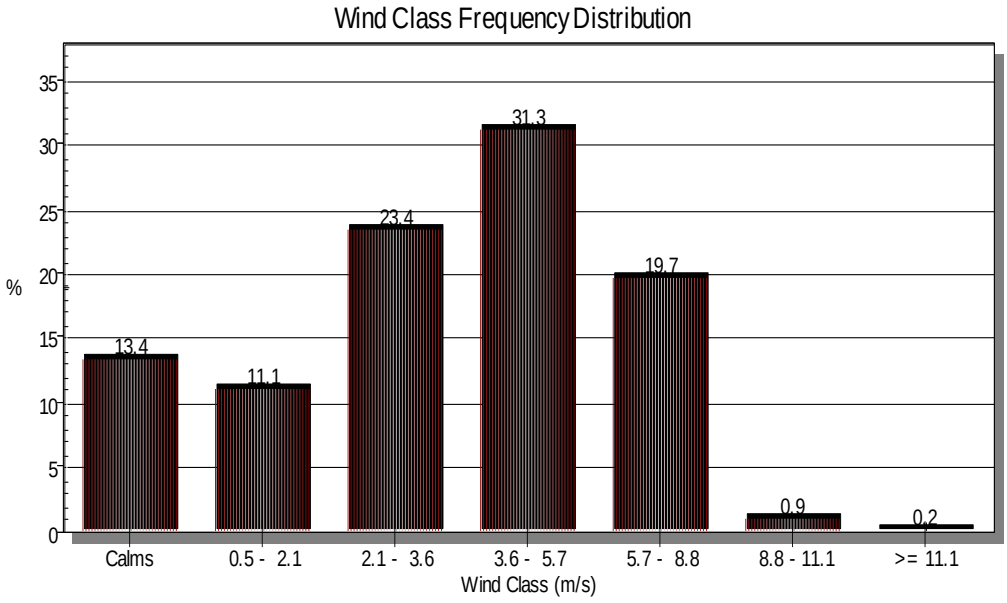
The wind rose was generated using the hourly meteorological data from Maputo Weather Station #64 from 2007–2011. The weather station is about 4.5 km northeast of the Project site. The wind rose consists of 12 petals, which represent the directions from which winds blew during the survey period. The colors used in the wind rose as shown in Figure 11.2-4 reflect the different

categories of wind speeds. The dotted circles provide information of the frequency of occurrence of wind speed and direction categories. The frequency at which calm occurred when the wind speed was below 0.5 m/s is also predicted. As shown in the figure, the predominant wind direction was from the south-southwest, with an approximate occurrence of 16%. The second predominant wind direction is from the east.



(Source: JICA Study Team)

Figure 11.2-4 Wind rose for Maputo at Station No. 64 (2007–2011)

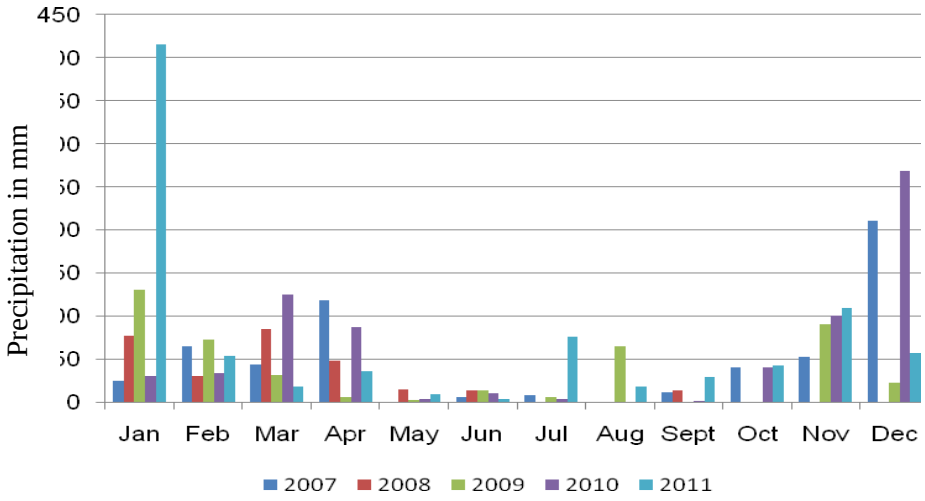


(Source: JICA Study Team)

Figure 11.2-5 Wind class frequency distribution at Station No. 64 (2007–2011)

(d) Rainfall

The rainfall data is shown in Figure 11.2-6. The annual rainfall data suggests that Maputo received annual rainfalls ranging from 284 mm to 865 between 2007 and 2011. The rainfall pattern shows a relatively higher rainfall in the months from November to April, which also justifies the temperature pattern observed at the point nearest the Project site.



(Source: Instituto Nacional de Meteorologia -INAM)

Figure 11.2-6 Monthly rainfall, Maputo 2007–2011

(2) Air Quality

The proposed Project site is located near the Maputo Port Terminal. In the greater Maputo area, there are a number of other industries that are considered to be of significant pollution sources, namely: cement processing, light fuel refining, coal storage and ship loading, informal industries and waste material burning. In close proximity to the proposed site, pollution sources are generated from vehicular traffic at the EN2 highway, the MPDC train lines of the Maputo Cargo Terminal, the coal burning in the adjacent community, the ships traveling within Maputo Bay and the ships loading at the Maputo Cargo Terminal.

In order to determine the baseline ambient air quality, the JICA Study Team conducted air quality monitoring from 23 Nov to Dec 01, 2012. The monitoring point was established close to the center of the Project site between the fuel tanks of the existing GTs (see Figure 11.2-7). The GPS coordinates of the point are 452914.00 m E, 7130896 m S. The sampling of SO_2, NO_2 and PM_{10} were carried out in accordance with NIOSH methods as detailed in Table 11.2-1 below.

(Source: JICA Study Team)

Figure 11.2-7 Location of air quality monitoring points

Table 11.2-1 Air quality sampling methods

Compound	Sampling Media	NIOSH Method
Sulfur Dioxide (SO_2)	Treated filters	6004
Nitrogen Oxides (NO_2)	Treated sorbent tubes	6014
Particulate matter less than 10 µm (PM_{10})	Pre-weighted filters	600

(Source: JICA Study Team)

The ambient samples were collected using precision sample pumps that were calibrated on site with a portable flow calibrator. The sampling duration was approximately 24 hours for each of the seven samples for which results are shown in Table 11.2-2.

Table 11.2-2 Daily Ambient Concentrations for PM_{10}, SO_2 and NO_2

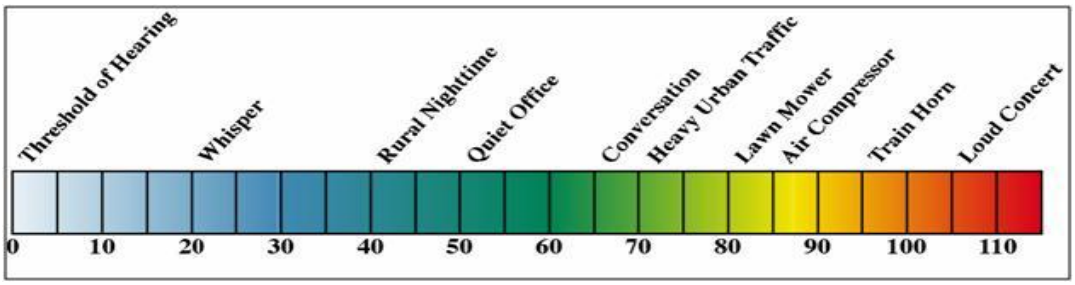
Sample	Parameters		
	PM_{10} (µg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)
1	72.9	< 0.01	19.51
2	60.4	5.01	2.66
3	75.3	4.11	10.72
4	12.6	4.10	4.60
5	33.5	5.36	16.04
6	78.4	1.58	14.71
7	76.7	0.07	5.11

(Source: JICA Study Team)

As shown in Table 11.2-2 above, the current SO_2 concentrations were below the Mozambican 24-hour guideline of 365µg/m^3 and the RSA guideline of 125µg/m^3. The measured ambient NO_2 concentrations were also within the Mozambican 24-hour guideline of 200µg/m^3. There are no guidelines in Mozambique, however, for PM_{10} so the international standards and guidelines were observed and adopted. The measured ambient PM_{10} concentrations were within the current RSA 24-hour guideline of 125µg/m^3; however, they were above the WHO guideline of 50µg/m^3 on 5 out of the 7 sampling days. Refer to the next section (Section 11.3.1) of this Report for detailed presentation of the ambient air quality standards and guidelines applicable to this Project.

(3) Noise Level

Sound is created when an object vibrates or radiates and part of that energy travels as acoustic pressure or waves through air, water or solids. Sound and noise are measured in units of decibels (dB), which are logarithmic in scale. Small changes in ambient sound levels less than 3 dB(A) will not be detected by a human ear but 10 dB(A) sound levels would be perceived as a doubling of sound loudness. To compare the effects of different fluctuating sounds, the average sound level over a time period will be compared to the constant level of steady, non-varying sound that produces the same energy during the same period. The fluctuating average noise levels over a time period is termed as L_{eq} and is represented by the constant noise level producing the same sound energy over the same time period as the fluctuating noise level. Figure 11.2-8 shows typical noise levels in various environments.



(Source: JICA Study Team)

Figure 11.2-8 Typical sound levels (dB(A))

In order to determine the ambient noise level in the study area, a baseline noise monitoring survey was conducted. The monitoring was conducted based on noise measurements obtained and done by the use of a Type 1 precision impulse integrating sound level meter, as prescribed by the international standards for sound level meter specifications, i.e., IEC 61672:1999, IEC 61260:1995 and IEC 60651, as well as ISO 19961:2003 and ISO 3095:2001 for the measurement and assessment of environmental noise.

A total of 10 monitoring points were pre-selected and one additional point (MP11) was chosen to carry out a 24-hr continuous measurement as shown in Figure 11.2-9. Its Global Positioning System (GPS) coordinates are shown in Table 11.2-3. The monitoring points consist of:

- Five (5) monitoring points at the Project site
- Five (5) monitoring points at local communities
- One location close to the fuel tanks, about 30 m northwest of the existing No.2 GT.

(Source: JICA Study Team)

Figure 11.2-9 Location of noise monitoring points

Table 11.2-3 Noise monitoring coordinates

Measurement Points	GPS Coordinates (WGS 84, UTM)	
MP01	452843.90 m E	7131027.27 m S
MP02	452954.91 m E	7130936.00 m S
MP03	452925.38 m E	7131035.01 m S
MP04	453056.00 m E	7130909.96 m S
MP05	453157.84 m E	7130804.78 m S
MP06	453172.86 m E	7130930.07 m S
MP07	453274.77 m E	7130868.29 m S
MP08	453228.12 m E	7130845.98 m S
MP09	453293.45 m E	7130777.91 m S
MP10	453333.31 m E	7130831.58 m S
MP11	452914.00 m E	7130896.00 m S

(Source: JICA Study Team)

The noise measurements were performed intermittently during the day and night for a period of 5 days covering four time periods (Morning: 06:00-08:00; Daytime: 08:00-18:00, Evening: 18:00-23:00 and Night-time: 23:00-06:00), within a 24-hour period representing weekdays and weekends. Table 11.2-4, Table 11.2-5 and Figure 11.2-10 illustrate the results of the noise levels at each monitoring point.

Table 11.2-4 Noise levels at each monitoring points

Monitoring Points	Area Type	Noise Level L_{Aeq} (dB(A))							
		Morning 06:00-08:00		Daytime 08:00-18:00		Evening 18:00-23:00		Night-time 23:00-06:00	
		WD[a]	WE[b]	WD	WE	WD	WE	WD	WE
MP01	Industrial	55.4	60.8	56.2	56.8	53.8	56.5	41.6	60.5 [c]
MP02		50.8	60.1	55.3	57.8	57.9	57.5	48.5	72.1[c]
MP03		55.2	59.4	55.2	59.3	60.5	59.3	55.7	64.7 [c]
MP04		74.4	56.2	64.3	56.4	60.0	56.6	41.3	66.9 [c]
MP05		52.2	67.4	46.7	58.4	67.6	61.2	52.0	54.2 [c]
MP06	Residential	60.6	64.5	65.7	62.4	64.8	61.0	56.7	61.9 [c]
MP07		59.3	60.6	62.7	61.3	64.1	59.9	52.6	58.6 [c]
MP08		60.0	57.1	68.6	58.1	61.3	66.7	41.0	50.9 [c]
MP09		55.9	59.1	54.9	59.0	60.6	58.9	43.1	49.2 [c]
MP10		57.9	60.8	60.6	59.4	62.3	59.6	52.9	54.4 [c]

[a] WD: weekday.

[b]WE: weekend or public holiday.

[c]: Note: The existing No. 2 GT was in operation during the weekend night-time measurements.

(Source: JICA Study Team)

Table 11.2-5 Noise level at MP11*

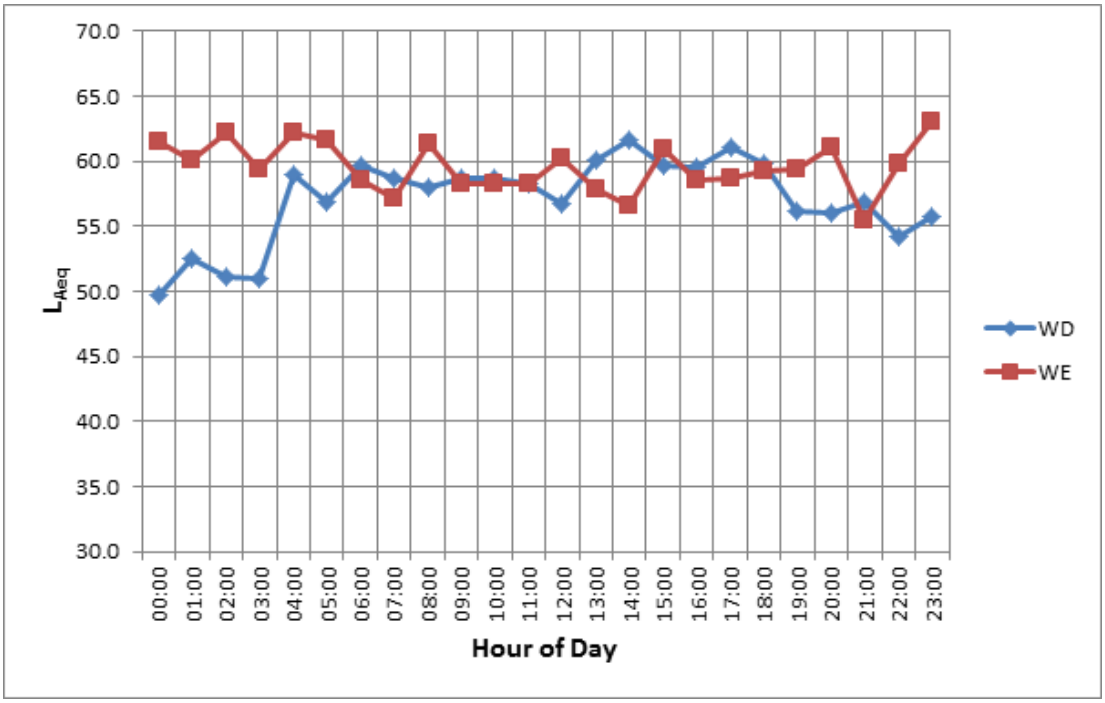
Day	Noise Level L_{Aeq} (dB(A))			
	Morning 06:00-08:00	Daytime 08:00-18:00	Evening 18:00-23:00	Night-time 23:00-06:00
WD	58.8	59.4	55.8	53.4
WE	59.0	58.7	59.8	61.2

WD: weekday.

WE: weekend or public holiday.

*Note: Noise measurements were performed at 10 locations within and around the site and continuously at MP11 within the site.

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 11.2-10 Average noise level at MP11 over 9 days period (Nov 23–Dec 01/2012)

Based on the results of the noise monitoring, the main noise sources within and around the Project area were the vehicular traffic from the EN2 highway, the trains to and from the Maputo Terminal and the existing GTs in CTM Maputo. The ambient noise levels at the monitored points within the power station site were found to be below the World Bank/IFC Ambient Noise Guidelines of 70 dB(A) for industrial zones, except for MP02 and MP11, which were in close proximity to the existing No.2 GT. The noise level from GT operation increased the noise levels on site, but they are lower than the noise levels at the Bairro Luis Cabral community. The noise levels at Bairro Luis Cabral community during the weekend at night were found to be higher than those during weekdays. This may be attributed to the increased night-time activity, such as loud music, coupled with noise from the traffic and the GT. Table 11.2-6 shows the summary of the noise monitoring results of each monitoring point.

Table 11.2-6 Monitoring results in 11 monitoring points

Monitoring point	Discussion of Results
MP01	This point is situated at the entrance of the Power Station site. It is approximately 100 m from the EN2 highway. The noise environment was mainly affected by the traffic noise from the EN2 and the noise from the GTs when in operation. The distance of this point to the existing No. 2 GT is approximately 180 m. The measured ambient noise levels at this point were below the World Bank/IFC Ambient Noise Guidelines of 70 dB(A) for industrial zones.
MP02	MP02 is at the center of the site, approximately 120 m from the EN2 highway and 60 m from the existing No. 2 GT. The noise environment at this point was dominated by the GT operation and by the highway traffic. When the No. 2 GT was in operation, the noise level reached 72.1 dB(A). The noise levels for the remaining time periods were all below the World Bank/IFC Ambient Noise Guidelines of 70 dB(A) for industrial zones.
MP03	This point is located near the northern corner of the site, approximately 50 m from the EN2 highway. The noise environment at this point was dominated by the road traffic and the GT operation. In addition, the noise levels were intermittently elevated due to passing trains. The measured ambient noise levels at this point for all time periods were below the World Bank/IFC Ambient Noise Guidelines of 70 dB(A) for industrial zones.
MP04	This point is located at the center of the northeastern fence line of the site, approximately 100 m from the EN2 highway and 120 m from the existing No. 2 GT. The predominant noise sources at this point were the vehicular traffic from the highway and the GT when it was in operation. Similar to MP03, the noise levels at MP04 were intermittently elevated due to the passing trains. The measured ambient noise levels were below the World Bank/IFC Ambient Noise Guidelines of 70 dB(A) for industrial zones, except for a weekday morning measurement reaching 74.4 dB(A), due to a passing train from the Maputo Terminal.
MP05	This point is located near the southeastern corner of the site. It is approximately 150 m from the EN2 highway. The noise environment at this point was primarily affected by the EN2 road traffic and the railway activity. The two elevated noise levels measured, i.e., 67.4 dB(A) and 67.6 dB(A), were all due to passing trains. In the evenings, the noise levels at this point were increased due to insect and frog activity. The evening noise levels, without the influence of the passing trains, reached 61.2 dB(A). The measured noise levels at this point for the remaining time periods were around 50 dB(A). As can be seen from the weekend night-time measurement, GT operation did not cause any significant increase of the noise level at MP05. This was due to the fact that nearby buildings provided shielding from the noise generated by the turbine operation.
MP06	This point is at the northern border of the Bairro Luis Cabral community, about 20 m from the EN2 highway. The noise environment at this point was primarily affected by the vehicular traffic on the EN2. The measured noise levels at this location were above the World Bank/IFC Ambient Noise Guidelines for residential and the SANS guidelines for urban districts with main roads. The average measured noise level reached 62.2 dB(A).

Monitoring point	Discussion of Results
MP07	The location of this point is within the Bairro Luis Cabral community, approximately 120 m from the site's fence line and 25 m from the EN2 highway. The main contributor to the noise environment at this location was the vehicular traffic on the EN2. The measured noise levels at MP07 were above the World Bank/IFC Ambient Noise Guidelines for residential zones and the SANS guidelines for urban districts with main roads.
MP08	This point lies within the Bairro Luis Cabral community, approximately 70 m from the site's fence line and the EN2 highway. The noise environment is affected by the vehicular traffic on the EN2 and localised domestic activities, including music, peoples' conversations, children playing and other human activities. The measured noise levels at this point were above the World Bank/IFC Ambient Noise Guidelines for residential and the SANS guidelines for urban districts with main roads.
MP09	This point is situated within the Bairro Luis Cabral community, which is approximately 100 m from the EN2 highway. Similar to MP08, the main noise sources here were the traffic from the EN2 and domestic activities. The noise from GT operation was audible at this point, but not intrusive. The measured noise levels at this point were slightly above the World Bank/IFC Ambient Noise Guidelines for residential, but within the SANS guidelines for urban districts with main roads.
MP10	This point is close to the northern border of the Bairro Luis Cabral community, approximately 35 m from the EN2 highway. The noise environment at this point was primarily affected by the vehicular traffic on the above-mentioned road. The measured noise levels at this point exceeded the World Bank/IFC Ambient Noise Guidelines for residential areas and were slightly above the SANS guidelines for urban districts with main roads.
MP11	The MP11 is situated 70 m southwest of point MP02 at the center of the site and close to the existing fuel tanks and the existing No. 2 GT. The noise environment at this point was primarily dominated by the GT operation and by the vehicular traffic on the EN2. When the existing No. 2 GT was in operation, the noise levels reached 74 dB(A), thus exceeding the World Bank/IFC Ambient Noise Guidelines of 70 dB(A) for industrial zones. The noise levels for the remaining time periods were all below the World Bank/IFC Ambient Noise Guidelines for industrial areas.

(Source: JICA Study Team)

(4) Topography

The elevation in the study area is considered to be low (<4 m above MSL of Port Maputo) due to its coastal location. The topography of the site is regular with elevations descending steadily towards the coast and consequently the slopes are mild. Refer to Chapter 5 for a detailed description of the topographic condition of the proposed site.

(5) Geology and Soil

The soil texture of the proposed site is considered to be sandy-clay-loam in nature. The origin of the soil in the site is likely from alluvial deposits associated with the proximity of the site to the major river system, the Infulune River. Refer to Chapter 5 for a detailed description of geology and soil condition of the proposed site.

(6) Hydrology

The proposed site is associated with the Infulune River, which is approximately 300 m west of the proposed Project site. Fronting the Project site is an intertidal zone and a mangrove forest that slightly extends to the southern end of the site.

To the north of the site, a storm water channel was observed running parallel to the railway. At two points along this storm water channel, culverts passed beneath the railway enabling the routing of storm water to Maputo Bay and beneath the site. A 'saturated surface depression' was also noted at the north of the CTM site. This depression runs parallel to the CTM boundary (and railway). The source of the water saturating this area is unknown and may be due to a number of reasons such as surface water run-on and an associated impermeable depression, groundwater extrusion or a burst pipe. Refer to Chapter *5* for a detailed description on hydrological conditions of the site.

(7) Water Quality

On the basis of the hydrological characteristics of the site, surface water samples were taken in order to determine the quality of water surrounding the site. Four (4) samples were tested from the following monitoring locations namely:

1) Sample 1 at the existing tap on site which supplies domestic water;
2) Sample 2 at the Infulune river at the west side of the site;
3) Sample 3 at the Maputo Bay intertidal area at close proximity to the site; and
4) Sample 4 at the storm channel located southeast of the site, which drains the roads and housing upstream.

Figure 11.2-11 shows the location map. The results of the laboratory sample tests are illustrated in Table 11.2-7.

(Source: JICA Study Team)

Figure 11.2-11 Location of water quality monitoring points

Table 11.2-7 Water quality at monitoring points

Sample Number (Concentrations in mg/l unless indicated otherwise)	WHO Drinking Water (Fourth Edition)	Mozambique-Ministry of Health	Sample 1	Sample 2	Sample 3	Sample 4
pH – Value at 25°C		6.5-8.5	7.8	7.9	7.7	7.8
Electrical Conductivity in mS/m at 25°C		50-2000	55.9	4 460	4 180	517
Total Dissolved Solids at 180°C		1000	324	31 894	29 598	3 286
Total Suspended Solids at 105°C			14.8	171	142	76
Total Alkalinity as $CaCO_3$			124	136	196	372
Bicarbonate as HCO_3			151	166	239	453
Carbonate as CO_3			<5	<5	<5	<5
Chloride as Cl	250	250	90	17 572	11 830	1 148
Sulphate as SO_4	500	250	22	2 614	2 425	287
Fluoride as F	1.5	1.5	0.3	0.8	0.8	0.5
Nitrate as N [NO3]	50	50	0.2	<0.2	<0.2	30
E Coli / 100 mℓ	0	0	0	14	8	47
Total Petroleum Hydrocarbons (TPH-BTEX) [s] (see detailed report)			<0.001	<0.001	<0.001	<0.001
Alkanes (see detailed report)			<0.001	<0.001	<0.001	<0.001
Ag			<0.025	<0.025	<0.025	<0.025
Al	0.2	0.2	0.278	1.46	1.82	0.266
As	0.01	0.01	<0.010	<0.010	<0.010	<0.010
B	2.4	0.3	0.09	4.41	4.13	0.56
Ba	0.7	0.7	0.095	0.032	0.048	0.091
Be			<0.025	<0.025	<0.025	<0.025
Bi			<0.025	<0.025	<0.025	<0.025
Ca		50	22	340	343	149
Cd	0.003	0.003	<0.005	<0.005	<0.005	<0.005
Co			<0.025	<0.025	<0.025	<0.025
Cr	0.05	0.05	<0.025	<0.025	<0.025	<0.025
Cu	2	1	<0.025	<0.025	<0.025	<0.025
Fe		0.3	0.134	0.988	1.34	0.749
K			3.7	431	377	76
Li			<0.025	0.25	0.21	<0.025
Mg		50	15	777	734	92
Mn	0.1	0.1	<0.025	0.069	0.469	0.364
Mo	0.07	0.07	<0.025	<0.025	<0.025	<0.025
Na	200	200	68	10530	7852	747
Ni	0.07	0.02	<0.025	<0.025	<0.025	<0.025
P		0.1	<0.025	<0.025	0.072	0.565
Pb	0.01		<0.020	<0.020	<0.020	<0.020
S			5.73	585	538	70
Sb	0.02		<0.010	<0.010	<0.010	<0.010
Se	0.04	0.01	<0.020	<0.020	<0.020	<0.020
Si			4.9	2.1	3.3	5
Sn			<0.025	<0.025	<0.025	<0.025
Sr			0.155	6.85	6	1.08
Ti			<0.025	0.035	0.044	<0.025
V			<0.025	<0.025	<0.025	<0.025
W			<0.025	<0.025	<0.025	<0.025
Zn		3	<0.025	<0.025	<0.025	<0.025
Zr			<0.025	<0.025	<0.025	<0.025

(Source: JICA Study Team)

As shown in the above table, it is evident that water from Sample 1 is of good quality and the only parameter highlighted that is of concern is aluminum; however, the concentration can be skewed by mobilization of aluminum under lower ph values (acidified bottles). Samples 2 and 3 indicate a saline environment with elevated concentrations of chlorine, sulphate, aluminum, boron, calcium, magnesium and sodium. The total dissolved solids and electrical conductive are also high. E-coli were present, presumably from the immediate upstream informal settlement. The

result of Sample 4 showed a high level of E-coli (47/100 ml) with elevated concentrations of chloride, sulphate, aluminum, boron, calcium, magnesium, iron, magnesium, manganese, sodium and phosphorous. All samples were tested for hydrocarbons via TPH BTEX testing and none of these samples indicated the presence of hydrocarbons.

11.2.2 Socio-economic Conditions

(1) Socio-demographic Conditions

(a) Administrative division and demography

The proposed Project site is located in Luis Cabral suburb, which is administratively under Ka Mubukwana District (formerly Urban District 5) of Maputo City. The Ka Mubukwana District is composed of 14 suburbs, of which Luis Cabral has the highest population accounting for a total of 6,985 households based on the 2007 census. Table 11.2-8 provides detailed information as to the total population in Luis Cabral.

Table 11.2-8 Population in Ka Mubukwana District, 2007

Area	1997 Census	2007 Census	Growth Rate
Maputo City	966,837	1,094,315	
Ka Mubuwana	211,008	293,995	39.3
Luis Cabral suburb	33,553	33,800	0.7
% of population in urban district	15.9	11.5	-4.4

(Source: Adapted from INE 1999, INE 2010 and CmMaputo 2010)

Administratively, the urban district is headed by an Administrator nominated by the President of the City Council and the suburbs are headed by a Suburb Secretary. Each suburb is divided into city blocks delimited by roads called *quarteróes*. The *quarteróes* are numbered and each is headed by a Head of the Q*uarteráo*. The Luis Cabral suburb is divided into 83 *quarteróes*. The *quarteróes* surrounding the proposed Project site are the *quarteróes* 39 and 40a and b.

(b) Housing

Housing varies considerably in Luis Cabral suburb and consists of predominantly reed houses or huts built with either light or concrete materials. The reed houses in *quarteróes* 40a and 40b are generally covered with a zinc roof and the structures are generally either wood or tin sheets and most have no windows. Inside, they are divided into compartments with a compacted mud floor. The yards are generally reed fenced.

(c) Education

There are three complete primary schools in Luis Cabral but no secondary schools. In 2012, there were 5,334 students enrolled in these schools. There is also a newly established Dom Bosco Higher Institute, constructed in 2007 to train teachers through distance learning. In 2008, the institute introduced new courses in tourism and administration. At present, there are 266 students enrolled. The location of Dom Bosco Higher Institute is at the former Maquinag plot, the land area opposite to the proposed Project site.

(d) Health and sanitation

In terms of health concerns, malaria, tuberculosis and HIV/AIDS are the common diseases. Most of the people in Luis Cabral have access to health services in the nearby Jose Macamo Hospital, which is located not far from the Project site, but it belongs to Malanga suburb (Urban District Nhamankuku).

Sanitation is one of the major concerns in Luis Cabral suburb because of the absence of good sewage and solid waste disposal systems. Most *quarteróes* next to the proposed Project site do not have proper latrines. However, there are on-going initiatives that are taking place in order to improve the sanitation and public health funded by Family Health International.

(e) Water supply

The water is administered by the FIPAG (Fundo de Investimento and Património de Abastecimento de Água). The public provider of tapped water to households in Maputo City is Águas de Moçambique (AdM). Accordingly, of the 14 suburbs in Ka Mubukwana Urban District, only 10 were covered by AdM's water supply. The majority of the people in Luis Cabral suburb are covered by the public water supply network. However, in quarteirõ 39 (which comprises quarteirão 39 and 39a-39f) and quarteirão 40 (which comprises quarteirão 40 and 40a-40b), households have no tapped water supply. A public water fountain has been installed in the each one of the "mother"-quarteirões (which means in city blocks 39 and 40), where households can fetch water they need. The public fountain is located across the EN2.

(2) Economic Conditions

(a) Agriculture

Considering that the land use of the proposed Project site and its surrounding environment is industrial, agriculture activities are very limited except for vacant and unused land where some communities get permission to cultivate. The vacant and unused land close to the Project site is used by nearby *quoarteróes* to plant cash crops and maize for domestic consumption.

(b) Fisheries

The first inhabitants in Luis Cabral suburb were from Inhambane province and practiced fishing in Maputo Bay. However, in recent years, only a few people rely on fishing and only a small number of *quarteróes* own wooden boats. Fishing in Luis Cabral is limited to domestic consumption.

(c) Industries

Most people near the Project site are laborers and workers of industrial companies like Ford (opposite the proposed Project site), small companies for air conditioning and freezer repairs, Volvo and Hyundai, FRESPO (trucking company), and the port terminal, which is not far from the Project site.

11.3 System and Organization of Environmental and Social Considerations in Mozambique

11.3.1 Environmental Laws, Regulations and Standards in Mozambique

(1) Environmental Laws and Regulations

Mozambique has relatively well-developed legal frameworks for environmental management and protection. These are manifested by the adequate number of well-enforced legal instruments. Some of these laws and regulations are listed in Table 11.3-1.

The umbrella law, known as the Environmental Law (Law No. 20/97) mandates all environmental matters in Mozambique and is considered to be an important instrument in the enactment and passage of various and specialized environmental decrees and regulations in the country.

Significant highlights of this Law include, among others, the following basic principles for environmental management in Mozambique:

- Rational utilization and management of the environment with a view to the promotion of improved quality of life of citizens and maintenance of biodiversity and ecosystems
- Recognition of traditions and local knowledge which may contribute to the conservation and preservation of natural resources and the environment
- Equitable access to natural resources for all
- Public participation

The domain of the Environmental Law comprises all activities private or public, which directly or indirectly influence the environment and those that fall under the constitutional provision for “an ecological balanced environment” for all citizens.

Table 11.3-1 Environmental regulations in Mozambique

Description of the Environmental Regulation	Legal Instrument Title
• Environmental Law (Lei do Ambiente)	Law No. 20/97
• Land Act	Law No. 19/97
• Regulations on Waste	Municipal Law No. 2/97
• Forestry & Wildlife Act	Law No. 10/1999
• Regulation for Flora and Fauna Resource Protection	Decree No. 12/2002
• Environmental Auditing *(Regulamento relative ao processo de auditoria ambiental)*	Decree No. 32/2003
• Regulation for Industrial Activities *(Regulamento do Licernciamento da Actividades Industrial)*	Decree No. 39/2003
• Standards for Environmental Quality and Effluent Emissions *(Regulamento sobre os pa sobre os padrões de qualidade ambiental e de emissão de efluentes)*	Decree No. 18/2004
• Regulation on Mining *(Regulamento ambiental para actividade miniera)*	Decree No. 26/2004
• Regulation on EIA Process, replacing Decree No. 76/98 *(Regulamento sobre o processo de avaliação do impacto ambiental)*	Decree No. 45/2004
• Regulation on Waste Management	Decree No. 13/2006

(Source: MICOA)

(2) Environmental Standards Applicable to the Proposed Project

(a) Mozambican Environmental Standards

Mozambique has not yet developed any guidelines related to environmental assessment that are applicable to the industrial sector. However, Decree No. 18/2004 was passed on standards for environmental quality and effluent emissions, which serves as the basis for the EIA Authority in evaluating EIA reports. The purpose of this regulation is to establish the standards for environmental quality and effluent emissions in order to control and maintain admissible levels of concentration of pollutants into the environment. The provision of the regulation is applied to all new public and private activities having a direct or indirect impact on the environment. The existing power plants are required to evaluate and adapt their equipment to ensure compliance within five years of the date of publication of the regulations. Although the regulation covers air quality, water quality, soil quality, and noise, standards for certain other parameters are yet to be established. Accordingly, non-compliance with any of the pollution standards set out under the regulations or those applicable recognized standards and the failure to report exceedance, is punishable by a fine of between 20 million to 200 million MTn.

Table 11.3-2 to Table 11.3-4 illustrate the environmental guidelines set forth under the environmental quality and effluent emissions standards in Mozambique.

Table 11.3-2 Air quality standards in Mozambique

(mg/Nm^3)

Parameters	Sampling Time							
	1 hour		8 hours		24 hours		Annual Arithmetical Mean	
	Primary	Second-ary	Primary	Second-ary	Primary	Second-ary	Primary	Second-ary
Sulfur dioxide (SO_2)	800				365		80	
Nitrogen dioxide (NO_2)	400				200		100	
Carbon monoxide (CO)	40,000		10,000					
Ozone (O_3)	160				50		70	
Total suspended particle					200			
Lead (Pb)	3						0.5-1.5	

(Source: Government Bulletin, 02 June 2004 (Decree No. 18/2004))

Table 11.3-3 Standards of emission for airborne pollutants by thermal power stations

(mg/Nm^3)

Activity	Total of Suspended Particles	SO_x	NO_x	Others
Thermal power stations (new)	50	0.2 per day (500 MW) 0.1 per day (>500 MW)	Coal = 750 Diesel = 460 Gas = 320	

(Source: Government Bulletin, 02 June 2004 (Decree No. 18/2004))

Table 11.3-4 Standards of potentially harmful substances

Parameter	Maximum Limits	Parameter	Maximum Limits
Aluminum	1.5 mg/l	Phenols	0.001 mg/l
Ammonia	0.4 mg/l	Soluble Iron	0.3 mg/l
Antimony	0.2 mg/l	Fluorides	1.4 mg/l
Arsenic	0.05 mg/l	Manganese	0.1 mg/l
Barium	1.0 mg/l	Mercury	0.0001 mg/l
Beryllium	1.5 mg/l	Nickel	0.1 mg/l
Boron	5.0 mg/l	Nitrates	10.0 mg/l
Bromine	0.1 mg/l	Nitrites	1.0 mg/l
Cadmium	0.005 mg/l	Silver	0.005 mg/l
Lead	0.01 mg/l	Selenium	0.01 mg/l
Cyanide	0.005 mg/l	Surface-active substances that react to methylene blue	0.5 mg/l
Residual chlorine	0.01 mg/l	Sulphides such as H_2S	0.002 mg/l
Copper	0.05 mg/l	Thallium	0.1 mg/l
Total chrome	0.05 mg/l	Uranium	0.5 mg/l
Tin	2.0 mg/l	Zinc	0.01 mg/l

(Source: Government Bulletin, 02 June 2004 (Decree No. 18/2004))

(b) Regional and International Environmental Standards

In the absence of environmental quality and effluent standards set forth under Decree No. 18/2004, particularly on significant parameters, the Mozambique government follows the standards set by the following:

- South African Bureau of Standards
- World Health Organization
- World Bank – International Financial Corporation

1) South African National Ambient Air Quality Standards on Selected Parameters

Mozambique's Decree No. 18/2004 on Environmental Quality Standards and Effluent Emissions has yet to establish the standards for the following parameters: $PM_{10,}$ dust, and noise; thus, the following standards are adopted from the South African National Air Quality values. Table 11.3-5 and Table 11.3-6 illustrate the standards for the parameters mentioned.

Table 11.3-5 Ambient air quality standards for PM_{10} parameter

Pollutants	Average Period	Limit value in $\mu g/m^3$	Frequency of Exceedance	Compliance Date
PM_{10}	24 hours	120	4	Up to 31 Dec 2014
		75	4	Up to 1 Jan 2015
	1 Year	50	0	Up to 31 Dec 2014
		40	0	Up to 1 Jan 2015

(Source: Air Quality Act- (No. 39 of 2004) (NEM:AQA), SANS 69 and SANS 1929:2005 Ambient Air Quality)

Table 11.3-6 Dust-fall criteria

Classification	Description
Slight	Less than 250 $mg/m^2/day$
Moderate	250 to 500 $mg/ m^2/day$
Heavy	500 to 1,200 $mg/ m^2/day$
Very Heavy	More than 1,200 $mg/ m^2/day$

(Source: Air Quality Act (No. 39 of 2004))

2) World Health Organization

The global environmental standards set by WHO are also being used as a reference in Mozambique as far as environmental health is concerned, including some of the significant parameters illustrated in Table 11.3 7.

Table 11.3-7 WHO ambient air quality guidelines

Parameter	Guideline
PM_{25}	10 μg/m^3 annual mean
	25 μg/m^3 24 hour mean
PM_{10}	20 μg/m^3 annual mean
	50 μg/m^3 24 hour mean
Ozone (O_3)	100 μg/m^3 8 hour mean
Nitrogen dioxide (NO_2)	40 μg/m^3 annual mean
	200 μg/m^3 1 hour mean
Sulfur dioxide (SO_2)	20 μg/m^3 24 hour mean
	500 μg/m^3 10 minute mean

(Source: WHO Air Quality Guideline Global Update 2005)

3) International Finance Corporation (IFC) – World Bank Group

In the absence of standards and guidelines, Mozambique uses the guidelines for noise levels set by the South African Noise Control Standards and the International Finance Corporation – World Bank Group Environmental Health and Safety Guidelines. Table 11.3-8 illustrates the following ambient noise levels set the IFC-World Bank Group.

Table 11.3-8 IFC ambiant noise level guidelines

Receptor	1 Hour L_{Aeq} (dBA)	
	Daytime: 07:00 – 22:00	Night Time: 22:00 – 07:00
Residential, Institutional and Educational	55	45
Industrial, Commercial	70	70

(Source: IFC-World Bank Group Environment Health and Safety (EHS) Guideline on Noise Management, 2007)

With regards to effluent standards, the IFC-EHS Guidelines for Thermal Power Plants (2008) have specified performance indicators and environmental monitoring requirements. This guideline stipulates: *"Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the General EHS Guideline (2007). Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in standards of countries with recognized regulatory frameworks. These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels due to specific local project conditions should be justified in the environmental assessment."*

Table 11.3 9 provides the effluent guidelines based on parameters.

Table 11.3-9 IFC Effluent Guidelines

Parameter	Unit mg/L, except for pH and Temp
pH	6-9
TSS	50
Oil and grease	10
Total residual chlorine	0.2
Chromium-Total (Cr)	0.5
Copper (Cu)	0.5
Iron (Fe)	1.0
Zinc (Zn)	1.0
Lead (Pb)	0.5
Cadmium (Cd)	0.1
Mercury (Hg)	.005
Arsenic (As)	.05
Temperature increase by thermal discharge from cooling system	• Site specific requirement to be established by the EIA • Elevated temperature areas due to discharge of once-through cooling system (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EIA depending on the sensitive aquatic ecosystem around the discharge point.

(Source: IFC-EHS Guidelines for Thermal Power Plants, 2008)

11.3.2 Environmental Impact Assessment System in Mozambique

(1) Legal Basis of Environmental Impact Assessment

Decree No. 45/2004, known as the Regulation on EIA Process, provides the EIA procedural framework in the conduct, evaluation and overall management of EIA process in Mozambique. It outlines the steps to be undertaken for all development activities, whether public or private.

The EIA Regulation also mandates that only EIA professionals *(técnicos médios e superiores)* who are registered environmental consultants can undertake an EIA process in Mozambique. Consultants are required to register either as individuals, companies or as a consortium of companies (e.g., for a specific project) and are required to have at least five years of relevant experience at the time of registration. Only an 'advanced' professional can act as a project manager and sign on EIA reports. For non-Mozambican companies who wish to conduct an EIA process in the country, the process must be subcontracted to a company registered in Mozambique. In addition, the company must submit documentation consisting of a list of similar projects undertaken, CVs and the qualifications of each member proposed for the EIA team. Corresponding fees are collected in accordance to the following:

Table 11.3-10 Licensing and fees

Required Fees	Amount
Issuance of Registration Certificate for Environmental Consulting Firms	30 million MTn
Issuance of Registration Certificate for Individual Environmental Consultants	10 million MTn
Updating of Registration (every 3 years for environmental consulting firms)	15 million MTn
Updating of Registration (every 3 years for individual environmental consultants)	5 million MTn

(Source: Country Report, 2007-South African Development Community Handbook on Environmental Legislation)

(2) System of Project Categorization

(a) Classification and Categorization of Project

Environmental assessment requirements of projects depend on the significant impacts and are evaluated based on location, sensitivity, scale, nature and magnitude of impact. Therefore, projects are screened based on their expected environmental impacts and are classified as one of the following categories.

- Category A are those projects that may have a significant impact on the environment and whose activities are listed in Appendix 1 of the EIA Regulations including, among others, power generation, transmission lines with a voltage of 110 kV with a length of more than 10 km, and gas pipelines longer than 5 km. Project types like these require an EIA level study and the formulation of an Environmental Management Plan.
- Category B are those projects or activities listed in Appendix 2 of the EIA Regulations, which do not significantly affect communities, environmentally sensitive areas and for which, the intensity and extent of impact are lower than that of those in Category A. Category B projects only require a Simplified Environmental report (SER).
- Category C are those projects or activities listed in Appendix 3 of the EIA Regulations, which show insignificant or negligible impacts on the environment. A declaration for exemption for any EIA or SER requirement will be issued by the EIA authority or responsible DPCA.

(3) Process of Environmental Impact Assessment

A brief description of the salient EIA process is described below and Figure 11.3-1 shows the schematic presentation of such process.

(a) Application and Screening

A compulsory application form called the Preliminary Environmental Information Form shall be filed by the project proponent and submitted to MICOA or at a designated Provincial Directorate

for Environmental Affairs (PDCA). Based on the information contained in the application form, MICOA or PDCA will conduct a screening or pre-evaluation in order to determine the project classification and categorization.

(b) Environmental Pre-Viability Report and Scoping Definition (EPDA)

An EPDA is a compulsory requirement for all Category A projects. This document contains a preliminary prediction of impact and identification of significant environmental and social issues to be scoped during the EIA Study.

(c) TOR for the Environmental Study

The Terms of Reference (TOR) is a set of steps and processes to be followed by the registered consultants in the conduct of an EIA level study for Category A projects and SER level study for Category B projects.

(d) Review and Approval Process

The TOR for Category A projects shall be submitted to the EIA Authority for review and approval before the start of the EIA Study, while for the Category B projects, the TOR shall be submitted to the respective DPCA for review and approval.

(e) EIA Report and SE Report

EIA Report and SE Report shall be submitted to an EIA Authority and DPCA, respectively for review and approval.

(f) Public Participation Process

For Category A projects, intensive public participation processes are required and compulsory in order to generate feedback from the general public on their perceptions and ideas regarding the project. The public participation process is optional for Category B projects.

(g) Schedule of Decision-making

Decisions by the EIA authorities (MICOA and/or DPCA) are to be made in accordance with the following schedule:

Table 11.3-11 Schedule of decision-making, by project category

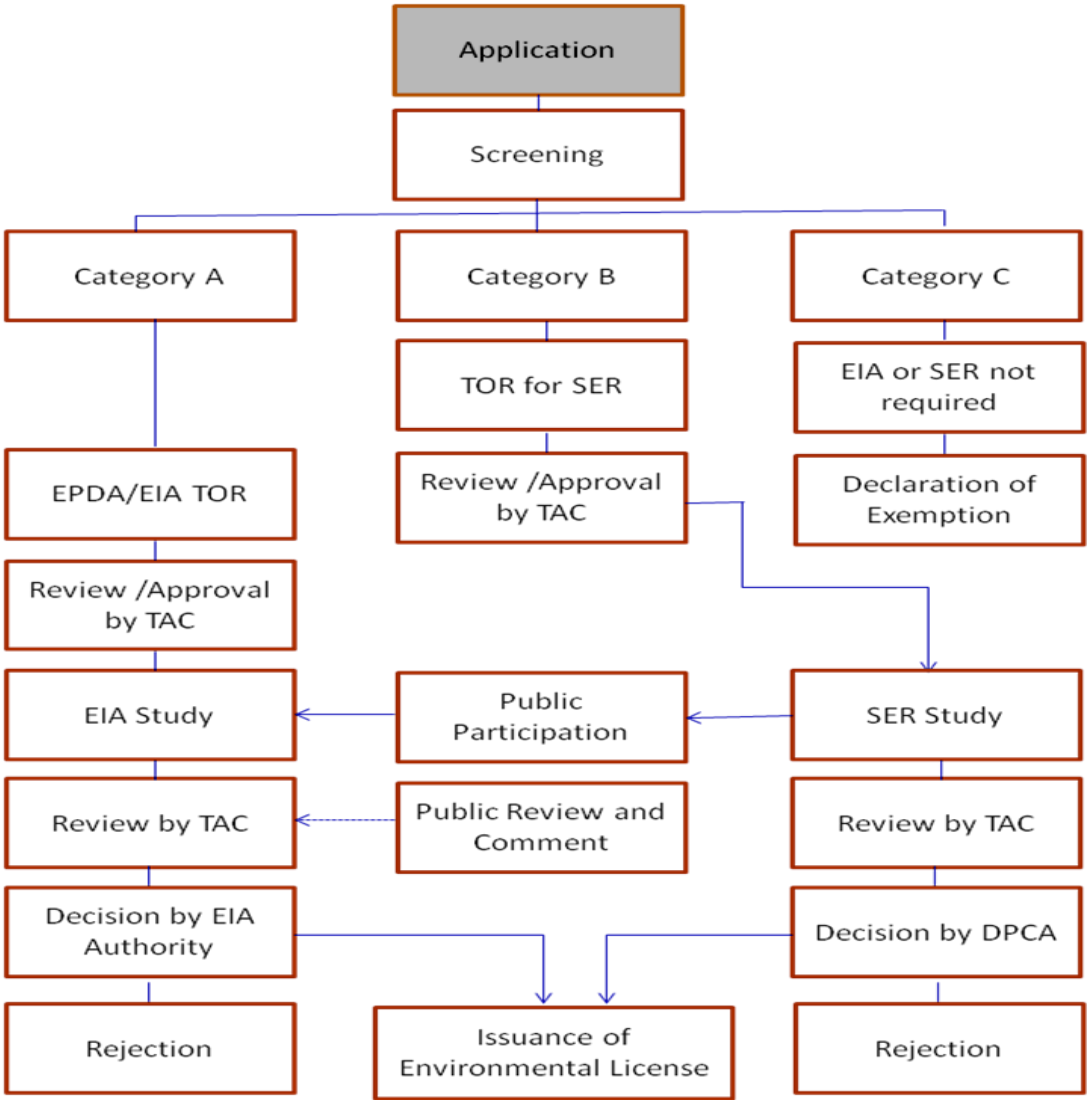
EIA Process	Schedule of Decision-making (in days)		
	Category A	Category B	Category C
Screening/IE	5	5	5
EPDA/TOR	30	15	-
EIA/SER Review	45	30	-
Public Participation Process	30 days	Optional	-

(Source: MICOA, Article 18 of Decree 45/2004-EIA Regulation)

(h) Issuance of Environmental License

The issuance of the environmental licenses are granted by the MICOA and/or DPCA upon the payment of licensing fees applied based on the classification and categorization of the projects as follows:

- Environmental license for Category A and B projects: 0.1% of the total value of investments
- Issuance for exemption declaration for Category C projects: 0.01% of the total value of investments



(Source: MICOA)

Figure 11.3-1 Schematic presentation of the EIA process in Mozambique

(4) Comparison of Environmental and Social Considerations Guidelines

The JICA Guidelines of April 2010 on environmental and social considerations is the fundamental instrument used in carrying out the environmental assessment for this Project in Mozambique. However, environmental laws and regulations in Mozambique are also being considered. In addition, the policies and guidelines published by the Asian Development Bank (ADB) are being referred to in order to ensure that significant environmental and social elements of the Project are balanced and looked into fairly. Based on the study conducted, no significant differences or gaps have been identified among the three legal documents mentioned. Table 11.3-12 shows the comparative descriptions of significant environmental and social considerations published by JICA, ADB and the Government of Mozambique, which are relevant in carrying out the Project.

Table 11.3-12 Comparison of environmental and social considerations by JICA, ADB and Mozambique

Significant Items	JICA	ADB	Mozambique
Disclosure of information	• Environmental assessment reports are accessible to any interested parties and general public and accessible through the JICA website.	• Environmental assessment reports for ADB projects are accessible to interested parties and the general public.	• Environmental assessment reports are accessible to the general public.
Public participation process	• JICA social acceptability policy dictates the need for public participation process. • In order to have meaningful meetings, JICA encourages project proponents to publicize and consult with local stakeholders, with particular attention to directly affected people. • In the case of Category A projects, project proponents need to consult with local stakeholders about their understanding of development needs, the likely adverse impacts on the environment and society, and the analysis of alternatives at an early stage. • In the case of Category B projects, project proponents are required to consult with local stakeholders when necessary.	• ADB requires public consultation in the environmental assessment process. • For Category A and B projects, the borrower must consult with groups affected by the proposed project and local non-government organizations (NGOs). • For Category A projects, ADB ensures that the borrower carries out public consultation at least twice: (i) once during the early stages of EIA field work; and (ii) once when the draft EIA report is available, and prior to loan appraisal by ADB. The public consultation process needs to be described in the EIA and SEIA reports.	• Article 13 of the EIA regulations sets out in broad terms the basic components of the public participation process during the compilation of environmental assessment reports. • In some cases, MICOA may see public comment or hold a public hearing during the review process of any documents submitted before approval. • For Category A projects, public participation is a mandatory process. It is optional for Category B projects. • Public meetings must be advertised at least 15 days in advance, to which all interested parties are invited to comment.
Safeguard Policies	• For projects that will result in large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. • It is desirable that the resettlement action plan will include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.	• ADB has three safeguard policies, namely: a) Indigenous People's (IP) Policy b) Environment Policy c) Involuntary Resettlement (IR) Policy. These policies set important provisions to make sure that development projects are not detrimental or harmful to the society	• MICOA coordinates with the Ministry of Gender and Social Affairs in cases of human resettlement, compensation and rehabilitation of people affected and displaced by development projects.

Significant Items	JICA	ADB	Mozambique
	• Measures for the affected indigenous peoples must be prepared as an indigenous peoples plan (which may constitute a part of other documents for environmental and social consideration) and must be made public in compliance with the relevant laws and ordinances of the host country. • It is desirable that the indigenous peoples plan will include the elements laid out in the World Bank Safeguard Policy, OP4.10. Annex B.	and the environment. These policies, in principle, set guidelines on how to ensure the observance of the rights of vulnerable groups and protection of the environment.	
Examination of measures	• Multiple alternatives must be examined in order to avoid or minimize adverse impacts. • In the examination of measures, priority is given to avoidance of environmental impacts; when this is not possible, minimization and reduction of impacts must be considered. • Compensation measures must be examined only when impacts cannot be avoided by any of the aforementioned measures. • Appropriate follow-up plans and systems, such as monitoring and environmental management plans, must be prepared including costs and the financial methods to fund such activities. Projects with particularly large potential adverse impacts must be accompanied by detailed environmental management plans.	• ADB requires proponents to study the comparison and evaluation of REASONABLE ALTERNATIVES included in the approaches to the selection of alternatives, NO ACTION alternative, and evaluation and comparison of alternatives, in relation to social and environmental problems, costs and benefits. • According to the Operation Manual issued October 2003, Category A and environmentally sensitive Category B projects require, as part of the environmental assessment process, the development of EMPs that outline specific mitigation measures, environmental monitoring requirements, and related institutional arrangements, including budgets.	• Article 2 of the EIA regulation mandates the study and comparison of alternatives including a No Go option. • An Environmental Management Plan including mitigation measures, and monitoring of impacts, environmental education, accident prevention and contingency plans are required to be incorporated in the EIA/SER reports. • Article 24 of EIA Regulations requires regular inspections and audits for Category A and B projects to ensure that EMP is properly implemented and enforced.

(Source: JICA Study Team)

11.3.3 Organization Responsible for EIA System in Mozambique

(1) Ministério para a Coordenação da Acção Ambiental (MICOA)

The Ministério para a Coordenação da Acção Ambiental (MICOA) was established in 1995 with the mandate to implement the National Environmental Management Plan, enforce environmental policies and legislation as well as to coordinate with relevant ministries on environmental concerns and ensure that the environmental considerations are integrated into sector plans, programs, policies and development projects. Figure 11.3-2 shows MICOA's organizational structure.

MICOA is composed of five departments, namely: environmental impact assessment, management of natural resources, land planning, promotion of environmental awareness and planning, for which each department has its own respective mandates.

In December 1999, the EIA Department was upgraded to National Directorate of Environmental Impact Assessment in order to effectively and efficiently implement the mandate contained in Law No. 20/97 known as the Environmental Law. The new enhanced National EIA Directorate comprises of a team of professional staff, including a National Director, deployed flexibly to perform the tasks and supported by EIA Department and Environmental Auditing Department.

Furthermore, in line with the government's decentralization policy and in order to discharge its mandate more effectively, MICOA established the Provincial Directorates to coordinate environmental affairs (DPCAs) at the provincial level in ten provinces all over the country. In principle, the role of the provincial directorates is to facilitate the implementation of the centrally developed environmental legislation, policies and programs, including EIA regulations and guidelines at the local level. At present, most of the provincial governments have institutionalized a Department of Environmental Management and some provinces have established a separate EIA Department.

(2) Other Key Ministries/Departments Involved in Environmental Protection

(a) National Commission for Sustainable Development.

The National Commission for Sustainable Development is linked to the Council of Ministers, which was created in October 2000 by a provision in the Framework Environmental Act. This commission seeks to ensure the effective coordination and integration of sector policies and plans related to environmental management at the highest level.

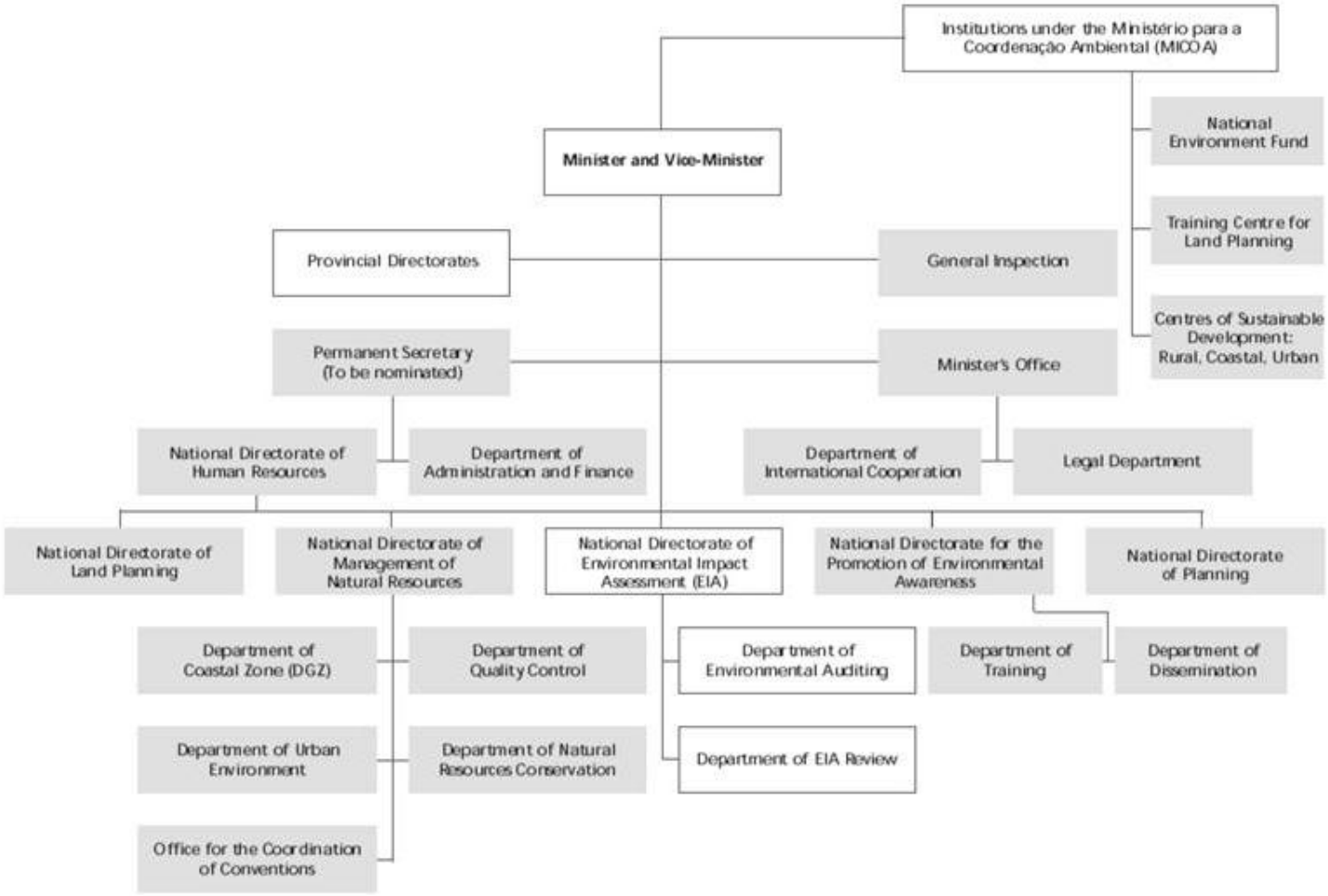
(b) The Ministry of Agriculture and Rural Development has a broad responsibility in relation to natural environmental management including agriculture, livestock, forestry and wildlife.

(c) The Ministry of National Directorate of Forestry and Wildlife is in charge of managing the country's vast forestry and wildlife resources outside national parks and reserves.

(d) The Ministry of Tourism also known as the Directorate for Conservation Areas is responsible for the protection of National Parks, unless these parks have been specifically declared by another agency.

(e) The Ministry of Fisheries is responsible for the implementation of Law No. 3/1990 known as the Fisheries Law that covers management of freshwater and marine fish resources as well as overseeing aqua and marine-culture industries.

(f) The Ministry of Trade and Industry is involved in larger development projects.



(Source: Country Report-South African Development Community Handbook on Environmental Legislation)

Figure 11.3-2 Organization structure of MICOA

11.3.4 Project Categorization of the Proposed Project

(1) Project Categorization

The Electriçidade de Moçambique (EDM) submitted the application to MICOA Headquarters and DPCA on October 11, 2012 in order to obtain the classification and categorization of the proposed Project. After the screening process, MICOA categorized the proposed Project as Category A as per official communication received by EDM on 23 October 2012. Based on information gathered, the result of the categorization of the proposed Project was in accordance with the following criteria:

- Project type (hydroelectric power plants, thermal power plant stations with 110 kV power transmission lines with more than 10 km in length, and a gas pipeline of more than 5 km as listed in Appendix 1 of the EIA Regulations
- Probability, nature, duration and extent and significance of potential impacts of the proposed Project
- Direct and indirect impacts of the Project with global cumulative effect
- Reversibility of impacts and the likelihood of compliance with Mozambican environmental quality standards or applicable regional and international standards
- Previous knowledge of the proposed Project site
- Amount or value of the investment

(2) Undertakings of EDM

EDM is scheduled to proceed with the official EIA procedure required by MICOA (refer to Figure 11.3-1 for the process involved in Category A projects) and shall take the necessary steps in obtaining the environmental license. A tentative schedule of work related to the EIA process has been drawn as shown in Table 11.3-13. The schedule was drawn on the basis of JICA's information disclosure policies related to the sharing of the results on the Environmental and Social Considerations ("ESC") studies undertaken during the FS stage of the Project.

Table 11.3-13 Tentative schedule of official EIA process of the proposed project

Broad Tasks/Activities	2012			2013											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Application to MICOA	▲														
Consultancy Service Procurement Procedure		┈┈	┈┈	┈┈											
Commission Local Consultant for follow thru activiies on JICA ESC Study					▬										
Follow thru activities and EPDA/TOR submission						▬									
MICOA's decisions on EPDA/TOR						▬	▬								
EIA Study							▬	▬	▬						
Approval Process of EIA Report									▬						
Issuance of Environmental License										▬	▬	┈┈	┈┈		

(Source: JICA Study Team)

11.4 Comparison and Study of Alternatives (including Zero Option or Without Project)

11.4.1 Project Site Selection

There are two sites proposed for the development of the new power plant in Mozambique namely: the site in Beluluane Industrial Park and the existing Maputo Thermal Power Plant (CTM) in Maputo City. The Beluluane Industrial Park site is located along the Maputo Corridor, approximately 18 km west of Maputo city and about 20 km from the Port of Maputo. The CTM site is located approximately 3 km west of the urban district of Maputo city. There are no significant environmental and social considerations (refer to Chapter *3* of this Report for detailed information about the sites) in either site, and no sensitive environmental characteristics or areas of environmental significance have been identified. Hence, the criteria used in the selection of the Project site centered on the following:

- Land use
- Area size for development
- Site accessibility and ease in land preparation
- Topographic condition of the site
- Maximum applicable output based on transmission line capacity
- Availability of fuel gas volume
- Availability of water resource
- Applicability of appropriate cooling system
- Availability of potential configuration of CCGT

On the basis of the above criteria, the CTM site is considered to be the most advantageous site compared to the Beluluane site.

Table 11.4 1 shows the results of the comparative analysis undertaken by the JICA Study Team in October 2012.

Table 11.4-1 Summarized results of the comparative study on site selection

Criteria		Proposed Sites	
		CTM Site	Beluluane Site
1	Land use	Industrial use/Mixed use	Industrial use
2	Area size for development	3.7 hectares	1.5 hectares
3	Site accessibility and ease in land preparation	Easy access during transport and land clearance	Easy access during transport and land clearance
4	Topographic condition of the site	Flat	Moderate
5	Maximum applicable output based on transmission line capacity	100 MW or more	50 MW
6	Availability of fuel gas volume	6.0 MGJ/year	3.0 MGJ/year
7	Availability of water resource	Sufficient water resource	Insufficient water resource
8	Applicability of appropriate cooling system	3 applicable cooling system alternatives: once-through, wet cooling tower and air-cooled condenser	Cooling system option is limited to air-cooled condenser
9	Availability of potential configuration of CCGT	Wide selection of prospects for of CCGT configuration	Prospects for selection of CCGT configuration are few

(Source: JICA Study Team)

11.4.2 Type of Cooling System

There are three (3) cooling systems identified that are potentially applicable to the envisioned new power plant namely: once-through, wet cooling tower and air-cooled condenser.

The following criteria are used to determine the best possible option:

- Environmental consideration
- Technical consideration
- Administrative consideration
- Duration of construction
- Construction cost
- Lifetime cost

The comparative results of the evaluation by the JICA Study Team in October 2012 are shown in Table 11.4 2 below.

Table 11.4-2 Summarized results of the comparative study on cooling system

Criteria		Cooling Condenser System		
		Once-through	**Wet cooling tower**	**Air-cooled condenser**
1	Environmental consideration	Uses sea/river water for cooling (about 7,000 m^3/h)	Uses fresh water for cooling (about 300 m^3/h)	Doesn't use water for cooling
		Abundant source of water near Project site (Maputo Bay and Infulune River)	Water is expensive in Maputo	Considerable impact on noise and vibration
		Considerable impact on the coastal zone including near shore deformation, coastal water quality and sea-bottom sedimentation, marine ecosystem including fishery, sea grass, benthos, beach vegetation including mangroves, etc. caused by the change in ecosystem conditions and increase in temperature of the discharge water	Considerable impact on the carryover when salt and other contaminants are present in the water droplets	
2	Technical consideration	Highest plant efficiency	Lower plant efficiency by vacuum level	Lower plant efficiency by vacuum level
3	Administrative consideration	Requires approval from Maputo Port Development Company[1] for the use of the coastal zone	n/a	n/a
4	Duration of construction	Longer construction period	Shorter construction period	Shorter construction period
5	Construction cost[2]	Relatively higher construction cost	Relatively high construction cost comparable to once-through	Relatively lower construction cost compared to once-through and wet condenser system
		Needs construction of new intake system and pipeline		
6	Estimated lifetime cost[3]	US$ 360.3 million	US$ 357.3 million	US$ 340.2 million

(Source: JICA Study Team)

[1] Maputo Port Development Company is an authority that operates and governs the Mozambique ports of Maputo and Matola. It holds the concession to manage, construct, operate, develop and optimize the concession area until 2033 with options to extend.
[2] Please refer to Chapter 9 for detailed information on Project cost.
[3] Please refer to Chapter 10 on economic and financial analysis.

11.4.3 Zero Option or Without Project

Without the Project, in order to bridge the gap in power balance up to completion of the STE Project, EDM needs to acquire power from gas-fired thermal plants being planned mainly in Ressano Garcia. Natural gas can be tapped off the existing gas pipeline transferring gas from the Pande & Temane Gas Fields in Mozambique to South Africa.

Since these power plants are generally located in inland hilly areas where cooling water cannot be easily obtained, gas engines are to be mainly used for power generation. On the other hand, the proposed new power plant is expected to be a Combined Cycle Gas Turbine (CCGT) plant, and can achieve a higher thermal efficiency than a gas-engine power plant. Therefore, even if the plant output is the same, CCGT plants will emit less CO_2 than gas-engine power plants. Assuming the gas-engine power plant with an output of 100 MW is replaced by a CCGT plant with the same output, the potential CO_2 emission reductions can be preliminarily calculated as follows:

Potential reduction in CO_2 emission

① Rated output: 100MW
② Capacity Factor: 83%
③ LHV/HHV ratio: 0.9019
④ Gas consumption of CCGT power plant (assuming thermal efficiency at LHV of 50%): 5,804,459 GJ/year
⑤ Gas consumption of gas-engine power plant (assuming thermal efficiency at LHV of 44%[4]): 6,595,977 GJ/year
⑥ CO_2 emission factor for natural gas: 0.051 tCO_2/GJ
⑦ CO_2 emission reduction: 40,774 tCO_2 (=(⑤-④)*⑤)

Since Mozambique with a significant proportion of hydro-generation capacity (95%) has an extremely low Grid Emission Factor (GEF), grid-connected CDM projects are not feasible.

[4] Environmental Pre-Feasibility Study and Scope Definition for Mozambique Gas Engine Power Plant (MGEPP) Project in Ressano Garcia, Mozambique (2011)

11.5 Scoping and TOR for the Environmental and Social Consideration Study

11.5.1 Scoping for Environmental and Social Consideration Issues

The scoping for significant environmental and social issues of the Project was undertaken in accordance to JICA Guidelines for Category B projects and the environmental regulations of Mozambique.

In order to ensure that all significant environmental and social issues are considered, an environmental checklist was generated, details of which are attached in the Appendix-7 of this Report. Table 11.5-1 below provides the summarized items in the environmental checklist.

Table 11.5-1 Items in the environmental checklist

Category		Item/Environmental Parameter
1	Permits, approval and public participation process	EIA and environmental license Public participation and stakeholders engagement
2	Environmental quality standards	Air quality Water quality Noise/vibration Waste management Soil Site contamination Climate change factors
3	Natural environment	Topography Geology Hydrology Ecosystem Biodiversity Protected areas Area of environmental significance
4	Economic and social environment	Local economy Resettlement Indigenous people Landscape Cultural heritage Health and Safety

(Source: JICA Study Team)

On the basis of the above, the JICA Study Team conducted an initial evaluation of these environmental elements to determine key environmental issues to be included and scoped in the environmental and social considerations study. Table 11.5-2 illustrates significant results.

Table 11.5-2 Draft scoping of environmental impact

Classification	Environment Parameter	Evaluation		Reasons for Evaluation
		Construction	Operation and Maintenance	
Environmental quality standard and pollution control	Air quality	B-	C-	During construction, air pollutants are expected from heavy equipment and trucks, which generate dust and CO_2 gas. During O&M, emissions to the atmosphere by significant pollutant parameters need to be clarified. Understanding the baseline conditions is important.
	Water quality	D	C-	Prior to construction, the quality of surface waters in the site and its surroundings need to be determined in order to understand its characteristics.
	Noise/vibration	B-	C-	Noise is a critical aspect. The Project site has existing facilities that are sometimes used by EDM. The site is near a national highway and a railway line. These and other sources of noise should be clarified apart from the noise level that the Project will produce during construction and O&M. This is an issue raised during Board Meeting with EDM in Oct. 2012.
	Waste	C-	C-	Domestic and industrial wastes including hazardous and a range of other typical waste material are expected during construction and O&M. It is important to understand waste management standards and ensure a good and effective waste management system.
	Soil	C-	D	The site used to be a coal power station. Soil contamination issues need to be clarified.
	Climate change Factors	D	C-	Emissions to the atmosphere by the significant parameter (CO_2), which maybe have an impact on the ozone layer, can be expected in the long run.
Natural Environment	Topography	D	D	The Project will not affect or change the topographic features of the Project site.
	Geology	D	D	The Project will not affect or change the geological characteristics of the Project site.
	Hydrology	C-	C-	In 2000, Maputo was submerged by floodwater. During O&M, measures to mitigate or avoid this should be taken into consideration.
	Ecosystem	D	D	The Project is not expected to affect the ecosystem.
	Biodiversity	D	D	The Project is not expected to impact biodiversity.
	Protected areas	D	D	The Project is not near any protected areas so an impact is not expected.
	Areas of environmental significance	D	D	No areas for environmental significance are present in the Project site although there is a mangrove forest in the surrounding area. However, the Project is not expected to impact the mangrove

Classification	Environment Parameter	Evaluation		Reasons for Evaluation
		Construction	Operation and Maintenance	
				forest.
Social Environment	Local Economy	C+	C+	The Project may result in employment generation and is expected to encourage and increase livelihood and business opportunities for people living near the Project site.
	Resettlement	D	D	Resettlement is not expected in the Project area. This was scoped out based on interviews and a site visit.
	Indigenous people	D	D	No indigenous peoples will be affected by the Project. This item was scoped out based on interviews and a site visit.
	Cultural Heritage	D	D	There is no identified cultural heritage site near the Project site. This item was scoped out based on interviews and a site visit.
	Health and Safety	B-	C-	During construction activities, tendencies are high that the Project will attract travelers to participate in some illegal activities such as prostitution, etc. During construction and operation works, workers are exposed to various types of risks.

Legend:
A+/- : Significant positive/negative impact is expected
B+/- : Positive/negative impact is expected
C+/- : Extent of positive impact/extent of negative impact is unknown (needs further investigation and clarification or whether the impact can be clarified as the ESC Study progresses)
D : No significant impact is expected or no impact at all is expected

(Source: JICA Study Team)

11.5.2 TOR for Environmental and Social Considerations Study

The results of the scoping activities are used in drawing out the TOR for the conduct of the environmental and social consideration study. There were five significant environmental issues that require clarification and further investigation namely: air quality, water quality, noise/vibration, waste management, and social and economic conditions of the people living in the surrounding area of the Project site. Soil and hydrological surveys are undertaken in conjunction with the civil works. More detailed investigation of significant environmental issues, including soil contamination and the significance of site contamination assessment are considered for intensive investigation during the official EIA study to be undertaken by EDM.

It is important to stress that while the principle in conducting the ESC study is following the JICA Guidelines for Category B, in the absence of secondary data, and in consonance with the environmental regulations of Mozambique, significant baseline level information are gathered in a simplified manner in order to provide baseline information necessary to predict and evaluate the impact of the proposed Project. Local consultants are commissioned to assist the

JICA Study Team in carrying out these tasks efficiently and effectively. It is noted, that the outputs of these studies will serve as a working document for EDM once the official EIA process commences. Table 11.5-3 outlines the terms of reference in the conduct of the environmental and social consideration study.

Table 11.5-3 TOR for environmental and social consideration study

Environmental and Social Issues		Survey Items	Methodology
1	Air Quality	• Clarify environmental standards • Review of climate data including temperature, humidity, wind direction and speed, rainfall and solar radiation in nearby observation station including hourly/monthly highest, lowest and average data for the past three years • Establish air quality condition in the Project site for NO_2, SO_2, dust/PM_{10} • Identify current air pollution sources • Evaluate the impact	• Collection of secondary data • Field survey • Interview with relevant agencies • Field reconnaissance Survey
2	Noise/Vibration Level	• Clarify environmental standards • Establish baseline conditions of noise level in the Project site and surrounding areas • Evaluate the impact	• Collection of secondary data • Field survey • Interview with relevant agencies
3	Water Quality	• Clarify water quality environmental standards • Establish water quality condition in the Infulune River including the following parameters: water temperature, pH, DO (dissolved oxygen), COD, BOD, SS and coliform • Evaluate the impact	• Collection of data • Field survey • Field reconnaissance survey • Interview with relevant agencies
4	Waste Management	• Clarify waste management standards including wastewater discharge to rivers • Predict types and generated amount of construction • Evaluate the impact	• Collection of secondary data • Interview with relevant agencies
5	Social and economic conditions of the communities surrounding the Project site	• Clarify social and economic conditions of communities in the surrounding area of the Project site • Evaluate the impact	• Interview • Simplified survey
6	Stakeholders' Engagement	• Clarify views and opinion of people about the Project • Clarify environmental and social issues that are important to the people • Evaluate stakeholders' stakes, interest and needs	• Perception survey • Stakeholders' meeting/small group discussion/consultation

(Source: JICA Study Team)

11.6 Land Acquisition and Resettlement

11.6.1 Land Acquisition

Land acquisition is not necessary for this Project because the proposed site is within the vicinity of the existing power plant owned and operated by EDM.

11.6.2 Resettlement

There are no resettlements involved in the Project because there are no legal or illegal settlers that will be displaced.

11.7 Results of the Environmental and Social Study based on Scoping

Based on the results of the environmental and social study, the scope for the environmental impact assessments are identified as contained in Table 11.7-1.

Table 11.7-1 Results of the environmental and social study based on scoping

Item		Impact at scoping		Impact based on Study Results		Reason for Evaluation
		Con	O/M	Con	O/M	
Environmental quality standards and pollution control						
1	Air quality	**B-**	**C-**	**B-**	**B-**	• Air pollution can occur caused by gas emissions generated from the use of machinery, equipment and heavy trucks. However, the value of the particulate matter is lower than the prescribed air quality standards of Mozambique and the standards used by IFC and SANS. • Dust is generated from various sources including the different kinds of heavy earth works, although this can be temporary, as leveling works will only be done for a certain period. • During the pre-construction and construction period, there will be an increase in vehicle traffic as a result of transporting construction materials and construction/domestic wastes. • Emission gas generated from the Project is predicted to meet the air quality standards set by Mozambique (Decree No. 18/2004), SANS Ambient Air Quality Standard and IFC. When the existing GTs and the new power plant operate at the same time, there might be an increased concentration of NOx that may exceed air quality standards; however, this is also negligible as there is a plan to rehabilitate and upgrade the existing GTs.
2	Water quality	**D**	**C-**	**B-**	**B-**	• Wastewater containing concrete and oil will be generated. • It is assumed that during construction, workers will generate wastewater. • Leakage of the fuel from construction machinery can cause underground water pollution.

Item		Impact at scoping		Impact based on Study Results		Reason for Evaluation
		Con	O/M	Con	O/M	
						• Industrial and domestic wastewater will be treated at the waste treatment facility to meet the discharge standards prior to discharge.
3	Noise/Vibration	**C-**	**C-**	**B-**	**B-**	• Temporal increase of noise level effect in the community around the site during construction.
4	Waste	**B-**	**C-**	**B-**	**B-**	• General waste and hazardous waste are generated during construction as well as during operation and maintenance. Wastewater is also generated and is expected to be treated at the water treatment facility. This treated wastewater will be discharged to Maputo Bay/Infulune River. It is important to ensure that the discharged wastewater meets the required effluent standards in Mozambique, IFC or SANS.
5	Soil	**C-**	**D**	**B-**	**D-**	• Results of the soil investigation survey revealed that soil is partially contaminated with leachate and the seepage originating from the former coal stockyard located at the north side of the site. However, the contamination is limited to the surface soil, and contamination of soil in the surrounding area is not expected.
6	Climate factors	**D**	**C-**	**B-**	**B-**	• Emissions to the atmosphere by significant parameters (CO_2) impact the ozone layer, but because the capacity of the proposed plant is very small, the impact is not very significant.
Natural environment						
7	Topography	**D**	**D**	**D**	**D**	• The Project is on vacant land within the existing power plant and thus no changes in land use and topography are expected.
8	Geology	**D**	**D**	**D**	**D**	• There is no geological impact.
9	Hydrology	**C-**	**C-**	**B-**	**B-**	• The site is fronting an intertidal zone that extends slightly into the site. During the field survey, the storm water channel was noted running parallel to the nearby railway. A saturated surface depression was also noted that runs parallel to the site boundary and the railway. The depression was coincident with sedges indicating that the soil in the area is wet for a significant part of the year.
10	Ecosystem	**D**	**D**	**D**	**D**	• There is no known significant impact on the ecosystem.
11	Biodiversity	**D**	**D**	**D**	**D**	• There is no known impact on biodiversity.
12	Protected areas	**D**	**D**	**D**	**D**	• There is no known impact on protected areas.
13	Areas of environmental value	**D**	**D**	**D**	**D**	• There is no known impact on areas of environmental value to Mozambique.
Social environment						
14	Local economy	**C+**	**C+**	**C+**	**C+**	• The plant plans to employ local laborers. • Creation of enterprises to local residents is promoted with increase construction workers.
15	Resettlement	**D**	**D**	**D**	**D**	• The land is owned by EDM and there is no inhabitants presently occupying the area..

Item		Impact at scoping		Impact based on Study Results		Reason for Evaluation
		Con	O/M	Con	O/M	
16	Indigenous peoples	**D**	**D**	**D**	**D**	• There are no indigenous peoples in the area and no impact is expected to them.
17	Cultural heritage	**D**	**D**	**D**	**D**	• There is no known impact on cultural heritage.
18	Health and safety	**B-**	**C-**	**B-**	**B-**	• High possibility of work related accidents and risks of safety and overall well-being of the people in and around the plant. It is important to ensure a good and effective environment, and health and safety management system to mitigate any risks occurring in the plant during the construction and operation phase.

Legend:
A+/- : Significant positive/negative impact is expected
B+/- : Positive/negative impact is expected
C+/- : Extent of positive impact/extent of negative impact is unknown (needs further investigation and clarification or whether the impact can be clarified as the ESC Study progresses)
D : No significant impact is expected or no impact at all is expected

(Source: JICA Study Team)

11.8 Evaluation of Significant Environmental Impacts

The construction and operational phase of the proposed Project comprises various activities, each of which may have an impact on environmental parameters as mentioned in the preceding sections of this Report. Various impacts during the construction and operation phase on the environment have been studied to predict the impact on the environmental attributes. The probable impacts of each of these activities are predicted depending upon the inputs from the source, efficacy of pollution control equipment and capacity of the receiving environment.

11.8.1 Impact during Construction Phase

The impact during construction will be localized and in the short term, and will be primarily related to the civil works and less intensive impact is expected during erection of the equipment and trial operation. The environment impact matrix illustrating the impact of each activity during construction on the specific environment parameters is presented in Table 11.8 1 below.

Table 11.8-1 Environmental impact matrix

Activities	Environmental Parameters						
	Air quality	Water quality	Waste	Noise and vibration	Soil	Local economy	Health and safety
Civil construction works	X	X	X	X	X	X	X
Materials storage and handling	X			X		X	X
Water supply		X					
Mechanical and electrical erection	X			X		X	X
Transportation	X			X		X	X

(Source: JICA Study Team)

(1) Impact on Air Environment

The main source of emission during the construction phase is the movement of equipment and vehicles at the site. The equipment deployed during the construction phase is also likely to result in marginal increase in the levels of SO_2, NO_X and particulate matter. The impact is reversible, marginal and temporary in nature. The construction activities on site will be minimal and restricted to civil and small structural fabrication. Generally, the equipment will be fabricated outside and will only entail erection activities that will be carried out on site. Therefore, it helps to limit the construction period to a short span. The main sources of air pollution are:

- Vehicular exhaust due to transport of materials
- Fugitive windblown dust due to construction and vehicle movements
- Portable diesel generator sets and other onsite power generators
- Emissions from vehicles and equipment

Water sprinkling will be regularly carried out in order to prevent the fugitive dust to the maximum extent possible. All construction equipment shall be maintained properly. Only certified vehicles of the contractor shall be deployed at the site. However, as the plant site will be cordoned off, such particulate impacts will be confined to only within the plant site. The vehicular exhaust and other related activities would result in a rise of NO_X. However, the incremental values are expected to be negligible.

(2) Impact on Water Environment

Requirements of water will be mainly for concrete curing, usage in spray and sprinklers for dust suppression. Surface run off from the construction area, equipment and materials and generation of domestic sewage, grey water and subsequent discharge will have an impact on surface water. The main pollutants are organic components and microorganisms with the potential to cause contamination of surface water. Disinfected latrines (e.g., through regular cleaning) will be used as the main component of the sanitation system. The resulting wastewater could potentially carry inorganic solids and rapidly react to alkalinity as mentioned above and the applicable discharge standards. The potential negative impact is considered minor as it mostly occurs during the construction period and has no long-term impact from the viewpoint of persistent pollution. Alkaline wash water containing excessive amounts of cement will be settled and neutralized before discharge.

The overall impact on the water environment during the construction phase due to the proposed Project would be short term in duration and is considered insignificant.

(3) Impact on Waste

During the construction phase, various wastes will be generated including industrial solid waste, domestic waste at the construction site, sewage and other construction debris. The main concern on waste that may cause serious impact is the use of materials that contain PCB (polychlorinated biphenyl), PCT (polychlorinated terphenyl), asbestos and other dangerous substances. Hence, use of these should be avoided when possible. Other construction wastes, domestic waste and sewages can be mitigated by establishing a good waste management plan and vigorously implementing it.

(4) Noise Impact

The study area is likely to experience a comprehensive increase in ambient noise level due to the heavy construction activities, the traffic for loading and unloading, fabrication and handling of equipment and materials, construction equipment like concrete mixers, cranes, generators pumps, compressors, earth drills, pneumatic tools, vibrators, etc. During the construction phase, this equipment will generate noise ranging between 55–70 dB (A). The affected areas will be those that are closer to the site. To minimize the impact on nearby communities, construction schedules would be optimized to daytime activities and the night activities will be scaled down. Extensive earthmoving and movement of heavy equipment would be conducted only during the regular working hours in the daytime. Noise and vibration impacts at construction sites will be minimized by:

- Locating generators as far away as possible from the working area
- Fitting mufflers to road vehicles and construction equipment

- Adequate personal protective equipment like ear plugs and ear muffs shall be provided to the plant workers to reduce the effect of noise

Overall, the impact of generated noise on the environment during the construction period is likely to be insignificant, reversible, localized in nature and mainly confined to the day hours. The noise level will only drop down to an acceptable level once the construction period is over.

(5) Impact on Soil

Site preparation activities (like site clearing and leveling, excavation, earth movement) and construction activities would result in a permanent loss of topsoil in the construction area. The eroded soil may also get carried away by winds and be deposited on the surrounding area, thereby interfering with the free gaseous exchange of the plants. These impacts are envisaged to be insignificant because of the following reasons:

- It shall be confined to the construction areas
- The removed topsoil may be utilized for landscaping and land improvement in other areas, which are not under construction
- A physical barrier shall be created to make sure that impact are confined to the construction site

(6) Impact on Social Environment

(a) Local economy

The Project will create both direct and indirect job opportunities to the local population as much as possible. There will be some migration of skilled labor force from outside the study area during the construction phase, which may put some pressure on the local settlements and resources. Considering the size and type of construction activities envisaged, the immigration of the work force for the construction phase (including contractor laborers) would be insignificant to the immediate vicinity area. In addition, the socioeconomic status of the area may improve due to the inflow of workers, materials and money. Infrastructure facilities such as sanitation, fuel, restrooms, medical facilities, safety, etc. during the construction phase are proposed to be provided for the labor force during construction as well as for the casual workers including truck drivers. Some positive impacts of these activities may lead to the following:

- Increase in employment opportunity to non-workers as non-skilled or semi-skilled workers.
- Growth of services (like retail shops, automobile workshops, etc.) and an increase in employment and trade opportunities in the service sector.

The negative impacts could be summarized as follows:

- Strain on civic amenities (like road, transport, communication, water supply and sanitation, health care and recreational utilities, etc.) due to an increase in floating population.

- Increase in consumer prices of indigenous services and produces like eggs, fish, vegetables, milk, etc.

It is difficult to assess the above impacts quantitatively on a measurable scale. However, most of these impacts will be short term and limited to the construction period only. The increase in employment opportunities (project and service sector) and overall economic improvement of the area is certain to happen.

(b) Traffic congestion

Traffic volume on nearby roads will take place due to movement of heavy vehicles during the construction phase, which may cause public inconvenience. This will have a minimal affect considering the size and nature of the Project. A traffic management plan for the area will be developed to ease the situation. The following arrangements would be made to ease the situation.

- Existing roads will be strengthened, if required, for transportation of materials, goods, etc.
- Drivers of trucks/dumpers engaged in construction work will be instructed to give way to passenger buses, cars, etc. to avoid inconvenience to the public transport system.
- Transport of construction materials and machineries shall be carried out during lean traffic period of the day or during the night.

11.8.2 Impact during Operation Phase

The impact during the operation phase will be continuous in nature. For a gas-based plant of this capacity (100 MW), the potential for imparting adverse impacts is not high. However, any impact on the environment is expected to be minimized by incorporating efficient technologies for pollution control measures.

(1) Impact on Air Quality

Natural gas will be used as the fuel for operation. The exhaust gas due to combustion of gas from GTs during the operation may lead to air pollution by NOx. The current air quality is below the limit of the ambient air quality standards of Mozambique. Appropriate measures must be taken to ensure that the standards will be met in the future as well.

(a) Basic assumptions

Given that CCGT uses natural gas for operation, NO_2 levels will be predicted under the following special conditions resulting in high concentrations as well as normal diffusion conditions.

- Inversion Layer: if there is a temperature inversion layer above the stack, the exhaust gas

may remain under the inversion layer and result in a high concentration.

- Downdraft / Downwash: a downward flow caused by leeward entrapment due to the influence of a nearby building may lower the rising height of smoke emitted from a stack and result in a higher concentration of pollutants. This phenomenon is called downdraft. This phenomenon may be caused in general when 2.5 times the building height exceeds the height of the stack. On the other hand, a stack may entrap the smoke emitted from it due to the influence of a nearby building during strong wind and may lower the rising height of the smoke and result in a high concentration of pollutants. This phenomenon is called downwash. In general, downwash reportedly occurs with a wind speed 1.5 times or more than the exhaust gas speed.

(b) Present concentration of pollutants

As explained in Section 11.2, measurement is conducted at seven points in CTM Maputo. NO_2 ranges from 2.66μg/m^3 to 19.51μg/m^3 and SO_2 from less than 0.01μg/m^3 to 5.36μg/m^3 and those values fully meet those standards. Table 11.8-2 shows the results with the environmental quality standard of Mozambique and IFC/WB guideline value.

Given that actual data was not available at the time of conducting simulation analysis, the present NO_2 concentration for prediction was set at the highest level of 5.74μg/m^3.

Table 11.8-2 Measurement cases of atmospheric pollutants

(Unit: $\mu g/m^3$)

Item	Time	Reference	Mozambique's Environmental Quality Standard	EU Limit Value	IFC EHS General Guidelines	Japan's Environmental Quality Standard
Sulfur dioxide (SO_2)	10 min.	—	—	—	500	—
	1 hr	<0.01 – 5.36	800	350	—	260 (0.1ppm)
	24 hrs		365	125	125	100 (0.04ppm)
	Annual		80	20	—	—
Nitrogen dioxide (NO_2)	1 hr	1.17 - 5.74	400	200	200	—
	24 hrs		200	—	—	75 - 110 (0.04 - 0.06ppm)
	Annual		100	40	40	—
Suspended particulate matters (PM_{10})	1 hr		—	—	—	200
	24 hrs		200 (TSP)	50	150	100
	Annual		—	40	70	—

Note: 1. The IFC guidelines adopt a WHO value if there is no guideline in the relevant country. Of various stages of values of sulfur dioxide and suspended particulate matters such as from target values to guideline values, this table shows the Target value 1 that is of high emergency and equivalent of the environmental quality standards specified in other countries.

2. EU, "COUNCIL DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2008 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

3. Japan, "Environmental Quality Standard for Air Pollution", http://www.env.go.jp/kijun/taiki.html

4. IFC, "Environmental, Health, and Safety General Guidelines"

(Source: JICA Study Team)

(c) Prediction formula

The concentration under normal and special diffusion conditions will be predicted using different Gaussian diffusion models as shown below according to the time scale in the environmental quality standards of Mozambique.

■ Normal conditions

$$C(x,y,z)=\frac{Q}{2\pi\,\sigma_y\sigma_z u}\exp\left(\frac{y^2}{2\sigma_y^2}\right)\left(\exp\left\{-\frac{(z-He)^2}{2\sigma_z^2}\right\}+\exp\left\{-\frac{(z+He)^2}{2\sigma_z^2}\right\}\right)$$

In which,

C : Concentration at ground level and y (m) distance leeward

Qp : Volume of exhaust gas (g/s)

σ_y : Parameter in horizontal direction (m)

σ_z : Parameter in vertical direction (m)

u : Wind Speed (m/s)

y : Horizontal distance from the point of exhaust gas source to the calculation point (m)

z : Height from the ground (m)

He : Effective stack height (m)

$He = H + \Delta H$

H : Stack Height (m)

ΔH: Rising Height of Exhaust Gas (m)

Rising Height of Exhaust Gas is calculated using CONCAWE model.

■ Special conditions

<Inversion Layer>

$$C(x) = \frac{Q_p}{2\pi\cdot\sigma_y\cdot\sigma_z\cdot u}\cdot\sum_{n=-3}^{3}\left[\exp\left\{-\frac{(He+2n\cdot L)^2}{2\sigma_z^2}\right\}+\exp\left\{-\frac{(-He+2n\cdot L)^2}{2\sigma_z^2}\right\}\right]$$

In which,

C(x) : Concentration at ground level and y (m) distance leeward

Qp : Volume of Exhaust gas (g/s)

σ_y : Parameter in horizontal direction (m)

σ_z : Parameter in vertical direction (m)

u : Wind Speed (m/s)

He : Effective stack height (m)

L : Height of mixed layer (m)
(L = He in the worst case)
n : Number of reflection

<Downdraft / Downwash>

For the effective stack height, the following prediction formula was used with the lowered heights taken into consideration.

$He = Ho + \Delta H + \Delta H' + \Delta H''$

He : Effective stack height (m)
Ho : Actual stack height (m)
ΔH : Rising height (m)
$\Delta H'$: Reduced plume main axis in consideration of the effect of the stack
$\Delta H''$: Reduced plume main axis in consideration of the effect of the building

(d) Emissions specifications

The values as shown in Table 11.8-3 were used as emission specifications while the exhaust gas amount, temperature, and speed, and nitrogen oxide emissions were used for diffusion prediction based on the design conditions for the GT planned at present. The prediction was made on the assumption that all the exhaust nitrogen oxides are nitrogen dioxide. The suspended particulate matters from the GT were excluded from the prediction because the emissions are too small.

Table 11.8-3 Emissions specifications

Item	Unit	Newly installed GT		Existing GT
		No. 1	No. 2	Natural gas
Exhaust gas amount (wet)	Nm^3/h	381,960	381,960	
Exhaust gas temperature	°C	117	117	
Exhaust gas speed	m/s	18.8	18.8	
Actual stack height	m	30	30	
Nitrogen oxide emissions	kg/h	18	18	

Note: The values are at the maximum continuous load.

(Source: JICA Study Team)

(e) Meteorological conditions

The maximum concentration resulting from the diffusion of smoke emitted from the stack significantly is dependent on the wind speed and the diffusion parameter at the ground level. Hence, in order to study the actually predicted wind speed and diffusion parameter cases, data

and measurement from Instituto Nacional Weather Station # 64 covering the period from 2009 to 2011 were utilized. The meteorological data used are as shown below.

a. Temperature and humidity

The annual maximum ambient temperature range is 38.5°C to 43.0°C, the annual minimum temperature range is 8.9°C to 12.1°C and the annual average humidity range is 72.8% to 74.6% as shown in Table 11.8-4 and Table 11.8-5.

Table 11.8-4 Monthly ambient temperature

(°C)

Year	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2009	Maximum	39.2	39.9	33.8	34.2	36.5	32.4	33.1	31.9	35.3	36.0	31.8	41.5	41.5
	Minimum	17.5	18.4	16.6	15.2	15.0	9.8	8.9	10.6	13.5	12.2	14.2	17.0	8.9
2010	Maximum	35.9	35.6	36.3	35.1	34.2	31.3	28.7	34.5	37.6	38.1	38.5	37.4	38.5
	Minimum	18.2	19.7	20.0	13.5	14.5	9.4	10.3	11.0	13.7	14.0	16.5	-	9.4
2011	Maximum	37.9	36.1	34.3	35.8	34.7	34.5	32.9	37.7	41.1	41.7	43.0	38.4	43.0
	Minimum	20.9	19.9	17.0	12.5	13.0	12.8	12.1	13.6	14.1	14.8	15.0	17.9	12.1

(Source: JICA Study Team)

Table 11.8-5 Monthly humidity

(%)

Year	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2009	Average	79.9	78.2	74.4	69.0	74.3	70.4	70.6	73.5	73.2	78.0	79.0	75.3	74.6
	Minimum	66.0	64.0	62.0	47.0	56.0	34.0	52.0	53.0	39.0	57.0	59.0	65.0	34.0
	Maximum	97.0	95.0	94.0	79.0	86.0	98.0	93.0	93.0	95.0	98.0	97.0	93.0	98.0
2010	Average	76.6	74.0	78.2	80.5	75.7	69.4	75.5	68.3	63.9	69.2	70.4	71.8	72.8
	Minimum	62.0	65.0	67.0	60.0	48.0	46.0	46.0	32.0	30.0	41.0	40.0	48.0	30.0
	Maximum	98.0	93.0	92.0	97.0	94.0	87.0	89.0	95.0	73.0	91.0	94.0	92.0	98.0
2011	Average	76.8	76.0	79.9	78.3	76.1	73.9	77.6	73.2	76.5	78.6	78.1	75.1	76.7
	Minimum	66.0	68.0	73.0	66.0	57.0	39.0	37.0	32.0	42.0	56.0	65.0	61.0	32.0
	Maximum	90.0	92.0	91.0	86.0	88.0	88.0	95.0	88.0	91.0	90.0	92.0	86.0	95.0

(Source: JICA Study Team)

b. Wind direction/wind speed

The occurrence conditions of wind direction/wind speed during the period from 2009 to 2011 are as shown in Table 11.8-6 to Table 11.8-8 and Figure 11.8-1 to Figure 11.8-2. The most prevailing wind direction is southwest with an occurrence ratio of 23.2% followed by northwest with the occurrence ratio of 18.0% and west with the occurrence rate of 15.0%.

The most prevailing wind speed is 1.0 m/s to 1.9 m/s with 25.3% followed by 2.0 m/s to 2.9 m/s with 25.0% and 0.5 m/s to 0.9 m/s with 21.3%. Thus, the site has relatively weak winds in general but also a wind speed of more than 6 m/s with an occurrence ratio of more than 1%.

The annual average wind speed is 2 m/s. The wind speed is low from January to July and high

from August to December.

Table 11.8-6 Annual occurrence ratio by wind speed/wind direction (2009–2011)

(%)

Wind direction / Wind speed	N	NE	E	SE	S	SW	W	NW	Total
0.5-0.9 (m/s)	1.4	0.6	1.1	1.4	3.2	5.2	3.8	4.6	21.3
1.0-1.9 (m/s)	3.3	0.8	0.6	1.7	2.8	6.9	4.5	4.8	25.3
2.0-2.9 (m/s)	2.0	1.0	1.2	2.4	3.5	6.7	3.9	4.4	25.0
3.0-3.9 (m/s)	1.2	0.9	0.9	1.3	1.9	2.7	2.0	2.9	13.7
4.0-5.9 (m/s)	0.6	1.2	0.5	1.2	1.6	1.3	0.6	1.3	8.3
6.0-7.9 (m/s)	0.4	0.2	0.1	0.3	0.3	0.3	0.1	0.0	1.6
8.0< (m/s)	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Total	8.8	4.5	4.2	8.4	13.2	23.2	15.0	18.0	95.4
Calm (<0.4 m/s)									4.6

(Source: JICA Study Team)

Table 11.8-7 Monthly wind direction occurrence ratio (2009–2011)

(%)

Occurrence ratio	N	NE	E	SE	S	SW	W	NW
Jan	10.1	3.4	5.6	14.6	7.9	37.1	9.0	10.1
Feb	16.4	0.0	1.4	12.3	27.4	23.3	8.2	8.2
Mar	3.4	1.1	4.5	10.2	26.1	28.4	10.2	12.5
Apr	6.8	3.4	0.0	5.7	9.1	29.5	22.7	17.0
May	9.1	1.1	0.0	2.3	11.4	11.4	29.5	26.1
Jun	1.1	0.0	0.0	2.2	10.1	21.3	29.2	28.1
Jul	3.4	0.0	0.0	0.0	4.6	27.6	31.0	31.0
Aug	11.2	3.4	0.0	3.4	14.6	19.1	16.9	27.0
Sep	11.1	10.0	4.4	13.3	12.2	18.9	4.4	21.1
Oct	12.6	10.3	12.6	16.1	8.0	20.7	5.7	9.2
Nov	15.1	16.3	8.1	11.6	11.6	12.8	7.0	12.8
Dec	6.7	4.5	13.5	10.1	18.0	28.1	4.5	11.2
Annual	8.8	4.5	4.2	8.4	13.2	23.2	15.0	18.0

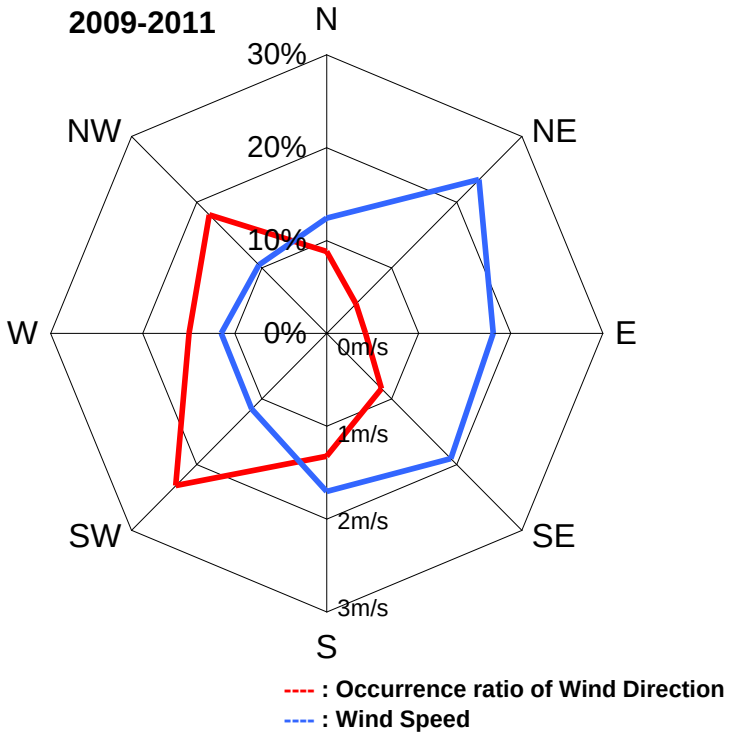
(Source: JICA Study Team)

Table 11.8-8 Monthly average wind speed by wind direction (2009–2011)

(m/s)

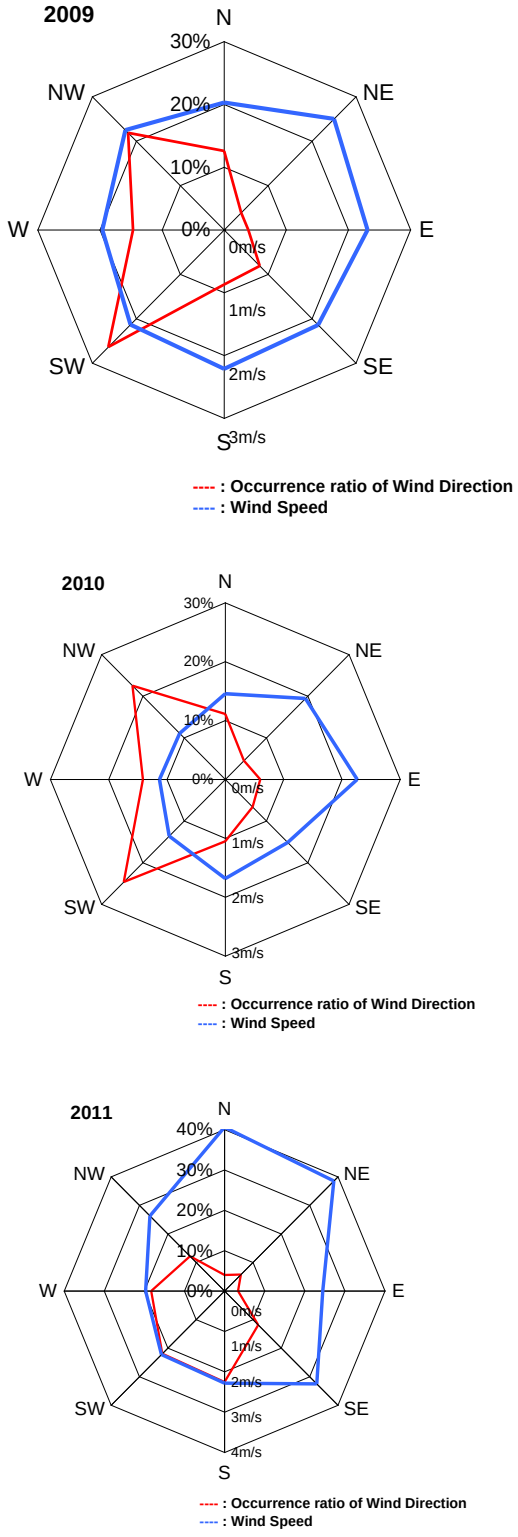
Month	N	NE	E	SE	S	SW	W	NW	Monthly
Jan	1.9	1.2	1.3	1.8	1.5	1.3	1.5	1.6	1.5
Feb	2.4		1.9	2.0	1.9	1.8	1.6	1.6	1.9
Mar	1.3	1.1	1.7	1.7	1.4	1.6	1.6	1.6	1.5
Apr	1.6	1.2		1.2	1.5	1.6	1.5	2.1	1.6
May	0.8	1.7		1.8	1.1	1.6	1.3	1.7	1.4
Jun	0.6			3.6	2.6	1.9	1.7	1.5	1.8
Jul	1.6				2.2	2.1	1.8	1.6	1.8
Aug	2.3	3.1		3.2	1.8	2.0	1.9	1.7	2.0
Sep	1.9	2.8	3.1	3.3	3.3	2.5	1.7	2.2	2.6
Oct	3.0	4.0	2.2	3.4	2.8	1.6	2.9	3.0	2.7
Nov	1.7	2.9	2.0	2.3	2.3	2.6	2.9	2.2	2.4
Dec	4.0	3.6	3.1	2.8	3.4	2.6	2.4	3.0	3.0
Annual	2.1	2.9	2.3	2.5	2.1	1.9	1.7	1.9	2.0

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 11.8-1 Wind rose (Average from 2009 to 2011)



(Source: JICA Study Team)

Figure 11.8-2 Wind rose (2009–2011)

(f) Study cases

a. Normal conditions

The calculation is conducted based on the stability and wind speed as shown in the Pasquill atmospheric stability categories. The wind speed observed at the Instituto Nacional Weather Station near the power plant is mostly low but sometimes exceeds 6 m/s. Accordingly, the wind speed was set at a range corresponding to the Pasquill atmospheric stability as shown in Table 11.8-10.

Table 11.8-9 Condition of the stability and wind speed

Stability		Wind speed at ground level (m/s)
Unstable	A	1, 2
	B	1, 2, 3, 4
Neutral	C	1, 2, 3, 4
	D	1, 2, 3, 4, 6, 8, 10

(Source: JICA Study Team)

Table 11.8-10 Pasquill stability categories

Wind speed at ground level U (m/s)	Daytime				Nighttime (rate of solar radiation = 0)
	Rate of solar radiation Q (unit 0.01 kWm-2)				
	60 < Q	30 - 59	15 - 29	1 – 14	
U < 2.0	A	A-B	B	D	F
2.0 - 2.9	A-B	B	C	D	E
3.0 - 3.9	B	B-C	C	D	D
4.0 - 5.9	C	C-D	D	D	D
6.0 < U	C	D	D	D	D

(Source: JICA Study Team)

The contributing concentration distribution was set at the southwest wind considering the typical wind directions recorded by the Instituto Nacional Weather Station are towards the southwest and northwest. The exhaust gas from the power plant heads towards the sea with a northwest wind, it heads towards residential areas with a southwest wind. The wind speed was calculated under the conditions where it shows the highest concentration at the ground level.

b. Special conditions

<Inversion layer>

The inversion layer was calculated with the atmospheric stability and wind speed with the highest concentration in light of the above diffusion results under the normal conditions.

<Downdraft/downwash>

The exhaust gas from the stack is emitted from a height of 30 m. Given that the downdraft phenomenon due to the building is caused by buildings with a height, 2.5 times of which exceed

the height of the stack, the study targeted buildings of 12 m or higher.

The structures with a height of 12 m or more at the power plant include the bypass stack (30 m), which is the highest at the power plant, and the heat recovery steam generator (HRSG, 30 m).

Downdraft was calculated by selecting all the cases shown in Table 11.8-9 in accordance with general diffusion conditions. The impact of downwash was insignificant given that the speed of the exhaust gas is set high (18.8 m/s) and the wind speed is 1.5 times higher than the set wind speed (28 m/s).

(g) Analytical results

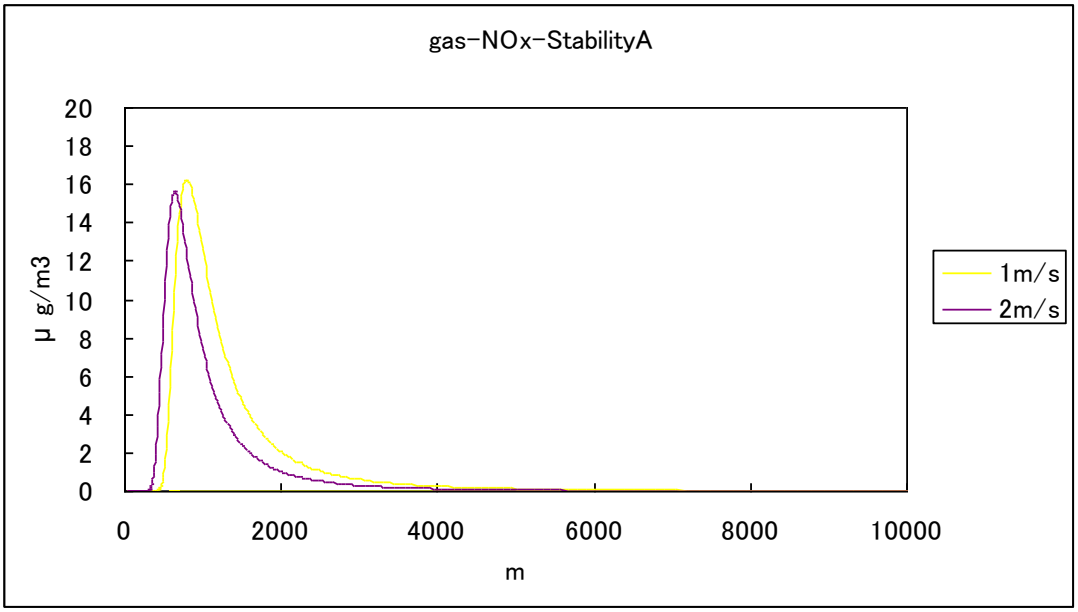
a. Normal conditions

The prediction results of the maximum concentration at the ground level of nitrogen dioxide emitted from CCGT are as shown in Figure 11.8-3, Figure 11.8-4 and Table 11.8-11.

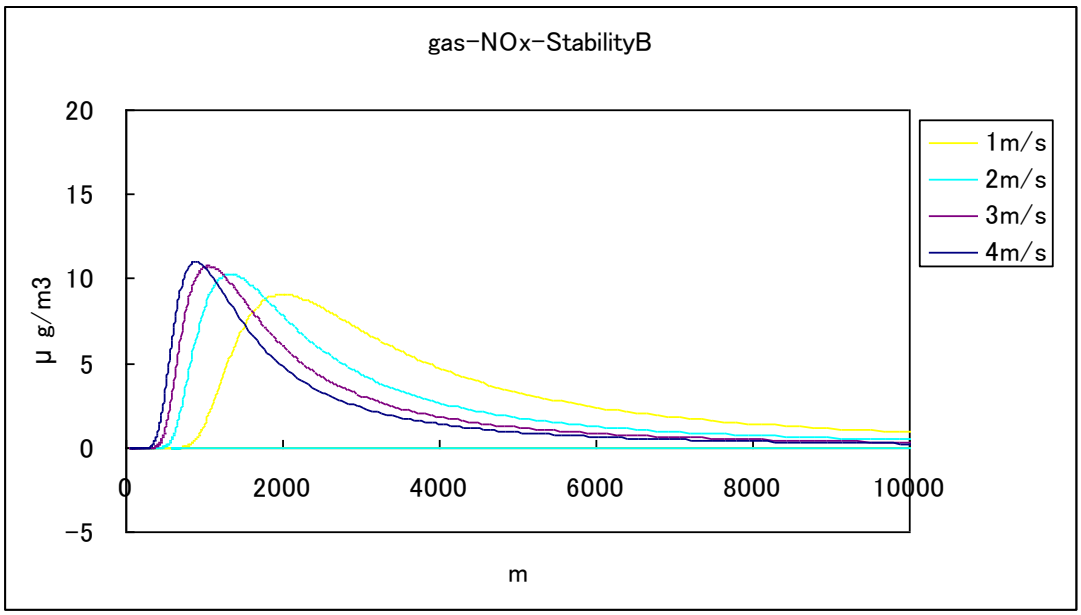
The maximum concentration of nitrogen dioxide is 16.3 $\mu g/m^3$, which is the highest at the wind speed of 1.0 m/s with atmospheric stability A at the ground level. This concentration is approximately 4% of Mozambique's environmental quality standards and approximately 8% of the IFC/WB guidelines.

As to the maximum future concentration (obtained by adding the present concentration to the predictive value), the concentration value is 22.04 $\mu g/m^3$, which is significantly lower than Mozambique's environmental quality standards and the IFC/WB guidelines.

(Atmospheric Stability A)



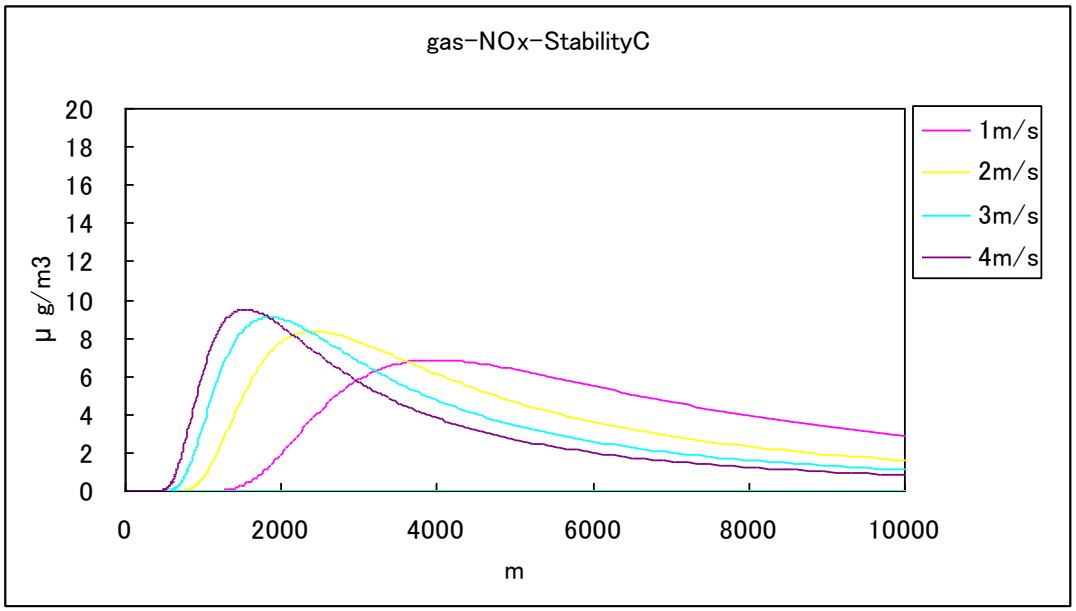
(Atmospheric Stability B)



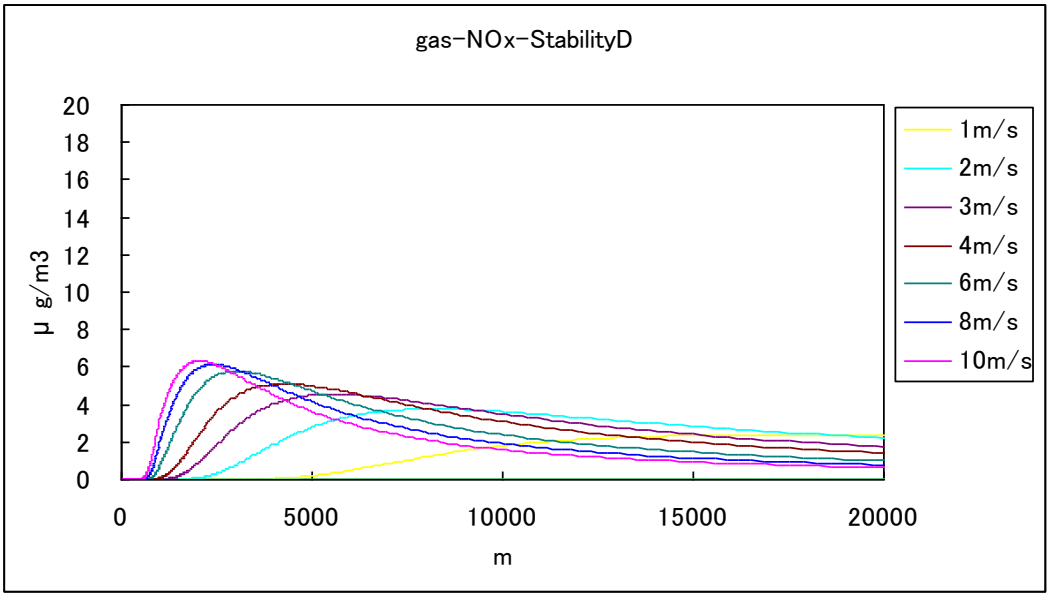
(Source: JICA Study Team)

Figure 11.8-3 Prediction Result of the Maximum Concentration at the Ground Level of NO_2 under the Normal Conditions Resulting from Installation of New CCGT (1 Hour Value) for Atmospheric Stabilities A and B

(Atmospheric Stability C)



(Atmospheric Stability D)



(Source: JICA Study Team)

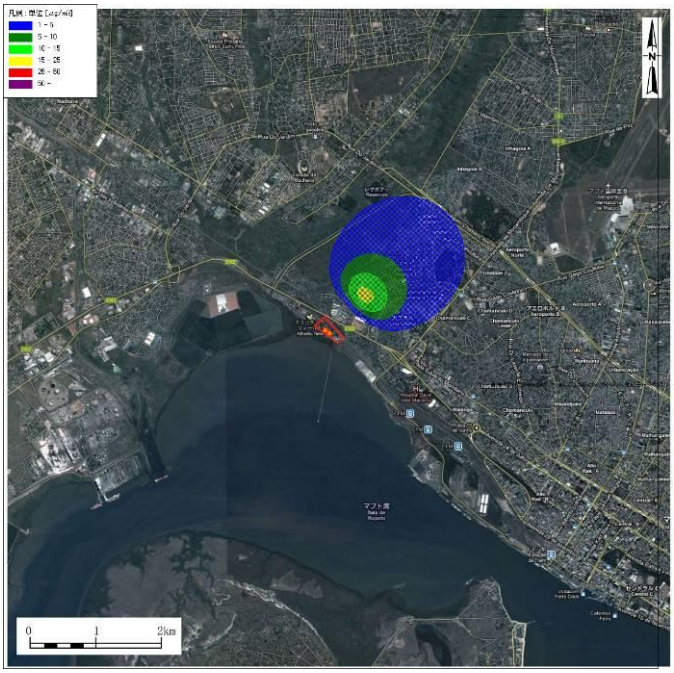
Figure 11.8-4 Prediction Result of the Maximum Concentration at the Ground Level of NO_2 under the Normal Conditions Resulting from Installation of New CCGT (1 Hour Value) for Atmospheric Stabilities C and D

Table 11.8-11 Prediction Result of the Maximum Future Concentration at the Ground Level of NO2 under the Normal Conditions Resulting from Installation of New CCGT (1 Hour Value)

Item	Stability	Wind speed	Maximum concentration at the ground level a ($\mu g/m^3$)	Distance for maximum concentration at the ground level (km)	Present concentration b ($\mu g/m^3$)	Maximum future concentration a+b ($\mu g/m^3$)	Mozambique atmospheric environmental quality standard ($\mu g/m^3$)	IFC/WB EHS guidelines ($\mu g/m^3$)
NO_2	A	1 m/s	**16.3**	0.8	5.74	**22.04**	400	200
		2 m/s	15.6	0.6		21.34		
	B	1 m/s	9.1	2.0		14.84		
		2 m/s	10.3	1.3		16.04		
		3 m/s	10.8	1.0		16.54		
		4 m/s	11.0	0.9		16.74		
	C	1 m/s	6.9	4.0		12.64		
		2 m/s	8.4	2.1		14.14		
		3 m/s	9.1	1.8		14.84		
		4 m/s	9.5	1.5		15.24		
	D	1 m/s	2.4	16.9		8.14		
		2 m/s	3.8	8.3		9.54		
		3 m/s	4.6	5.6		10.34		
		4 m/s	5.1	4.3		10.84		
		6 m/s	5.5	3.5		11.24		
		8 m/s	5.8	3.0		11.54		
		10 m/s	6.2	2.3		11.94		

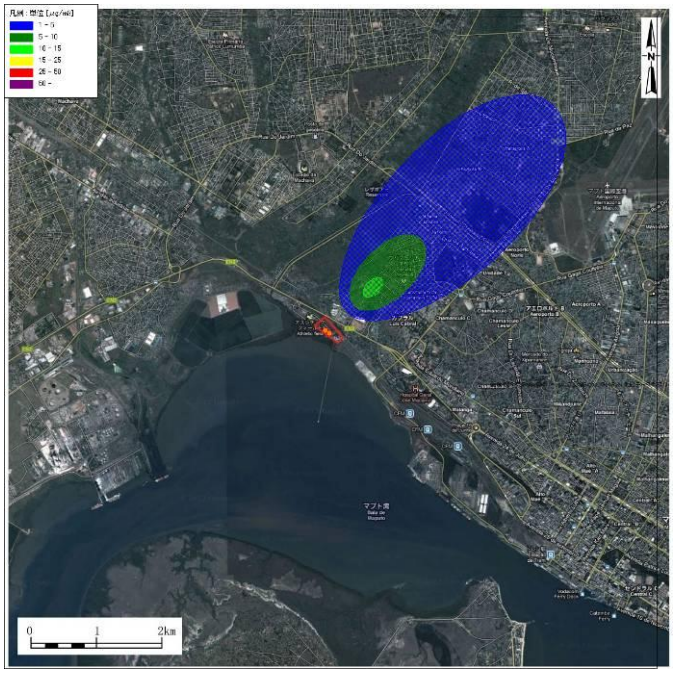
(Source: JICA Study Team)

The prediction results of the maximum concentration distribution of nitrogen dioxide from CCGT with southwest wind at each stability level are as shown in Figure 11.8-5 to Figure 11.8-8.



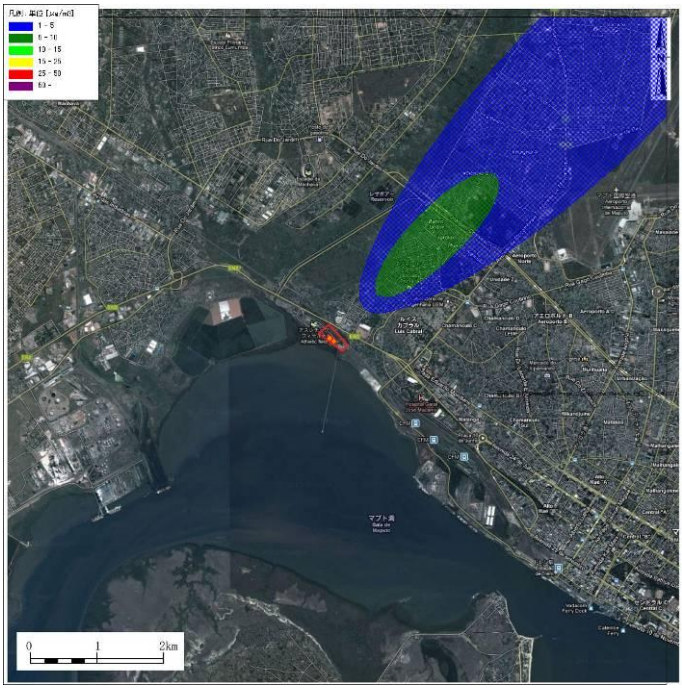
(Source: JICA Study Team)

Figure 11.8-5 Predicted Concentration Distribution Chart of NO_2 (Southwest Wind, Stability A, Wind Speed 1.0 m/s)



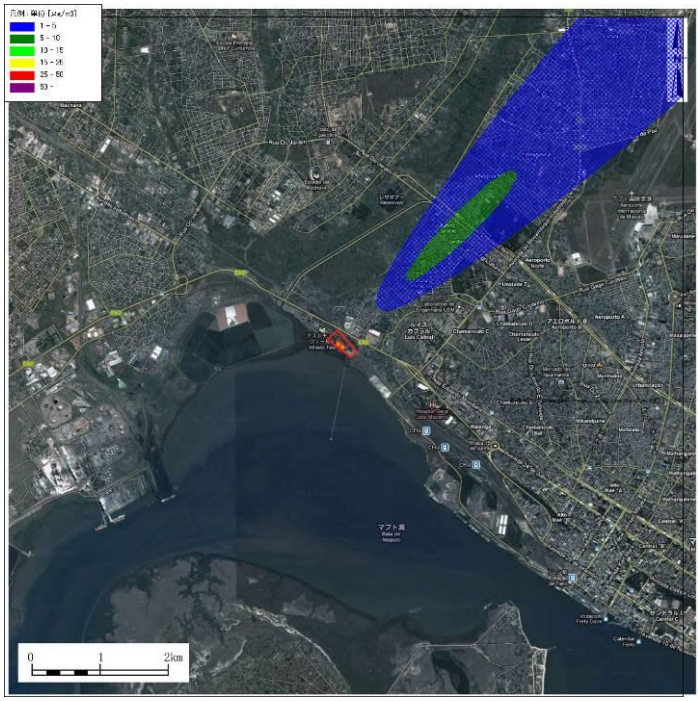
(Source: JICA Study Team)

Figure 11.8-6 Predicted Concentration Distribution Chart of NO_2 (Southwest Wind, Stability B, Wind Speed 4.0 m/s)



(Source: JICA Study Team)

Figure 11.8-7 Predicted Concentration Distribution Chart of NOx (Southwest wind, Maximum Level at the Stability Level, C-1 Hour Value)



(Source: JICA Study Team)

Figure 11.8-8 Predicted Concentration Distribution Chart of NOx (Southwest Wind, Maximum Level at the Stability Level, D-1 Hour Value)

b. Special conditions

The prediction result of nitrogen dioxide under the special conditions is as shown in Table 11.8-12 and Figure 11.8-9.

The maximum concentration of nitrogen dioxide is highest, around 32.7μg/m^3, when the inversion layer occurs at the ground level. This value is approximately 8% of Mozambique's environmental quality standards and approximately 16% of the IFC/WB guidelines.

The maximum future concentration (obtained by adding the present concentration to the predictive value) is 38.44μg/m^3, which is significantly lower than Mozambique's environmental quality standards and the IFC/WB guidelines.

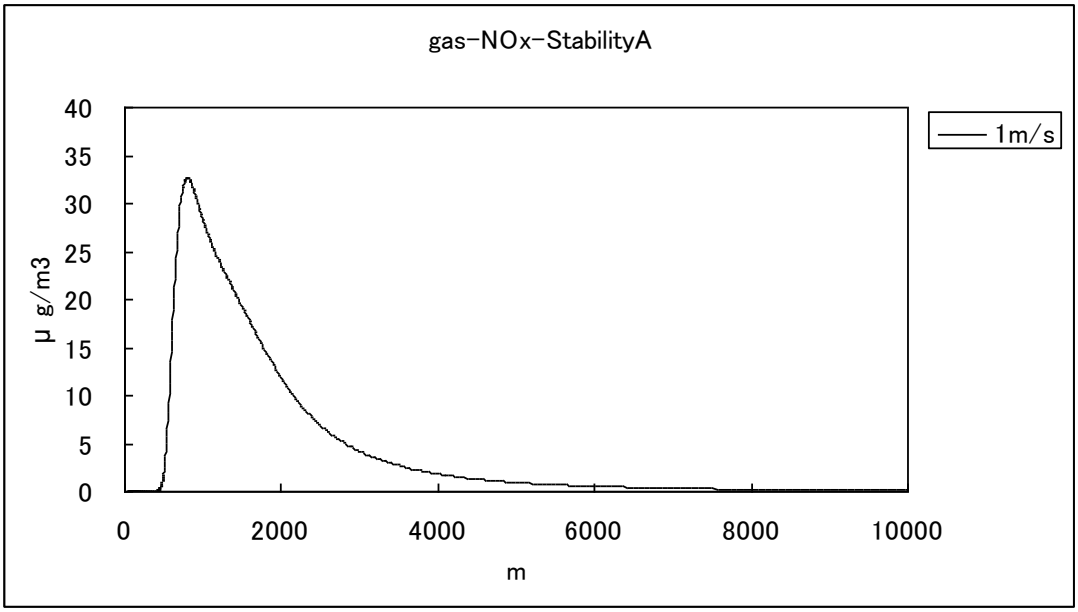
Table 11.8-12 Prediction Result of the Maximum Future Concentration at the Ground Level under the Special Conditions Resulting from Installation of New CCGT (1 Hour Value)

Item	Condition	Stability	Wind speed	Maximum concentration at the ground level a (μg/m^3)	Distance for maximum concentration at the ground level (km)	Present concentration b (μg/m^3)	Maximum future concentration a+b (μg/m^3)	Atmospheric environmental quality standard of Mozambique (μg/m^3)	IFC/WB EHS guidelines (μg/m^3)
NO_2	Inversion layer	A	1 m/s	32.7	0.8	5.74	38.44	400	200
	Downdraft	D	10 m/s	26.9	0.6		32.64		

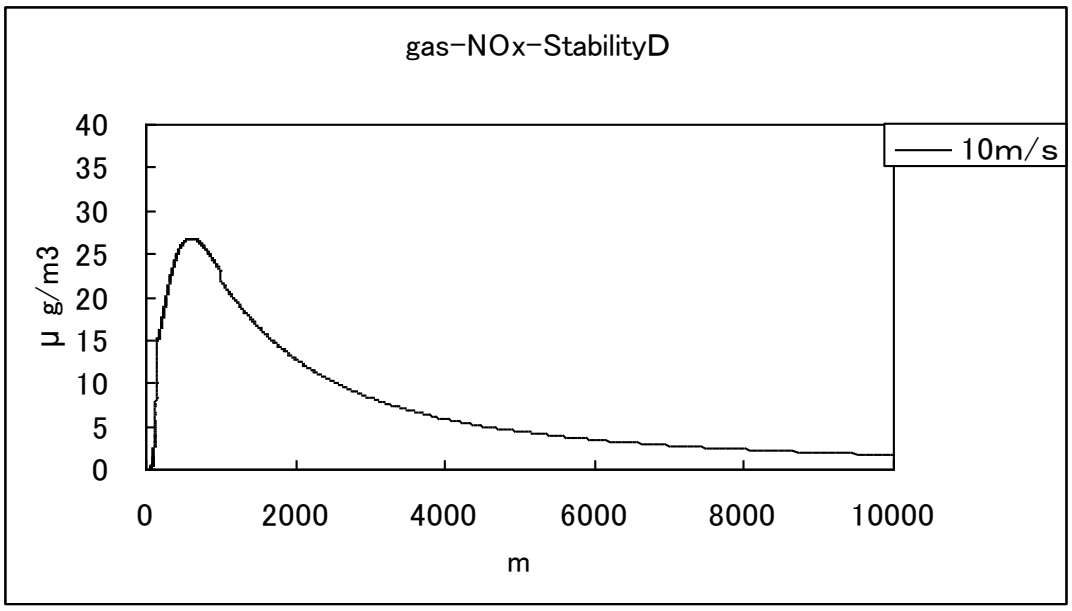
Note: The maximum concentrations at the ground level of downdraft are predicted maximum values of all the wind speed by stability level.

(Source: JICA Study Team)

(Inversion Layer)



(Downdraft)



(Source: JICA Study Team)

Figure 11.8-9 Prediction Result of the Maximum Future Concentration at the ground level of NO_2 under the Special Conditions Resulting from Installation of New CCGT (1 Hour Value)

(h) Conclusion

As a result of the simulation analysis, it was found that the predicted future concentration is sufficiently lower compared with the Mozambique's environmental quality standard and the IFC/WB guidelines. Since there is no significant difference between actual measured data at CTM Maputo and the assumed NO_2 concentration for prediction, need of changing the height of the stack is not expected.

(2) Impact on Noise

The main sources of noise during the operation phase are generated from GTs, heat recovery steam generators (HRSG), ST generator, air-cooled condenser (ACC), various pumps, ventilation fans and other miscellaneous equipment. These levels of noise generated can be readily controlled through the application of appropriate acoustic equipment. According to the Feasibility Study on the technical requirements of this Project (see Section 6.4.4), the ambient noise level for all equipment operating under steady state conditions shall not exceed 85 dB (A) at 1 m from the edge of the equipment or close to the source. Its equivalent noise level at a height of 1 m on the boundary of the plant shall not exceed 70 dB (A). With 70 dB (A), the prescribed and applicable standards for industrial and commercial areas (day-time and night-time) given in Section 11.3.1 are met. The results of the noise monitoring survey also revealed that the current cumulative noise level in the vicinity of the site is relatively high while the noise contribution from the existing No.2 GT is relatively low. (see Section 11.2.1). Given this, it can be assumed that the proportion of the noise level generated by the proposed CCGT with appropriate acoustic equipment will result in no significant increase of the overall noise level in the vicinity of the site.

(3) Impact on Water Quality

The proposed power plant will use the air-cooled condenser and therefore, water is not required for the power plant operation. Hence, there will be no impact on surface water and ground water. However, the effluent from the wastewater treatment facilities may need to be periodically monitored, as the clean wastewater streams will be discharged through the main drainage pipeline of Maputo Bay.

(4) Impact on Waste

During the operation phase, the power plant will generate hazardous and non-hazardous wastes including among others, oil and grease, dehydrated sludge, deposits from screens and filters and GTs. Landfill sites shall be identified in accordance with the regulatory requirements on industrial waste disposal. At present, there are two municipal dumping sites indentified for

general wastes located in Hulene in Maputo and Malhampsene in Matola and only one land fill site for hazardous wastes, the Mavoco land fill in Boane suburb.

Wastewater is also expected to be generated from the neutralized regeneration waste of the HRSG blow down, floor drains from GTs and the ST building, contaminated drains from the transformer areas and sewage, among others. This wastewater shall be treated and confer with the prescribed effluent standards of IFC and SANS before being discharged to Maputo Bay.

The plant is also predicted to generate other waste and domestic waste. Hence, it is important to establish a waste management system including the wastewater system as a measure of mitigating the adverse impact on waste while at the same time, providing a framework for an appropriate monitoring system.

(5) Impact on Traffic and Transportation

There will be no impact on the traffic and transport system as envisaged because the fuel and gas required for power plant operation will be transported through a pipeline via the new route linking the MGC pipeline to CTM Maputo.

(6) Impact on Health and Safety

During the operation phase, health and safety of operation and maintenance personnel are important. A vigorous fire-fighting system as well as a health and safety plan will be employed in order to respond to the worst-case scenario of the plant. This shall be implemented in accordance to the prescribed standards and guidelines set by Mozambique, IFC and SANS.

(7) Impact on Climate Change

CO_2 will be generated from the Project, contributing to the global climate change, but considering the capacity of the Project, the impact will not be significant.

(8) Impact on Social Environment

After the setting up of the proposed power plant, employment will be generated in the secondary sector, which will include the non-working population of the area.

During the operation phase, indirect job opportunities will be created in the plant and small and medium-scale enterprises can be promoted outside the Project boundary. Many will find employment in the service sector and marketing of day-to-day needs.

There will be no negative health impact on the people as the proposed plant will be gas-based, will have a very small concentration of SO_2 and the PM_{10} level will be in accordance to the prescribed standards. Overall, it can be said that there will be marginal impact on the socio-economic condition of the locality and the impact will be mostly positive.

11.9 Mitigation Measures and Cost of Implementation

Based on the analysis of the significant impact of the Project, measures are proposed and established in order to manage any adverse impact.

Table 11.9 1 and Table 11.9 2 illustrate the mitigation measures during the construction phase and operation phase, respectively

Table 11.9-1 Mitigation measures during construction phase

Item		Impact	Mitigation measures	Responsible agencies/ organization	Cost
(1) Environmental Pollution	Air pollution	• SO_X, NO_X, smoke, sand and dust dispersion from construction machines and equipment	• Regular monitoring and maintenance of construction machines and equipment will be conducted. • Burning of rubbish within the site will be strictly prohibited. • Introduction of an appropriate traffic and transportation management control to avoid unnecessary machine works and vehicle trips. • Limitation on the speed on heavy transportation vehicles will be observed.	Project Implementation Unit	Within EPC cost
		• Dust from earth and other civil works	• Regular water spraying at construction and disposal sites. • Introduction of an appropriate traffic and transportation management control to avoid unnecessary machine works and vehicle trips. • Limitation of speed on heavy transportation vehicles. • Covering sensitive dust producing materials with nylon plastic, whenever possible.	Project Implementation Unit	Within EPC cost
	Water pollution	• Soil runoff, turbid water and wastewater from machine and equipment cleaning	• Temporary installation of settling tanks and sediment fencing. • Water used for machine and equipment cleaning shall be collected in tanks and treated before discharge. • Monitoring of water outlet will be periodically conducted. • Construction of temporary rain drainage ditches to prevent accumulating water in levelled area in the construction site. • Oil and grease and chemicals shall be segregated and kept in temporal storage tanks. • Vehicles and machines/equipment are maintained and refueled on sealed, bunded and roofed areas. • Fuel storage tanks are installed in sealed, bunded and roofed areas.	Project Implementation Unit	Within EPC cost
		• Drainage water with soil	• Fences are established around the excavation works to prevent soil erosion and a temporal settlement pond is prepared to decrease turbidity of the discharged water.	Project Implementation Unit	Within EPC cost
	Waste	• Industrial solid waste	• Waste management plan shall be prepared. • Hazardous and non-hazardous materials shall be segregated. • Avoid the use of materials that contain PCB (polychlorinated biphenyl)/PCT (polychlorinated terphenyl), asbestos and other dangerous substances, when appropriate.	Project Implementation Unit	Within EPC cost
		• Domestic waste at construction site	• Construct a temporary domestic disposal area and regular disposal to avoid accumulation of odor. • Encourage workers to use reuse, recycle and reduce waste.	Project Implementation Unit	Within EPC cost
		• Sewage	• Sewage shall be treated by septic tanks.	Project Implementation Unit	Within EPC cost

Item		Impact	Mitigation measures	Responsible agencies/ organization	Cost
(1) Environmental Pollution		Construction debris	• Proper disposal of construction waste to designated disposal sites. • Waste management plan will be prepared.	Project Implementation Unit	Within EPC cost
	Noise and vibration	• Noise from machines, equipment and vehicles	• The latest noise-reduction machines and vehicles shall be used. • Silencer and mufflers on machines and vehicles shall be used if necessary. • Construction works shall be confined to daytime. • Construction of noise wall or installing a noise reducer in noise-affected areas. • Schedule and timing of vehicle and machines shall be optimized to standardize workload and reduce noise as much as possible. • Construction of temporary fence around Project site.	Project Implementation Unit	Within EPC cost
(2) Natural Environment	Soil	• Soil erosion due to rain and wind	• Spraying the site with water will be conducted. • Cover the soil whenever possible to avoid erosion.	Project Implementation Unit	Within EPC cost
	Climate factor	• Gas emission from construction machines, equipment and vehicles	• Regular maintenance of construction machines and equipment. • Moderate speed of vehicles will be observed. • Limitation of weight loads of vehicles.	Project Implementation Unit	Within EPC cost
(3) Social Environment	Local economy	• Employment by the Project	• Utilization of local services such as cleaning and catering among others.	Project Implementation Unit	Within EPC cost
		• Procurement of minor things by the Project	• Appropriate and acceptable procurement guidelines shall be formulated.	Project Implementation Unit	Within EPC cost
	Health and Safety	• Risks for infectious diseases	• Awareness about infectious diseases will be part of the education program to be prepared.	Project Implementation Unit	Within EPC cost
		• Accidents on site	• Health and safety plan will be prepared. • Basic health and safety education program will be prepared and conducted at the beginning of employment. • Personal safety gear (protective clothing and equipment) such as ear protection covers and safety shoes are provided to workers. • Safety measures near construction machines such as a “No Man Zone” shall be employed. • Medical unit will be established. • An emergency transportation plan will be initiated with the Jose Macamo Hospital, the hospital adjacent to the site. • Project Implementation Unit shall refer to the guidelines for Environmental, Health and Safety in Mozambique or IFC.	Project Implementation Unit	Within EPC cost
		• Traffic accidents around the site	• Traffic control plan shall be prepared. • Necessary traffic signals and signs are set up around the site. • Basic traffic education is provided to drivers.	Project Implementation Unit	Within EPC cost

(Source: JICA Study Team)

Table 11.9-2 Mitigation measures during operation phase

Item		Impact	Mitigation measures	Responsible agencies/ organization	Cost
(1) Environmental Pollution	Air pollution	• SO_X, NO_X, and PM_{10} from the plant	• Adoption of high stack. • Installation of Continuous Emission Monitoring System (CEMS) to monitor amount of flue gas and concentration of SO_X, NO_X, and $PM_{10.}$ • Conduct of regular monitoring and maintenance.	Project Implementation Unit EDM	Within EPC Within O&M
	Water pollution	• Effluent from waste treatment facility on the following parameters ph value and turbidity	• Periodic monitoring of the amount of effluent.	EDM	Within O&M
		• Generation of wastewater from HRSG blow down, floor drains from GTs, ST building and yard drains	• Adaption of wastewater system to separate oil and grease. • Installation and construction of waste treatment and purifying facilities.	Project Implementation Unit	Within EPC
	Waste	• Industrial solid waste	• Waste management plan shall be prepared. • Hazardous and non-hazardous materials are segregated. • Waste generated shall be treated in the treatment facilities. • Sludge will be recycled. • Dehydrated sludge (cake), deposits from the screens and filter screens and GTs shall be treated as solid waste and deposited to the identified solid waste dumping site. • Monitoring of water quality near the site. • The facility shall be managed and operated under the environmental standards and guidelines of Mozambique, SANS and IFC.	EDM Project Implementation Unit	Within O&M Within EPC
		• Domestic waste from plant	• Promotion of 3Rs in waste management (reduce, reuse and recycle).	EDM	Within O&M
	Noise and vibration	• Noise from machines, including the ACC	• Regular and periodic maintenance are conducted.	EDM	Within O&M
(2) Natural	Soil	• Soil erosion due to rain and wind	• Spraying the site with water will be conducted to reduce soil erosion by rainwater. • Installation of storm water drainage.	EDM Project Implementation Unit	Within O&M Within EPC
	Climate factor	• CO_2 gas emission from the plant	• Regular maintenance and monitoring of GTs.	EDM	Within O&M
(	Local	• Employment by the	• Labor guidelines in Mozambique are observed.	EDM	Within

Item		Impact	Mitigation measures	Responsible agencies/ organization	Cost
	economy	plant			O&M
		• Procurement of minor things by the Project	• Appropriate and acceptable procurement guidelines shall be formulated.	EDM	Within O&M
	Health and Safety	• Fire	• Formation of fire fighting system. • Installation of fire water pipeline will be strategically located in yard hydrants. • Ensure water supply from FIPAG/Aqua de Mozambique. • Fire water distribution will include sectionalizing valves so failure in any part of the system can be isolated. • Fuel oil tanks will be equipped with fire fighting systems. • Installation of electricity driven main pump and second duty diesel engine drive pump and shall be reserved for water demand for worst-case condition.	Project Implementation Unit	Within EPC
		• Accidents on site	• Health and safety plan will be prepared. • Basic health and safety education program will be prepared and conducted at the beginning of employment. • Personal safety gear (protective clothing and equipment) such as ear protection covers and safety shoes are provided to workers. • Safety measures near construction machines such as a "No Man Zone" shall be employed. • Medical unit will be established. • An emergency transportation plan will be initiated with the Jose Macamo Hospital, adjacent to the site. • Regarding Occupation, Health and Safety, EDM and LTSA shall refer to the following guidelines: o Environmental, Health and Safety General Guidelines (IFC, 2007) o Environmental, Health and Safety Guidelines for Thermal Power Plant (IFC, 2007).	EDM	Within O&M

(Source: JICA Study Team)

In terms of the estimated capital costs to be incurred for undertaking pollution prevention measures at the plant, the budgetary requirement during construction phase will be within the EPC cost, and the requirement during operation phase will be included in EDM's ordinary operation and maintenance cost as discussed in Chapter 9 of this Report.

11.10 Monitoring Plan

An environmental monitoring plan provides a delivery mechanism to address the adverse environmental impacts of a project during its execution, to enhance project benefits, and to introduce standards of good practice to be adopted for all project works. Hence, in order to assist in detecting the development and significant changes in any aspects of the environmental parameters and to provide timely adoption of appropriate control measures, a monitoring plan has been formulated to take care of impact of the proposed Project. The emission levels from the stack and the ambient air quality around the proposed plant will be periodically monitored. Further, noise levels will also be regularly monitored. Table 11.10-1 and Table 11.10-2 present the summary of the monitoring field including the number, location of monitoring stations, frequency of sampling and parameters to be covered.

Table 11.10-1 Environmental monitoring plan during construction phase

Monitoring Field	Monitoring Parameters	Monitoring Locations	Sampling Frequency
Ambient air quality	PM_{10}, SO_2, NO_x, CO (Meteorological data such as air, temperature, relative humidity, wind direction and wind speed)	Construction site boundary (three points: west, east and south)	Once a month
Effluent of water quality	Water temperature, pH, DO, BOD_5, COD, SS, oil and grease, and heavy metals (Heavy metals are indicated in the IFC standards)	Exit point of the temporary settlement pond	Once a month
River water quality	Water temperature, pH, DO, BOD_5, COD, SS, TD, oil and grease, and heavy metals based on standards and guidelines of Mozambique, SANS and IFC	Exit point of effluent from plant	Quarterly (four times a year)
Noise	dBA (Meteorological data such as air, temperature, relative humidity, wind direction and wind speed)	Construction site boundary (three points: west, east and south)	Once a month
Vibration	dB or ppv	Construction site boundary (three points: west, east and south)	Once a month

(Source: JICA Study Team)

Table 11.10-2 Environmental Monitoring during operation phase

Monitoring Field	Monitoring Parameters	Monitoring Locations	Sampling Frequency
Ambient air quality	PM_{10}, SO_2, NO_x, CO (Meteorological data such as air, temperature, relative humidity, wind direction and wind speed)	Plant boundary and four points at a radius of 2 km from the plant	Once a month
Effluent air quality	O_2, PM_{10}, SO_2, NO_x, CO	HRSG stacks	Continuance monitoring by CEMS
Effluent of water quality	Water temperature, pH, DO, BOD_5, COD, SS, oil and grease, and heavy metals (Heavy metals are indicated in the IFC standards)	Exit point of the water treatment facility	Quarterly (four times a year)
River water quality	Water temperature, pH, DO, BOD_5, COD, SS, TD, oil and grease, and heavy metals based on standards and guidelines of Mozambique, SANS and IFC	Exit point of effluent from plant	Quarterly (four times a year)
Noise	dBA (Meteorological data such as air, temperature, relative humidity, wind direction and wind speed	Plant boundary (three points: west, east and south)	Twice a month
Vibration	dB or ppv	Plant boundary (three points: west, east and south)	Once a month

(Source: JICA Study Team)

11.11 Stakeholders Meeting and Engagement

(1) Objective of the Consultation

The following are the objectives of the stakeholders' meeting:

- To inform the community surrounding the proposed Project about the plan for a new power plant in CTM
- To gather information on their initial views and opinions about the proposed Project

(2) Schedule and Participation

Two stakeholders' meetings were held in Luis Cabral suburb. The first meeting was conducted on January 24, 2013 at the Luis Cabral Community School. It was attended by 18 people including the Secretary of Luis Cabral suburb, Secretaries of urban blocks 40 and 40a and the Heads/In-charge of 10 houses. The second meeting was conducted on January 25, 2013 at Dom Bosco Higher Institute. It was attended by 9 representatives from 4 companies located adjacent

to the proposed Project site, namely: Dom Bosco Higher Institute, SOMOTOR Lda, Intertek and Petroauto. The Luis Cabral secretary, 1st Secretary of the Party Cell B and EDM also participated in the meeting. Refer to Appendix-6 for the list of participants. It is noted that these participants were selected on the basis of their interest to the Project, availability to the meeting and the nature of their leadership in the community. The following are some of the snapshots taken during the meetings.

(Source: JICA Study Team)

Figure 11.11-1 Participants from the Heads of 10 Houses, Urban Blocks 40 and 40a

(Source: JICA Study Team)

Figure 11.11-2 Participants from the Companies and Institutions adjacent to the Site

(3) Record of Discussion

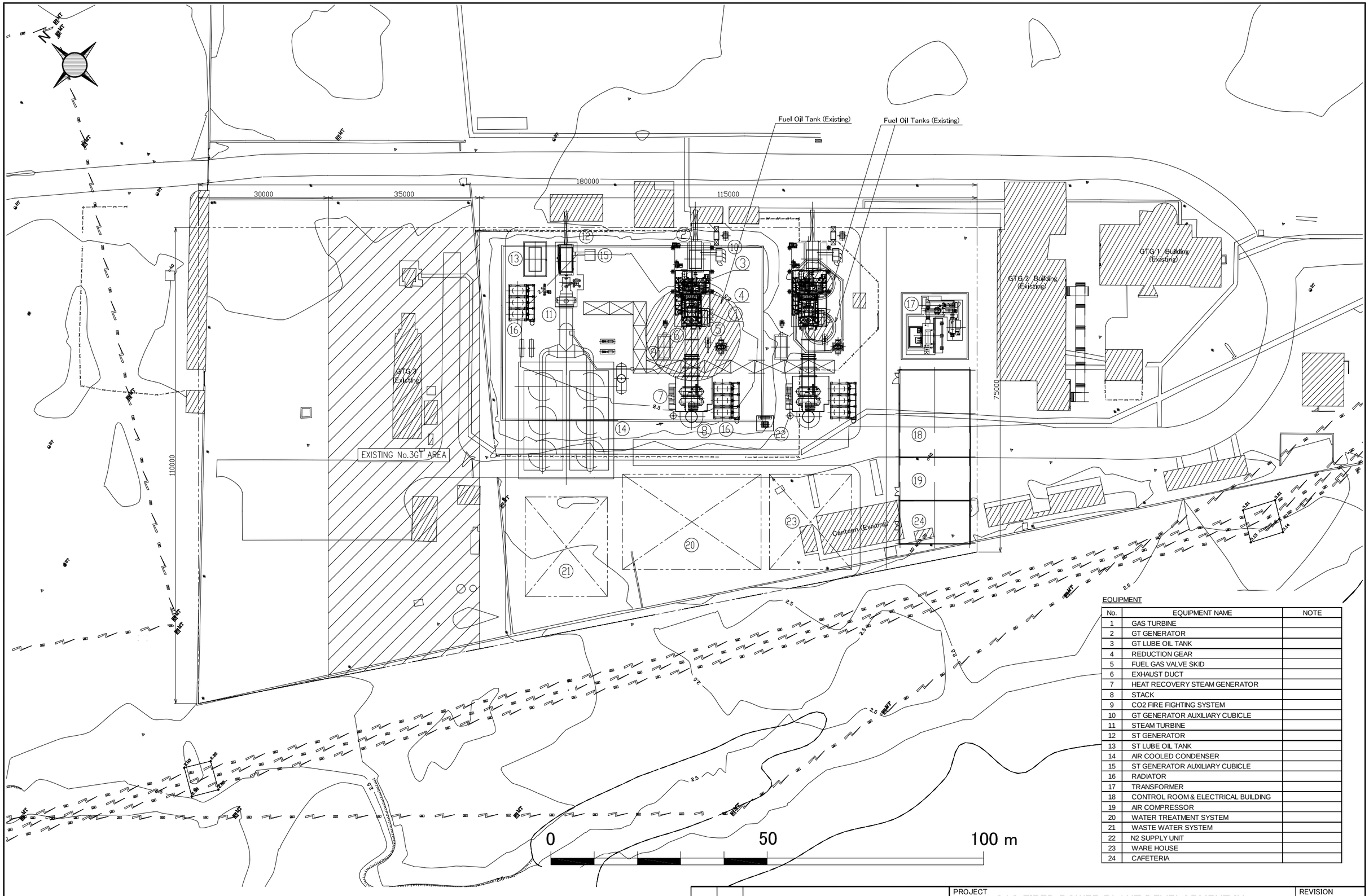
During the respective meetings, the initial ideas about the proposed Project were presented and various questions and comments were raised and clarified. Refer to Appendix 6 for the detailed recording of the discussion.

Appendix 1

Drawings

List of Drawings

No.	Title of Drawings
001	Overall Project Plot Plan
002	Overall Flow Diagram Steam Water Cycle
003	Steam System Diagram
004	Feed Water and Condensate System Diagram
005	Cooling Water System Diagram
006	Make-up Water System Diagram
007	Fuel System Diagram
008	Circulating Water System Diagram
009	Fuel Gas System Flow Diagram



EQUIPMENT

No.	EQUIPMENT NAME	NOTE
1	GAS TURBINE	
2	GT GENERATOR	
3	GT LUBE OIL TANK	
4	REDUCTION GEAR	
5	FUEL GAS VALVE SKID	
6	EXHAUST DUCT	
7	HEAT RECOVERY STEAM GENERATOR	
8	STACK	
9	CO2 FIRE FIGHTING SYSTEM	
10	GT GENERATOR AUXILIARY CUBICLE	
11	STEAM TURBINE	
12	ST GENERATOR	
13	ST LUBE OIL TANK	
14	AIR COOLED CONDENSER	
15	ST GENERATOR AUXILIARY CUBICLE	
16	RADIATOR	
17	TRANSFORMER	
18	CONTROL ROOM & ELECTRICAL BUILDING	
19	AIR COMPRESSOR	
20	WATER TREATMENT SYSTEM	
21	WASTE WATER SYSTEM	
22	N2 SUPPLY UNIT	
23	WARE HOUSE	
24	CAFETERIA	

NO.	REV.	DESCRIPTIONS

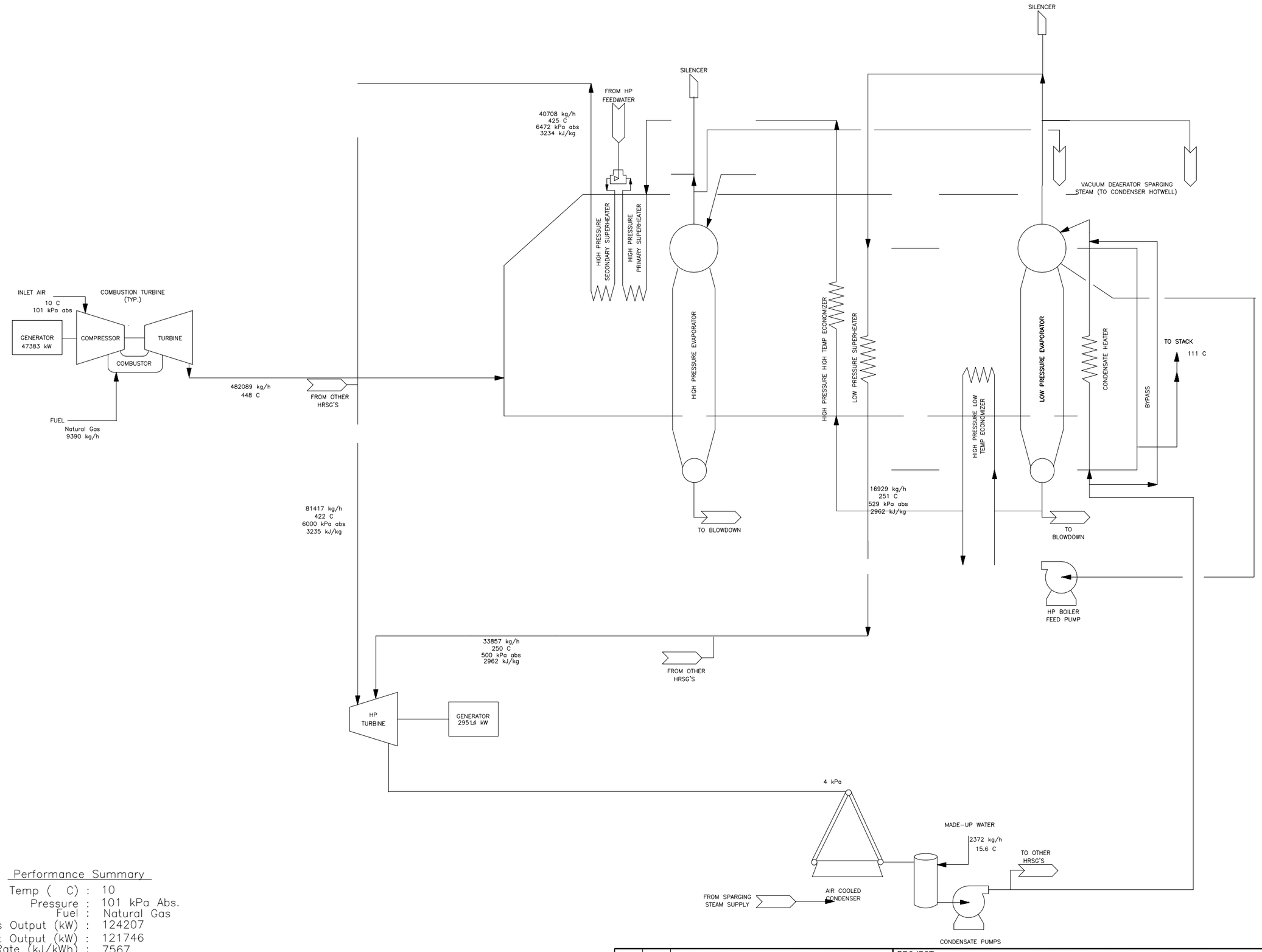
PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE

REVISION: 0

DRAWING TITLE: OVERALL PROJECT PLOT PLAN

SCALE: 1/400

DRAWING NO.: 001

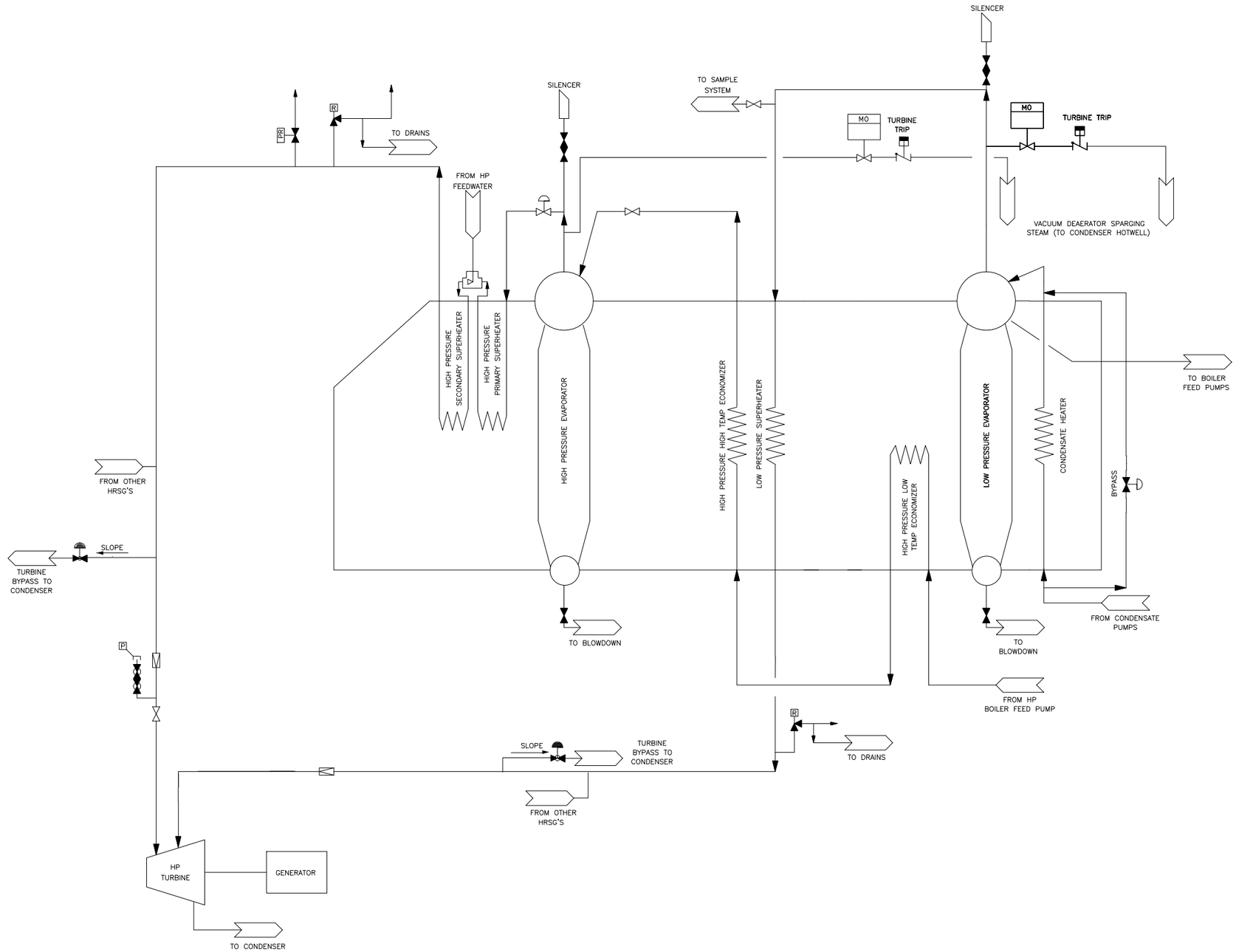


Performance Summary

Temp (C) :	10
Pressure :	101 kPa Abs.
Fuel :	Natural Gas
Gross Output (kW) :	124207
Net Output (kW) :	121746
Net Plant Heat Rate (kJ/kWh) :	7567
CT Model :	GE-LM6000-PDS-50 Hz

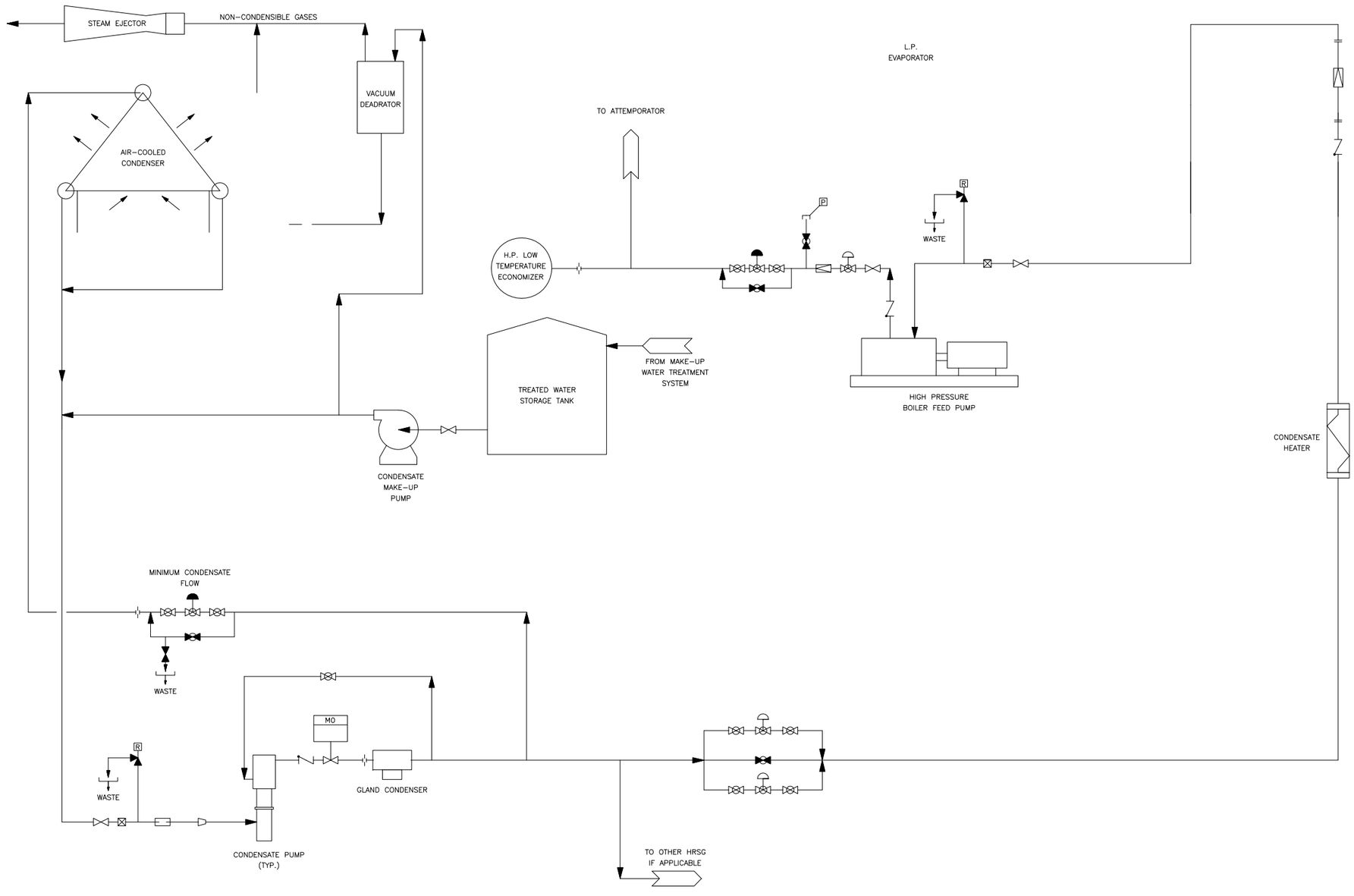
NO.	REV.	DESCRIPTIONS

PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE		REVISION: 0
DRAWING TITLE: OVERALL FLOW DIAGRAM STEAM WATER CYCLE	SCALE: NTS	DRAWING NO.: 002



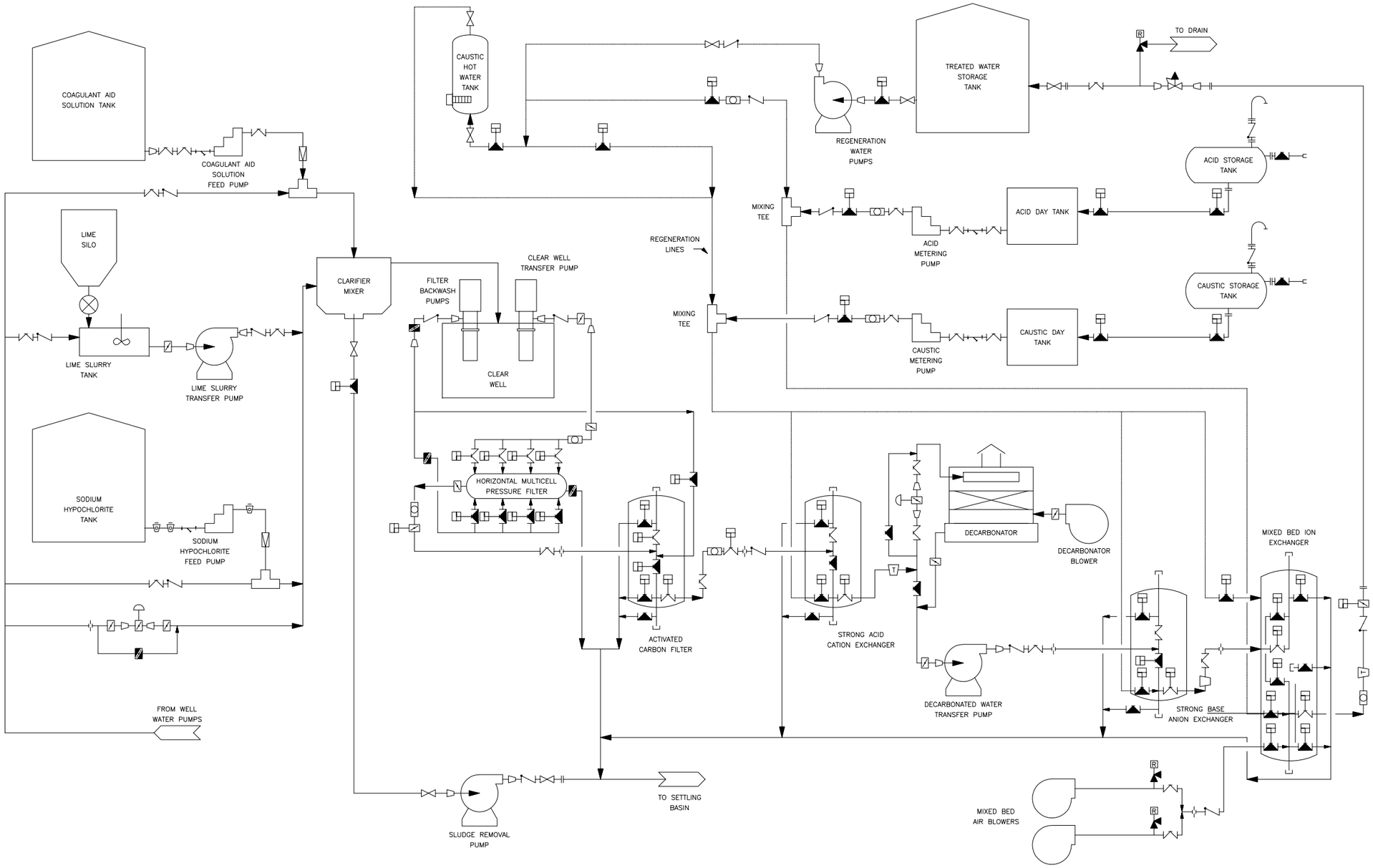
NO.	REV.	DESCRIPTIONS

PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE		REVISION: 0
DRAWING TITLE: STEAM SYSTEM DIAGRAM	SCALE: NTS	DRAWING NO.: 003



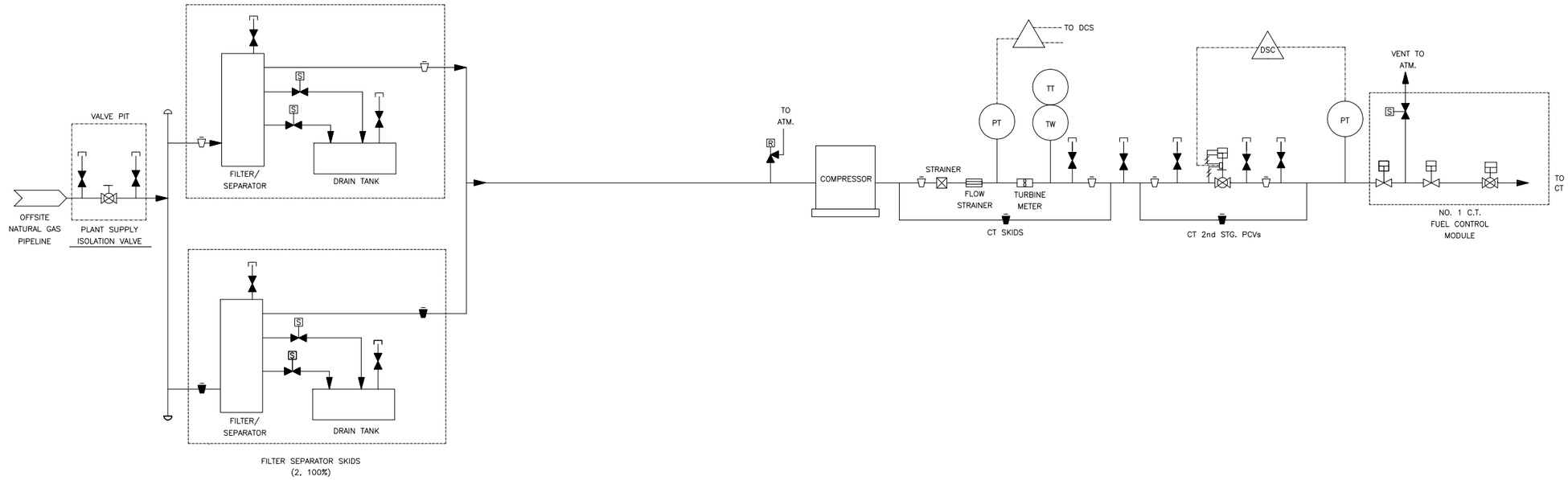
NO.	REV.	DESCRIPTIONS

PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE		REVISION: 0
DRAWING TITLE: FEED WATER AND CONDENSATE SYSTEM DIAGRAM	SCALE: NTS	DRAWING NO.: 004



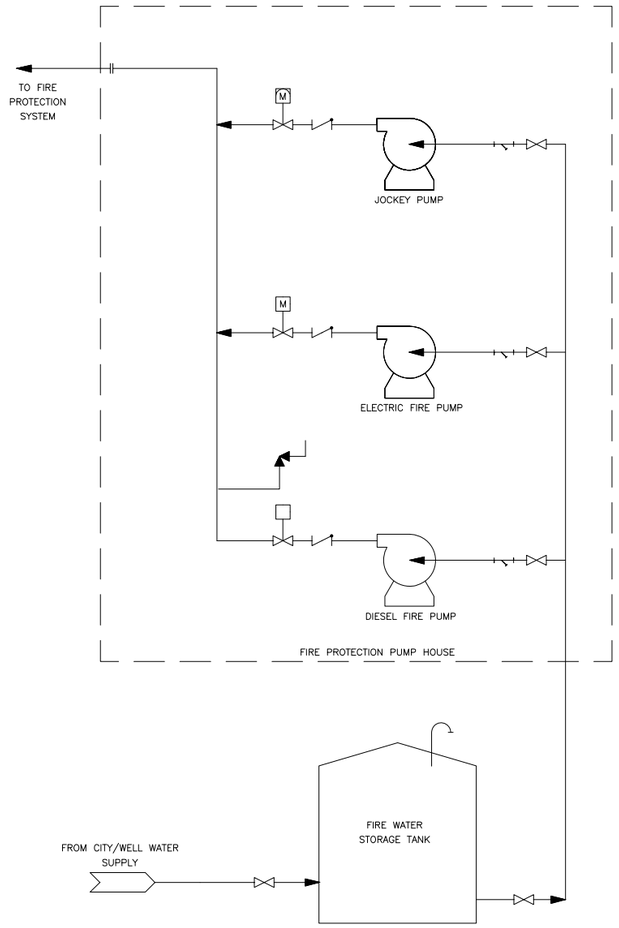
NO.	REV.	DESCRIPTIONS

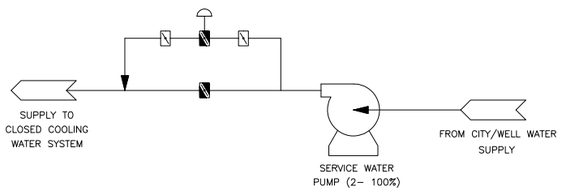
PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE		REVISION: 0
DRAWING TITLE: MAKE-UP WATER SYSTEM DIAGRAM	SCALE: NTS	DRAWING NO.: 006



NO.	REV.	DESCRIPTIONS

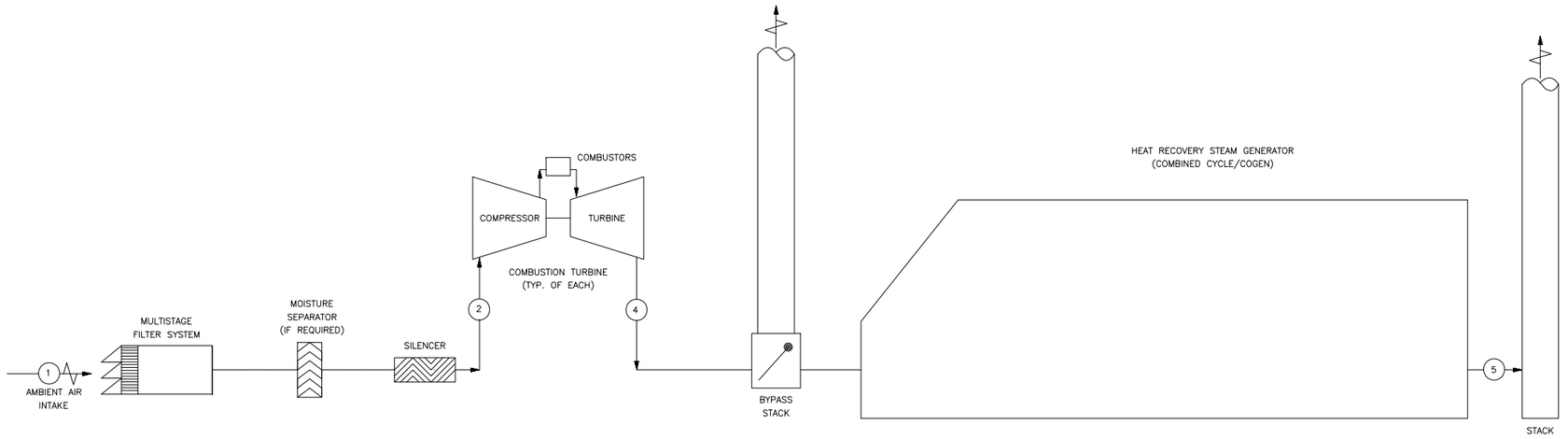
PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE		REVISION: 0
DRAWING TITLE: FUEL SYSTEM DIAGRAM	SCALE: NTS	DRAWING NO.: 007





NO.	REV.	DESCRIPTIONS

PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE		REVISION: 0
DRAWING TITLE: CIRCULATING WATER SYSTEM DIAGRAM	SCALE: NTS	DRAWING NO.: 008



Data Provided at Ambient Temperature of: 10 ° C

Data Provided Indicates Firing Fuel: Natural Gas

Stream Number	1	2	3	4	5	6	7	8	9
Stream Name	Ambient Air Intake	Compressor Inlet	Heat Recovery Absorption Chiller Inlet	Combustion Turbine Exhaust	Stack Inlet	Ammonia Feed	Ammonia Air Feed	Ammonia Mixture Injection	Heat Recovery Absorption Chiller Outlet
Mass Flow, kg/h	472699	472699	N/A	482089	482089	N/A	N/A	N/A	N/A
Volumetric Flow, m3/s-std	109	109	N/A	271	149	N/A	N/A	N/A	N/A
Pressure, kPa Abs.	101	99.8	N/A	104	103	N/A	N/A	N/A	N/A
Temperature, C°	10	10	N/A	448	111	N/A	N/A	N/A	N/A

NO.	REV.	DESCRIPTIONS

PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE

REVISION: 0

DRAWING TITLE: FUEL GAS SYSTEM FLOW DIAGRAM

SCALE: NTS

DRAWING NO.: 009

Appendix 2

Terms of Reference of Engineering Consultancy Services

TERMS OF REFERENCE (TOR)
OF
ENGINEERING CONSULTANCY SERVICES
FOR CTM 85 MW COMBINED CYCLE POWER PLANT
DEVELOPMENT PROJECT

A. PROJECT INFORMATION

a) Background Information

The Gas Fired Power Plant Development in Mozambique (hereinafter called "the project") is aiming for supplying electric power to satisfy middle- and long-term power demand in Southern region of the Republic of Mozambique (hereinafter called "Mozambique).

The nationwide power demand shows only 610 MW of the maximum generating capacity and 4,025 GWh/year of the gross power production but the annual average increase rate in past 5 years shows remarkable growth; i.e. 13.8% and 10.6% each. In particular, the maximum generating capacity only in Southern Mozambique is 369 MW which is 60% of 610 MW mentioned above and the annual average increase rate shows steady growth; i.e. 11.3%.

Although Electricidade de Mozambique (EDM) makes an effort to ensure power supply capacity; e.g. rehabilitation of aged small-scaled hydroelectric and thermal power plants, purchase of electric power from IPP power supply being built in Ressano Garcia area, and capital participation into IPP, the urgent issue to satisfy middle- and long-term power demand is to ensure a new power supply in Maputo city. Based on such a background, Mozambique government requested Japanese ODA from Japanese government in December, 2011 to support gas-fired combined cycle power plant building in Southern Mozambique.

b) Location of the project and information on the surrounding area

The project site is located approximately 6km west-north-west from down town of Maputo city, capital of Mozambique. The existing Maputo Thermal Power Plant is surrounded by the ocean and highway, and can be reached in approximately 20 minutes by car from the center of Maputo. Site of about 27,000 m^2 is available as a construction on the premises of an existing power station of EDM that is 3 km in the northwest from Maputo Port.

Maputo city features a tropical savanna climate that borders on a humid subtropical climate. The city has short rainy season lasting from November through March. Maputo also features noticeably warmer and cooler season, with its warmest month is January and coolest month is July. Average maximum and minimum temperature is 28^{o}C and 18^{o}C in the last 5 years. At present, the Maputo Thermal Power Plant has three gas turbine power generation facilities (Unit 1: jet fuel fired type having a generation capacity of 17.5 MW; Unit 2: diesel oil-fired type having a generation capacity of 36 MW; Unit 3: diesel oil-fired type having a generation capacity of 22 MW)

Since the site is on the premises of an existing power station, it is not necessary to develop or prepare land to construct a power plant. However, fuel tanks that are no longer used are on the premises and these fuel tanks need to be removed to construct new facilities in this area.

c) Stage reached in the project preparation and summary of the findings of studies to date

Feasibility study will be completed on March 2013 by Tokyo Electric Power Services Company Ltd and Oriental Consultants Company Ltd in Co-operation with JICA, JAPAN.

d) Implementing Organization

The Electricidade de Moçambique (EDM)

B. OTHER RELEVANT INFORMATION

a) Technical Information

The capacity of the Plant will be 85 MW (70MW – 110MW). One multi-shaft 2-on-1 Combined Cycle Gas Turbine (CCGT) will consist of two gas turbines unit and one steam turbine unit. In this project the technical standards to be followed will be JIS, IEC, ISO, ANSI, ASTM and DIN

b) Relevant laws and regulations

This Project will be guided by Laws of the land (Mozambique).

c) Related Projects.

New natural gas pipeline is planned by ENH.

I. INTRODUCTION

The Government of People's Republic of Mozambique (hereinafter called "GOM") is going to receive financing (Credit) from Japan International Cooperation Agency (JICA) (hereinafter called "loan") toward the cost of CTM 85 MW Combined Cycle Power Plant Development Project (hereinafter called "the Project") and intends to apply part of the proceeds of this credit to payments under the Consulting Services for the supervision of implementation of the Project. The Electricidade de Moçambique (EDM) intends to employ a firm of consultants for the contract to manage and supervise the implementation of the Project, CTM, Mozambique.

II. SCOPE OF WORKS UNDER THIS PROJECT

The scope of work (Including procurement & erection/ commissioning) for the project (under Turnkey contract) is as follows:-

1-1. Installation of CTM 85 MW Combined Cycle Gas Turbine (CCGT) and its auxiliaries.

1) Gas Turbine, Generators and auxiliaries
2) Steam Turbine, Generators and auxiliaries
3) Heat Recovery Steam Generator (HRSG) and auxiliaries

4) Air cooled condenser and related facilities
5) Closed cooling water system for cooling of lubricating oil and other cooling media
6) Drain Recovery System
7) Waste water treatment system
8) Main stack
9) Fuel Gas supply system (new gas station ~ CCGT)
10) Indirect type fuel gas heater (if necessary)
11) Generator step-up transformers
12) Unit auxiliary transformers
13) Auxiliary Power Supply System
14) Emergency diesel generator
15) DC Power Supply System
16) Power Cables and control cables
17) Electrical equipment and materials.

1-2. System facilities for CCGT

18) Protection, metering and control system
19) Plant Data Management system
20) Continuous emission monitoring system
21) Service and instrument air supply system
22) Compact Simulator
23) Communication facilities
24) Control and instrumentation equipment and materials

1-3. Buildings for CCGT

25) Steam turbine building including structural steel, siding, roofing windows
26) Overhead crane and mobile crane
27) Other buildings and houses for supplied equipment
28) Administration building.
29) Ventilation and air conditioning
30) Site & building lighting
31) Architectural materials
32) Finish painting of equipment and materials
33) Fire pump house including structural steel, masonry block walls, roofing, doors and louvers (if necessary)

1-4. Modification of existing 66kV Substations facilities

34) Cable head
35) Protection relay
36) Control system etc

1-5. Gas Facilities (Gas Station ~ RMS)

37) Gas supply piping with RMS (Regulatory & Metering Station) between Gas Station and gas compressor (or decompression facility)
38) Fuel gas compressor/booster or decompression facility (if necessary)
39) Fuel gas pre-treatment system(if necessary)

1-6. Civil Work

40) Site drainage/Site Sanitary
41) Piling (if necessary) and foundations for equipment.
42) All civil works including foundations for supplied equipment and buildings and houses.
43) Preparation, excavation and leveling works of site area including temporary storage area during construction and preparation of access road for carrying-in of heavy components.
44) Fencing around the new plant site and access road (including access road to equipment and drainages inside the new plant site)
45) Construction of approach road
46) Necessary temporary facilities on the downstream side from the connection points of utilities such as electric power, water and the like necessary for construction.
47) Irrigation canal shifting
48) Temporary works and facilities for construction

1-7. Others

49) Spare parts for one Combustion Inspection (CI), one Hot Gas Path Inspection (HGPI), one Major Inspection (MI), which will be out of scope of LTSA spare parts supply and supply of consumable parts for warranty period.
50) Standard and special tools.

III. UNDERTAKING BY EDM

For carrying out the engineering services of consultant, EDM shall provide the following to the consultant without any cost:

1) All available documents, drawings, maps, statistics, data and information related to the project, and
2) Full time counterparts of EDM project team to participate in the consultants activities, and
3) All necessary permits, recommendation and authorization for carrying out the construction work and
4) Working office required to be hired as near as possible to the EDM headquarter, during design phase. It will be shifted to the project site during construction phase.

IV. SCOPE OF SERVICE OF THE CONSULTANTS

The services of the consultant are to undertake the necessary conceptual study, design, engineering, project management and execution including supervision of construction, commissioning through the pre-construction stage, construction stage and warranty period of the Combined Cycle Power Plant together with the associated auxiliaries

and ancillary equipment to compete the project. The Consultant is required to offer a comprehensive proposal to include the following:

A. Review of implementation program and feasibility study.
B. Design and engineering.
C. Assist EDM in pre-qualification for Bidders.
D. Assist EDM in international competitive biddings.
E. Project Management at all levels including periodic review of budget estimate and administration of project cash flows.
F. Inspection, testing and delivery control during manufacturing
G. Construction supervision.
H. Commissioning and acceptance tests.
I. Ensure the quality of transfer of knowledge and technology from manufacture to EDM personnel.
J. Assist EDM in operation and maintenance.
K. Assist EDM for environmental aspects.
L. Conduct HIV/AIDS prevention program, and
M. Prepare reports and documents.

A) Review of implementation program and feasibility study

1) The scope of services would include all design concept study for the selection of plant, especially the type and design parameters of the main equipment after assessment of EDM's needs and analysis of the problem involved. The study should include a value analysis of alternatives and recommend the type of plants & auxiliaries to be selected.

2) The Consultant also shall make provisions to undertake the following:

   a) Review and comment on all the existing documents including the pre-investment study report, JICA Feasibility Study Report, design parameters, etc. and recommend revision or modification, if necessary to achieve the successful completion of the project.
   b) Review and comment on the project cost estimates originally envisaged and recommend modification or adjustment, if necessary, so that all the works originally envisaged including consulting services are completed within the original cost estimates.
   c) Prepare updated project program, cost estimate and cash flow.

B) Design and Engineering

The consultant shall be responsible for but not be limited to:-

a) Prepare design calculations, basic plans, drawings, specification and schedules for Bidders and for contract documents. The design shall include but not limited to; calculations to determine size or capacity requirements; single line diagram with control and protection scheme; layout and arrangement of components, plant area layout, selection of equipment and materials including those related to environmental issues; models of testing equipments and materials and specialized research, if any required.
b) Review and update the above mentioned documents based on EDM and JICA comments

C) Assist EDM in Pre-qualification for Bidders

The consultant shall undertake the following works:

a) Select pre-qualification criteria including but not limited to, eligibility requirement; joint venture requirement; general experience requirement; specific experience requirement; financial capability; organizational capability and others.
b) Prepare Pre-qualification documents.
c) Check and review pre-qualification proposal from Bidders with due co-ordination of guidelines of EDM and JICA.
d) Assist EDM for pre-qualification advertising.
e) Evaluate all Bids in accordance with established EDM and JICA approved criteria.
f) Review and update the draft report based on comments from EDM and JICA.
g) Prepare draft evaluation reports to EDM and assist EDM in preparing final evaluation reports.

D) Assist EDM in International Competitive Biddings

The consultant shall undertake the following works:

a) Prepare, check and review of Bid documents both for the EPC and Long Term Service Agreement (LTSA) contracts, including but not limited to, general and commercial terms and conditions for bidding purpose conditions of contract, technical specification and drawings for bidding purpose, schedule and forms for bidding purpose with due coordination of guidelines of EDM and JICA. Suggestion for appropriate level of service, Bidding method, timing for the LTSA contract to be provided.
b) Assist EDM for pre-bid conference.
c) Assist EDM in replying Bidders question and in issuing addenda to Bid documents
d) Examine and evaluate the technical Bids received (on qualification and technical aspects) in accordance with established EDM and JICA approved criteria.
e) Prepare draft evaluation report of EDM and assist EDM in selecting technically responsible Bidders.
f) Evaluate and tabulate contents of all Bids for compliance with the Bid documents, reasonableness of price and proposed time for completion of the work and any other guidelines as required by EDM and JICA.
g) Prepare final evaluation reports and recommend for award of contract taking into consideration to comments of EDM and JICA on draft evaluation report.
h) Prepare draft contract agreement issued by EDM to successful Bidder.
i) Assist EDM for contract negotiation of LTSA including service contents and duration, if it needs to be dealt separately.

E) Project management at all levels including periodic review of budget estimate and administration of project cash flows

The consultant shall establish a project management system acceptable to EDM, which will be used to monitor, track and pin point problem.

The works involved will include but not be limited to the following:

a) Establish the basic overall project construction schedule, budget and cash disbursement schedule for both foreign and local portion;
b) Establish and implement a project management system and procedures to monitor and control the cost and time schedule to enable timely corrective measures.

c) Support, co-coordinate, supervise, and make decision and issue instruction for all design and engineering related to the construction activities to EDM from view point of ensuring the engineering standards, quality assurance and safety of the project
d) Set up a quality reporting system of project progress and status to EDM.
e) Manage claims by and against the contractor properly and reasonably within reasonable time considering the best interest of EDM.
f) Anticipate and identify potential difficulties or conflicts and their effect on the implementation schedule and recommended and agree steps to be taken by the contractor or recommending steps to be taken by EDM to overcome the difficulties and to avoid delays.
g) Prepare and/or evaluate recommendations to EDM regarding any change proposals, technical amendments and change in the scope of work, if any, the appropriateness of their pricing and if agreed by EDM the timely issuance to the contractor of charged order, as per the conditions of the supply and installation contract.

F) Inspection, testing and delivery control during manufacturing

The consultant with EDM participation shall undertake to implement the following:

a) Check and approve proposal on quality assurance, quality control plan and delivery schedule prepared by the contractor.
b) Regularly review production and delivery schedule submitted by contractor.
c) Check and approve factory testing procedures and factory test results submitted by the contractor.
d) Monitor manufacturing progress by testing regular inspections to ensure compliance to contract documents.
e) Witness factory test of major equipment and preparation of corresponding certificates (test items to be witnessed are to be agreed between EDM and the contractor).
f) Check and review inspection report on each factory testing submitted by the contractor.

G) Construction Supervision

The consultant with EDM participation shall undertake the following;

a) Ensure that the contractor sets up his site works appropriately and in accordance with the contract terms and with due consideration to aspects of environmental protection.
b) Act on behalf of EDM by administrating the contract between EDM and the contractor.
c) Check and approve the contractors design and drawings of the projects.
d) Check and approve the contractor’s temporary works and facilities.
e) Check and approve the contractor’s equipments.
f) Coordinate, supervise and inspect all construction and erection activities.
g) Check and approve the construction methods and site works caries out by the contractor.
h) Check and approve the contractor’s quality assurance and control program.
i) Issue instructions to the contractor on behalf of EDM.
j) Indicate and approve final reference points for the setting out of all structures.
k) Check and approval of test procedure for materials and equipment to be tested on site by the contractor and witness of such tests.
l) Check and approve work progress for purpose of certifying progress payment.

m) Assist issuance of payment certificates by EDM.
n) Maintain records of payment made by EDM to the contractor.
o) Monitor and control work progress and initiation of corrective measures, if required
p) Recommended any modification of complementary items to be necessary to the contractor.
q) Hold monthly progress meeting and submission of monthly progress reports to EDM.
r) Support EDM to prepare quarterly progress reports to GOM/JICA.
s) Maintain records of contractual matters (Guarantees, performance bonds, issuance, claims etc.)
t) Assist EDM in contractual matters (Guarantees, performance bonds, issuance, claims etc.)
u) Inspect and direct preventive safety and environmental control measures.
v) Prepare project complementation report.
w) Check and approve as built drawings.
x) Issue "Certificate of Ready" for commissioning certificates.
y) Assist EDM for submitting Project Completion Report to EDM within six (6) months after the project completion

H) Commissioning and Acceptance Tests

The consultant shall undertake the followings.

a) Assist EDM during the various commissioning stages of the plants.
b) Check and approve the contractor's start-up and testing procedures including performance test to meet guarantees.
c) Coordinate and supervise all tests according the contract.
d) Check and approval of the contractor's commissioning test report after taking into consideration of EDM's comments
e) Issue tentative taking over certificates and final acceptance certificates for power plant equipment subject to prior approval of EDM.

I) Ensure the quality of transfer of knowledge and technology from Manufacture to EDM Personnel

The consultant shall undertake the following:

a) Define the manufacture's responsibility to develop, arrange and implement adequate on-the-job training program, both during construction and LTSA implementation period for EDM's operation/maintenance (O/M) staff assigned to operation and maintenance of the plant.
   It should be ensure that the manufacture shall provide the O/M training during the construction period of, including but not limited to, the assembly of the structure of the equipments of the power plant which cannot be checked during operation, and test operation, as well as during LTSA period, where EDM O/M staff should be able to observe and record the manufacture's of-site maintenance activities. It should also be ensured that the extension of LTSA training services without significant extra cost, if provided LTSA training is assessed insufficient or inadequate for EDM operation/maintenance staff to acquire the expected skill and technology levels.
b) Incorporate the manufacture's responsibility for the above mentioned on-the-job training for EDM's operation/maintenance staff into the Bid Documents.

c) Ensure the quality of training and knowledge transfer provided from the manufacture to EDM's O/M staff during both the construction period and LTSA implementation period.
   If it is found necessary, take corrective action to materialize the training and knowledge transfer outcome, where EDM become able to implement independently quality operation and maintenance activities, of which training are provided by the manufacture. Corrective action may include programming training of power station staff in coordination with the manufacture.
d) Support EDM O.M staff to acquire quality assurance skills to assess the quality of O/M and LTSA training and to identify training-needs.
e) Encourage and ensure EDM staff to acquire such skills as reading design drawings and circuit diagrams, listen to contractor on near-miss experiences and learn safety management scheme from contractors implementation scheme, learn maintenance skills from the manufacture and record such construction and maintenance experiences by video recording and through documentation.

J) Assist EDM in Operation and Maintenance

The consultant shall undertake the following:

Strategic Planning

a) Assist EDM to develop the Operation and Maintenance Strategy, including but not limited to, the plant performance target and plant Operation and Maintenance policy, where EDM O/M staff are to become able to conduct O/M activities in sustainable and independent manner.
b) Assist EDM to develop the procedure to make the breakdown targets from Key Performance Indicators for each department/division of the plant and employees
c) Assist EDM to establish and implement PDCA.

Good Practice

d) Assist EDM to develop and implement a system for recording data on plant efficiency and performance, including but not limited to, daily operation, daily inspection, periodical inspection, maintenance record and accident record.
e) Assist EDM to establish and implement maintenance schedule and procedure.
f) Assist EDM to acquire knowledge and skills of monitoring and checking during operation, such as materializing equipment functions, maintaining heat efficiency, reducing equipment wear, reducing creep and fatigue degradation of hot parts, by utilizing computer-based simulator and OJT through daily operation.
g) Assist EDM to establish and implement a trouble-management scheme, including trip cause analysis and recurrence prevention.
h) Assist EDM to establish and implement safety management scheme, including ex-ante and ex-post safety activities.
i) Assist EDM to prepare inventory records (assets listing) of nameplate, summary list of equipment facilities "as-built" drawings for electro-mechanical equipment
j) Assist EDM to acquire knowledge and skills to conduct non-destructive inspection.
k) Assist EDM to develop basic design of IT-enabled Operation and Management System which includes, but not limited to the plant budgeting

database and parts management system for system detailed design to be taken up in later stage.

l) Closely coordinate and communicate with management consultant, who will be responsible to develop EDM's finance and accounting capacity including budget management;

m) Guidance and coordination of the preparation of the Contractor's operation and maintenance manuals, which includes negotiation with the contractor to provide their operation/maintenance manuals before the commissioning so that EDM could customize the provided manuals to their operation/maintenance before the commissioning

K) Assist EDM for Environmental aspect

The consultant shall undertake the following:

a) Assist EDM in the further elaboration of environmental management and monitoring programs, both at corporate level and at management level.
b) Assist EDM to enhance respect to compliance in environmental aspects.
c) Assist EDM to implement energy conservation education.

L) Conduct HIV/AIDS prevention program

The consultant team shall incorporate specialists in the HIV/AIDS program with relevant experience regarding HIV/AIDS prevention program within large construction projects. The consultant team shall also incorporate a local NGO in the HIV/AIDS prevention program of the project.

(First stage: During the detailed design stage)

The consultant will conduct a study in order to prepare a HIV/AIDS prevention program ("The study") for the local people taking account of the nature of the project and the socio-economic contents. The consultant shall identify the appropriate HIV/AIDS prevention program for the construction workers to be carried out by NGO in the framework of construction contract under the project an the program for the local people to be carried out by NGO, and shall draft the HIV/AIDS prevention clauses to be included in construction contracts in the study. The program should be started as soon as practicable after worker arrive at the construction site, And the program should include at least (I) facilitation of condom access and promotion of condom uses, (2) HIV/AIDS education through peer education and (3) Provision of information on "Test and treatment of Sexual Transmitted Infection (STI) and "Voluntary Counseling and testing". The program shall be in the line with national strategic plan for HIV/AIDS, and shall be agreed upon with the relevant Ministry. The consultant shall identify a local NGO which is capable of implementing the program, obtain and discuss their proposal in order to decide on implementation plan. The program should cover the practical details of implementation plan including schedule and costs and the gender issue related to HIV/AIDS prevention will be discussed during the consultation.

(Second Stage: During the construction stage)

During the construction phase, the consultant will be a tasked to implement the HIV/AIDS prevention program for construction workers in the framework of the

construction contracts through the local NGO. Those activities will be reported to EDM, and the relevant Ministry monthly and to JICA in the progress report on a quarterly basis. The consultant shall ensure appropriate liaison with relevant health authorities and organizations.

(Third Stage: Upon Completion)

Upon completion, the consultant will be tasked to prepare the report on success/failure of the program to EDM, the relevant Ministry and JICA.

V. REPORTS & DOCUMENTS

The consultant shall prepare and submit to EDM the following documents reports.

1. Inception report (including schedule).
2. Engineering report (including basic design report).
3. Construction schedule and cost estimate.
4. Draft of pre-qualification documents.
5. Draft of Bid documents.
6. Draft of evaluation criteria and method of pre-qualification.
7. Draft of evaluation report of pre-qualification.
8. Draft of evaluation criteria and method of international competitive biddings.
9. Draft of evaluation report of international competitive biddings.
10. Monthly progress report.
11. Quarterly progress report.
12. Project completion report.

VI. EXPERTISE REQUIREMENT

The engineering services shall be provided by the foreign and local consultants, which shall include but not be limited to the following:

Foreign Consultant

1. Project Manager (Team leader: M or E).
2. Plant Design Engineer.
3. Mechanical Engineer (Gas Turbine).
4. Mechanical Engineer (Steam Turbine).
5. Mechanical Engineer (HRSG).
6. Mechanical Engineer (BOP)
7. Electrical Engineer.
8. I & C Engineer.
9. Civil Engineer
10. Contract Engineer.
11. Environmental Engineer.
12. HIV/AIDS Consultant

Local Consultant

13. Deputy Project Manager (deputy Team leader)
14. Plant Design Engineer.
15. Mechanical Engineer (Gas Turbine).
16. Mechanical Engineer (Steam Turbine).
17. Mechanical Engineer (HRSG).
18. Mechanical Engineer (BOP)
19. Electrical Engineer.
20. I & C Engineer.
21. Civil Engineer
22. Environmental Engineer.
23. HIV/AIDS Consultant

VII. DURATION OF SERVICE

The engineering service shall cover the duration of Forty-five (45) months, starting from commencement of consultant services to the completion of the project.

1)	Pre-Construction stage	:	15 Months
2)	Construction stage	:	30 Months
3)	Defect Liability Period	:	12 Months
3)	International Consultant	:	342-Man- Months
4)	Local Consultant	:	307-Man- Months

VIII. SELECTION CRITERIA OF CONSULTANTS

1. Basic Qualification

Based on submission after EOI, the Employer Electricidade de Mozambique (EDM) shall prepare a Short List of Consultants to be invited to submit proposals. The number of the short-listed consultants will be 3 to 5. The consulting firms shall satisfy the following conditions to be listed in the short list

1.1 Overseas experience of consulting services in similar power station project. Minimum requirement: A firm shall have experience of consulting services of at least in a developing country under similar environment 70 MW of (2-on-1, or 1-on-1*2) or above capacity combined cycle power station project under a single contract to be considered for short listing and contract value of such services shall be more than US $ 100 Million. Consultants must have origin from eligible source countries (i.e. *All countries and areas of the world*) as defined under Japanese ODA loans.

1.2 Firms that propose Man-Months less than those specified in the 'TOR' will be disqualified.

2. Technical Capability

Following additional criteria will be considered during evaluation of firms

2.1 Experience in a developing country in similar environment.

2.2 Experience under Japanese finance ODA Loan Projects.

2.3 Professional Strength.
2.4 Experience in relevant field.

Relevant field means experience in the following fields but not limited to:

2.4.1 Preparation of Specification of Power Station as well as Substation materials.
2.4.2 Preparation of bill of quantities.
2.4.3 Preparation of bidding document with commercial terms & designs..
2.4.4 Experience in Bid document evaluation.
2.4.5 Preparation of Contract document.
2.4.6 Review and Approval of technical design, drawing.
2.4.7 Preparation of Project Implementation Schedule.
2.4.8 Supervision and Monitoring of Construction works, Quality control, testing, & commissioning works.
2.4.9 Preparation of Test Schedule.
2.4.10 Completion and Acceptance certificate Issuance.
2.4.11 Preparation of Operation and Maintenance (O&M) Manual.

3. Financial Capacity

3.1 Turnover of the consulting firm
3.2 Contract value of consulting services already performed

4. Specific Requirement:

4.1 Both Foreign & Local consultant shall maintain their office separately at Maputo, Mozambique.
4.2 Foreign consultant should render their service staying in Mozambique for a reasonable time mutually agreed by Employer and Engineer.
4.3 Full time engineers shall stay in Mozambique covering 100% of Man-Months allocated for them.

Short listing will be made on the basis of the stated Criteria Section. VIII of EOI in accordance with the "Guidelines for Employment of consultant under Japanese ODA Loans" March 2009.

Appendix 3

Site Survey

CENTRAL PLAN

LEGEND

VEGETATION
- ALMOND TREE
- APLE TREE
- BUSH
- BAOTAN TREE
- EUCALYPTUS TREE
- BAOBAO TREE
- LIME TREE
- CASHEW TREE
- PINE TREE
- UNKNOW TREE
- ORANGE TREE
- COCONUT TREE
- PALM TREE
- VINE LINE
- BOTANICAL FENCE
- DENSE VEGETATION BOUNDERY
- GREEN AREA

WATER & SEWAGE
- STORMWATER COVER
- SEWER COVER
- SMALL WATER COVER
- UNKNOW COVER
- WATER COVER
- WATER TAP
- CONCEPT
- FIRE WATER
- PIPE INVERT LEVEL
- WATER LEVEL LINE
- WATER INVERT LEVEL LINE
- VISIBLE UNDERGROUND PIPE
- SURFACE PIPE
- UNDERGROUND PIPE
- WELL
- WATER TANK

CONSTRUCTION
- TOP OF SLOPE
- ASPALT RIDGE
- DIRT ROAD RIDGE
- WALL
- FENCE
- STONE WALL
- GATE
- ASPALT PATH
- SIDE WALK PATH
- BUILDING
- TEMPORARY BUILDING
- SLAB HIGHT

ELECTRIC
- LOW VOLTAGE POLE
- MEDIUM VOLTAGE POLE
- HIGH VOLTAGE POLE
- LIGHT POLE
- ELECTRIC CLOSET
- ELECTRIC COVER
- TRAFFIC ROBOT
- ELECTRIC LINE ENTRY
- LOW VOLTAGE LINE
- MEDIUM VOLTAGE LINE
- HIGH VOLTAGE LINE

GAS & TELEPHONES
- GAS EMERGEN
- GAS COVER
- PHONE POLE
- PHONE COVER
- PHONE LINE
- GEOTECHNICAL BOREHOLE

BOUNDERY
- PROPERTY BOUNDERY
- LAND BOUNDERY
- AREA OF INTERVENTION

TOPOGRAPHY
- BENCH MARK
- PROPERTY BENCH MARKS
- RELIEVATE HIGH
- CONTOURS OF 0.50 m

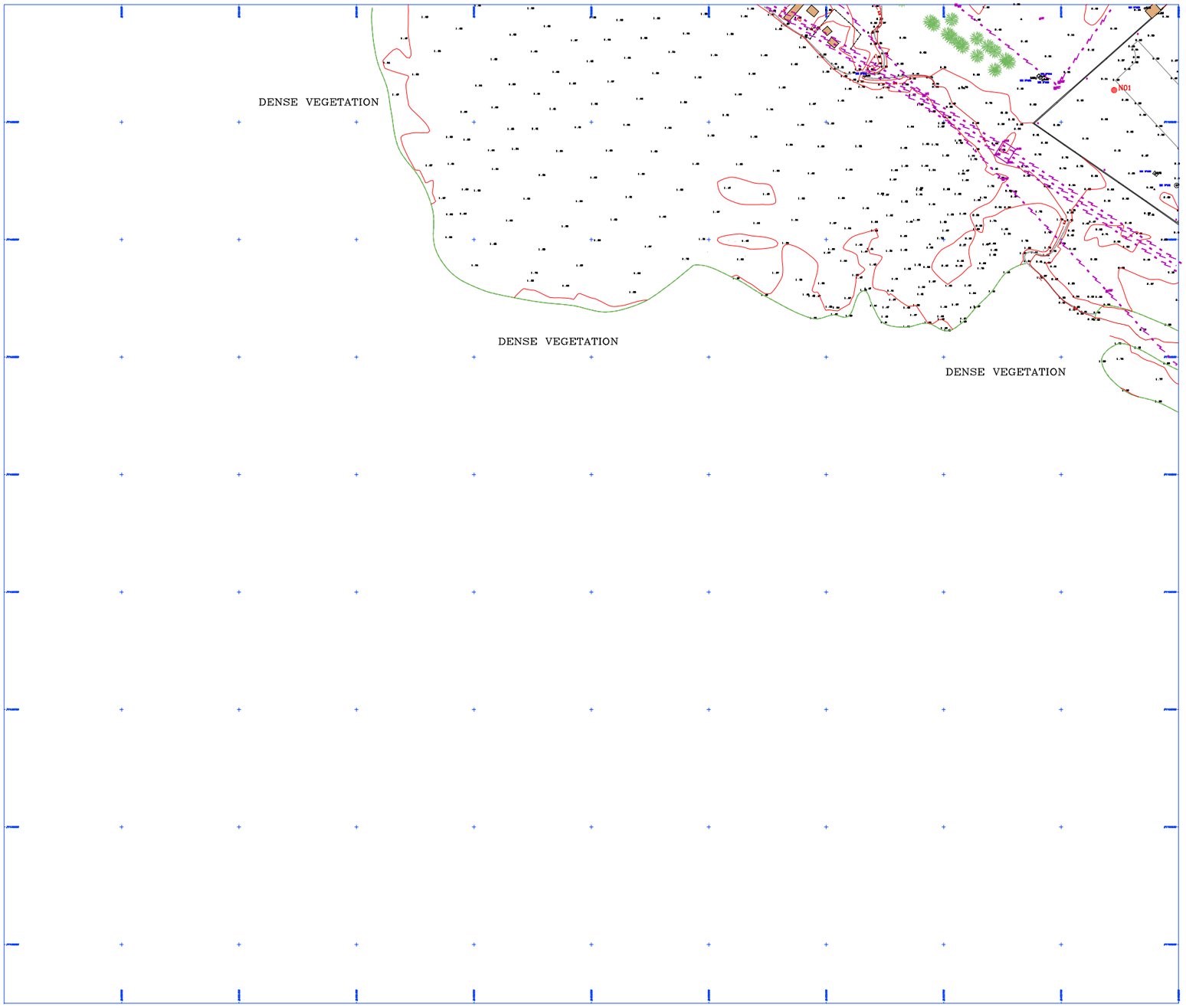
N

0 50 100 m

NO.	REV.	DESCRIPTIONS

PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE		REVISION: 0
DRAWING TITLE: CTM TOPOSURVEY CENTRAL PLAN	SCALE: 1/1000	DRAWING NO.: —

APP3-1



PLAN 01 OF 04

LEGEND

VEGETATION
- ALMOND TREE
- APPLE TREE
- BUSH
- BAOBAB TREE
- EUCALYPTUS TREE
- MANGO TREE
- LIME TREE
- CASHEW TREE
- PINE TREE
- UNKNOW TREE
- ORANGE TREE
- COCONUT TREE
- PALM TREE
- VINE LINE
- BOTANICAL FENCE
- DENSE VEGETATION BOUNDERY
- GREEN AREA

WATER & SEWAGE
- STORMWATER COVER
- SEWER COVER
- SMALL WATER COVER
- UNKNOW COVER
- WATER COVER
- WATER TAP
- CONCEPT
- FIRE WATER
- PIPE INVERT LEVEL
- WATER LEVEL LINE
- WATER INVERT LEVEL LINE
- VISIBLE UNDERGROUND PIPE
- SURFACE PIPE
- UNDERGROUND PIPE
- WELL
- WATER TANK

CONSTRUCTION
- TOP OF SLOPE
- ASPALT RIDGE
- DIRT ROAD RIDGE
- WALL
- FENCE
- STONE WALL
- GATE
- ASPALT PATH
- SIDE WALK PATH
- BUILDING
- TEMPORARY BUILDING
- SLAB EDGE

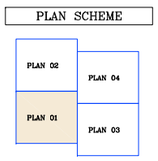
ELECTRIC
- LOW VOLTAGE POLE
- MEDIUM VOLTAGE POLE
- HIGH VOLTAGE POLE
- LIGHT POLE
- ELECTRIC CABINET
- ELECTRIC COVER
- TRAFFIC SIGNAL
- ELECTRIC LINE JOINT
- LOW VOLTAGE LINE
- MEDIUM VOLTAGE LINE
- HIGH VOLTAGE LINE

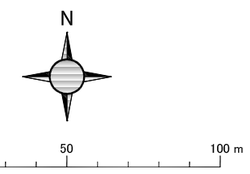
GAZ & TELEPHONES
- GAS SCREEDER
- GAS COVER
- PHONE POLE
- PHONE COVER
- PHONE LINE
- GEOTECHNICAL BOREHOLE

BOUNDERY
- PROPERTY BOUNDERY
- LAND BOUNDERY
- AREA OF INTERVENTION

BENCH MARK
- BENCH MARK
- PROPERTY BENCH MARKS
- RELIVATE BECH
- CONTOURS OF 0.50 m

PLAN SCHEME





NO.	REV.	DESCRIPTIONS

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DRAWING TITLE: CTM TOPOSURVEY PLAN – 1	SCALE: 1/1000	DRAWING NO.: —

PLAN 02 OF 04

LEGEND

VEGETATION
- ALMOND TREE
- APLE TREE
- BUSH
- BAOBAB TREE
- EUCALYPTUS TREE
- MANGO TREE
- LIME TREE
- CASHEW TREE
- PINE TREE
- UNKNOW TREE
- ORANGE TREE
- COCONUT TREE
- PALM TREE
- VINE LINE
- HEDGEROW FENCE
- DENSE VEGETATION BOUNDARY
- GREEN AREA

WATER & SEWAGE
- STORMWATER COVER
- SEWER COVER
- SMALL WATER COVER
- UNKNOW COVER
- WATER COVER
- WATER TAP
- CONCEPT
- FIRE WATER
- PIPE INVERT LEVEL
- WATER LEVEL LINE
- WATER INVERT LEVEL LINE
- VISIBLE UNDERGROUND PIPE
- SURFACE PIPE
- UNDERGROUND PIPE
- WELL
- WATER TANK

CONSTRUCTION
- TOP OF SLOPE
- ASPHALT RIDGE
- DIRT ROAD RIDGE
- WALL
- FENCE
- STONE WALL
- GATE
- ASPHALT PATH
- SIDE WALK PATH
- BUILDING
- TEMPORARY BUILDING
- SLAB HEIGHT

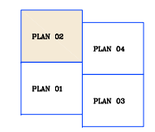
ELECTRIC
- LOW VOLTAGE POLE
- MEDIUM VOLTAGE POLE
- HIGH VOLTAGE POLE
- LIGHT POLE
- ELECTRIC CLOSET
- ELECTRIC COVER
- TRAFFIC POINT
- ELECTRIC LINE HIGTH
- LOW VOLTAGE LINE
- MEDIUM VOLTAGE LINE
- HIGH VOLTAGE LINE

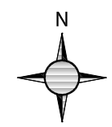
GAS & TELEPHONE
- GAS BREECHER
- GAS COVER
- PHONE POLE
- PHONE COVER
- PHONE LINE
- GEOTECHNICAL BOREHOLE

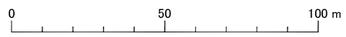
BOUNDERY
- PROPERTY BOUNDERY
- LAND BOUNDERY
- AREA OF INTERVENTION

TOPOGRAPHIC LANDMARK
- BENCH MARK
- PROPERTY BENCH MARKS
- RELEVATE HIGH
- CONTOURS EP 0.50 m

PLAN SCHEME







NO.	REV.	DESCRIPTIONS	PROJECT	REVISION
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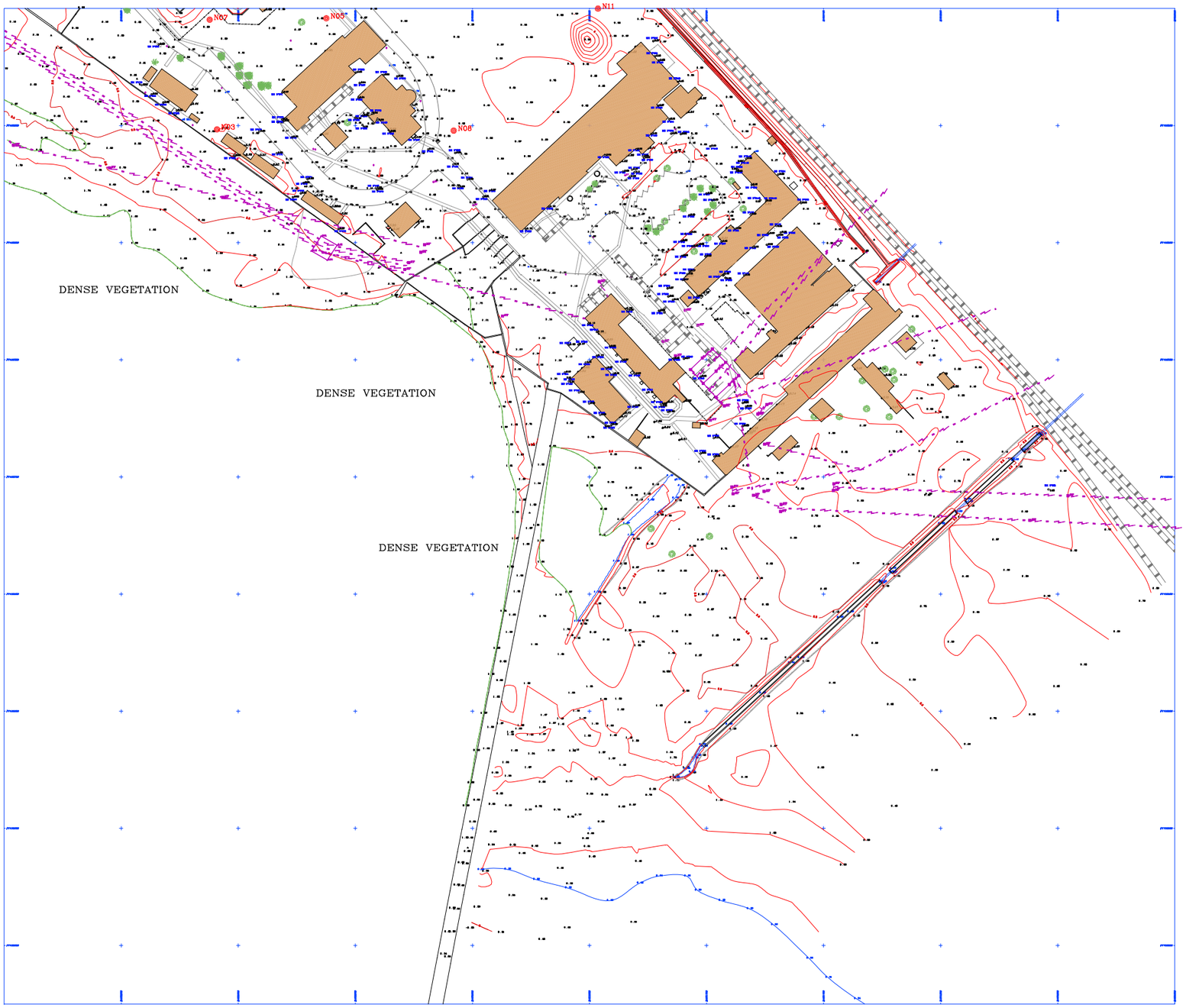
				DRAWING NO.: —



PLAN 03 OF 04

LEGEND

VEGETATION

- ALMOND TREE
- APPLE TREE
- BUSH
- BANYAN TREE
- EUCALYPTUS TREE
- MANGO TREE
- LIME TREE
- CASHEW TREE
- PINE TREE
- UNKNOW TREE
- ORANGE TREE
- COCONUT TREE
- PALM TREE
- VINE LINE
- BIOLOGICAL FENCE
- DENSE VEGETATION BOUNDARY
- GREEN AREA

WATER & SEWAGE

- STORMWATER COVER
- SEWER COVER
- SMALL WATER COVER
- UNKNOW COVER
- WATER COVER
- WATER TAP
- CONCEPT
- FIRE WATER
- PIPE INVERT LEVEL
- WATER LEVEL LINE
- WATER INVERT LEVEL LINE
- VISIBLE UNDERGROUND PIPE
- SURFACE PIPE
- UNDERGROUND PIPE
- WELL
- WATER TANK

CONSTRUCTION

- TOP OF SLOPE
- ASPACE RIDGE
- DIRT ROAD RIDGE
- WALL
- FENCE
- STONE WALL
- GATE
- ASPALT PATH
- SIDE WALK PATH
- BUILDING
- TEMPORARY BUILDING
- ROAD LIGHT

ELECTRIC

- LOW VOLTAGE POLE
- MEDIUM VOLTAGE POLE
- HIGH VOLTAGE POLE
- LIGHT POLE
- ELECTRIC CABINET
- ELECTRIC COVER
- TRAFFIC ROBOT
- ELECTRIC LINE JOINT
- LOW VOLTAGE LINE
- MEDIUM VOLTAGE LINE
- HIGH VOLTAGE LINE

GAZ & TELEPHONES

- GAS BURRIDER
- GAS COVER
- PHONE POLE
- PHONE COVER
- PHONE LINE
- GEOTECHNICAL BOREHOLE

ROUNDSAY

- PROPERTY BOUNDARY
- LAND BOUNDARY
- AREA OF INTERVENTION

TOPOGRAPHY

- BENCH MARK
- PROPERTY BENCH MARKS
- RELEVATE INCH
- CONTOURS OF 0.50 m

PLAN SCHEME

PLAN 02	PLAN 04
PLAN 01	PLAN 03

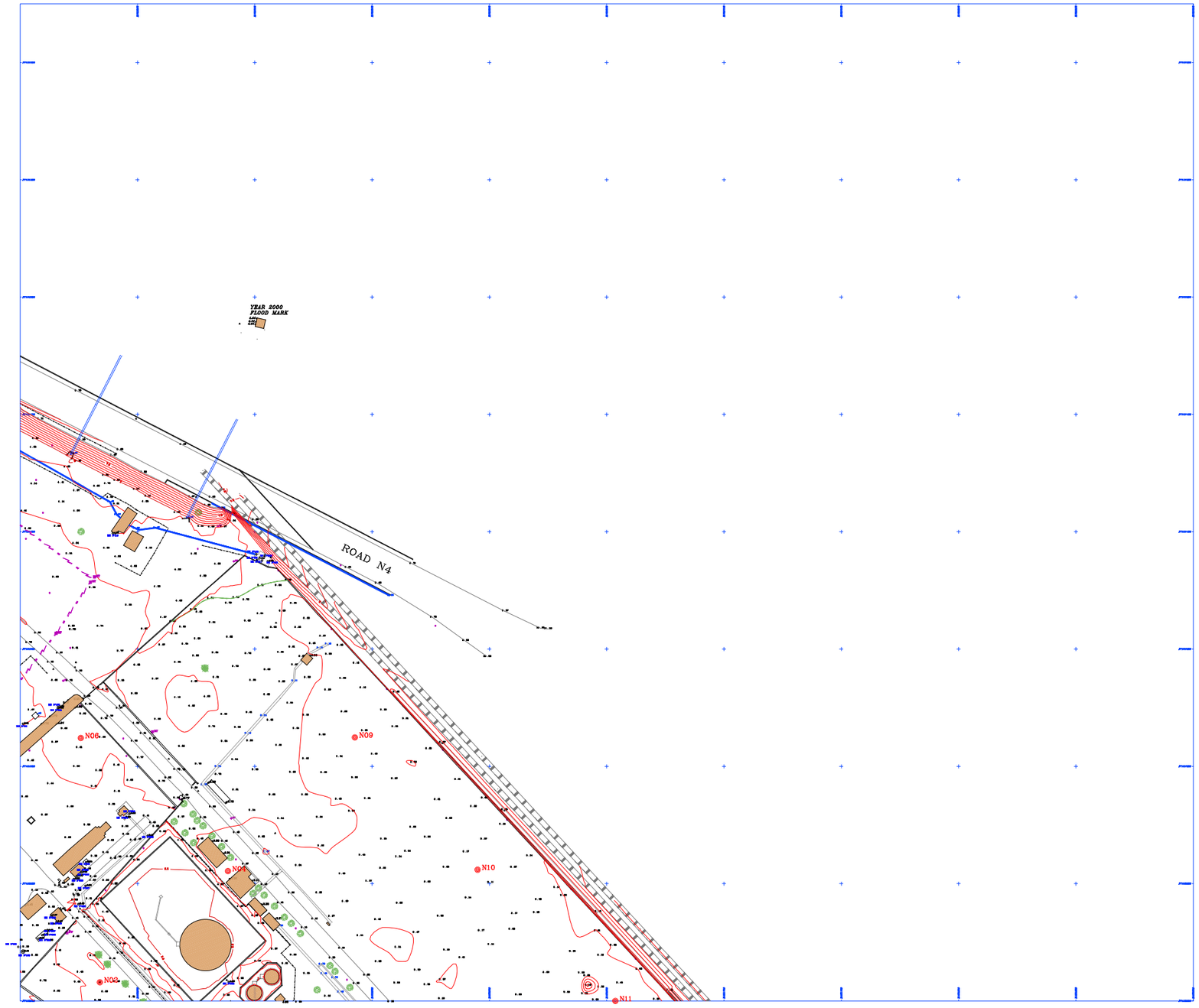
N

0 50 100 m

NO.	REV.	DESCRIPTIONS

PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE		REVISION: 0
DRAWING TITLE: CTM TOPOSURVEY PLAN – 3	SCALE: 1/1000	DRAWING NO.: —

PLAN 04 OF 04



LEGEND

VEGETATION
- ALMOND TREE
- APLE TREE
- BUSH
- BAOBAB TREE
- EUCALYPTUS TREE
- MANGO TREE
- LIME TREE
- CASHEW TREE
- PINE TREE
- UNKNOW TREE
- ORANGE TREE
- COCONUT TREE
- PALM TREE
- VINE LINE
- BIOLOGICAL FENCE
- DENSE VEGETATION BOUNDERY
- GREEN AREA

WATER SEWAGE
- STORMWATER COVER
- SEWER COVER
- SMALL WATER COVER
- UNKNOW COVER
- WATER COVER
- WATER TAP
- CHICKPIT
- FIRE WATER
- PIPE INVERT LEVEL
- WATER LEVEL LINE
- WATER INVERT LEVEL LINE
- VISIBLE UNDERGROUND PIPE
- SURFACE PIPE
- UNDERGROUND PIPE
- WELL
- WATER TANK

TOPOGRAPHY
- TOP OF SLOPE
- ASPALT RIDGE
- DIRT ROAD RIDGE
- WALL
- FENCE
- STONE WALL
- GATE
- ASPALT PATH
- SIDE WALK PATH
- BUILDING
- TEMPORARY BUILDING
- SLAB EDGE

ELECTRIC
- LOW VOLTAGE POLE
- MEDIUM VOLTAGE POLE
- HIGH VOLTAGE POLE
- LIGHT POLE
- ELECTRIC CABINET
- ELECTRIC COVER
- TRAFFIC ROBOT
- ELECTRIC LINE STATE
- LOW VOLTAGE LINE
- MEDIUM VOLTAGE LINE
- HIGH VOLTAGE LINE

GAZ & TELEPHONES
- GAS BURRENDER
- GAS COVER
- PHONE POLE
- PHONE COVER
- PHONE LINE
- GEOTECHNICAL BOREHOLE

BOUNDERY
- PROPERTY BOUNDERY
- LAND BOUNDERY
- AREA OF INTERVENTION

TOPOGRAPHY BOUNDERY
- BENCH MARK
- PROPERTY BENCH MARKS
- RELIEVATE HIGH
- CONTOURS OF 0.50 m

PLAN SCHEME

PLAN 02	PLAN 04
PLAN 01	PLAN 03

N

0 50 100 m

NO.	REV.	DESCRIPTIONS

PROJECT: GAS FIRED POWER PLANT DEVELOPMENT IN SOUTHERN MOZAMBIQUE

REVISION: 0

DRAWING TITLE: CTM TOPOSURVEY PLAN – 4

SCALE: 1/1000

DRAWING NO.: —