ELECTRIÇIDADE DE MOÇAMBIQUE (EDM)
MINISTRY OF ENERGY (ME)
THE REPUBLIC OF MOZAMBIQUE

DATA COLLECTION SURVEY
ON
THE POWER SECTOR OF MOZAMBIQUE
IN
THE REPUBLIC OF MOZAMBIQUE

FINAL REPORT

JULY 2012

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD. (OC)
TOKYO ELECTRIC POWER SERVICES CO., LTD. (TEPSCO)

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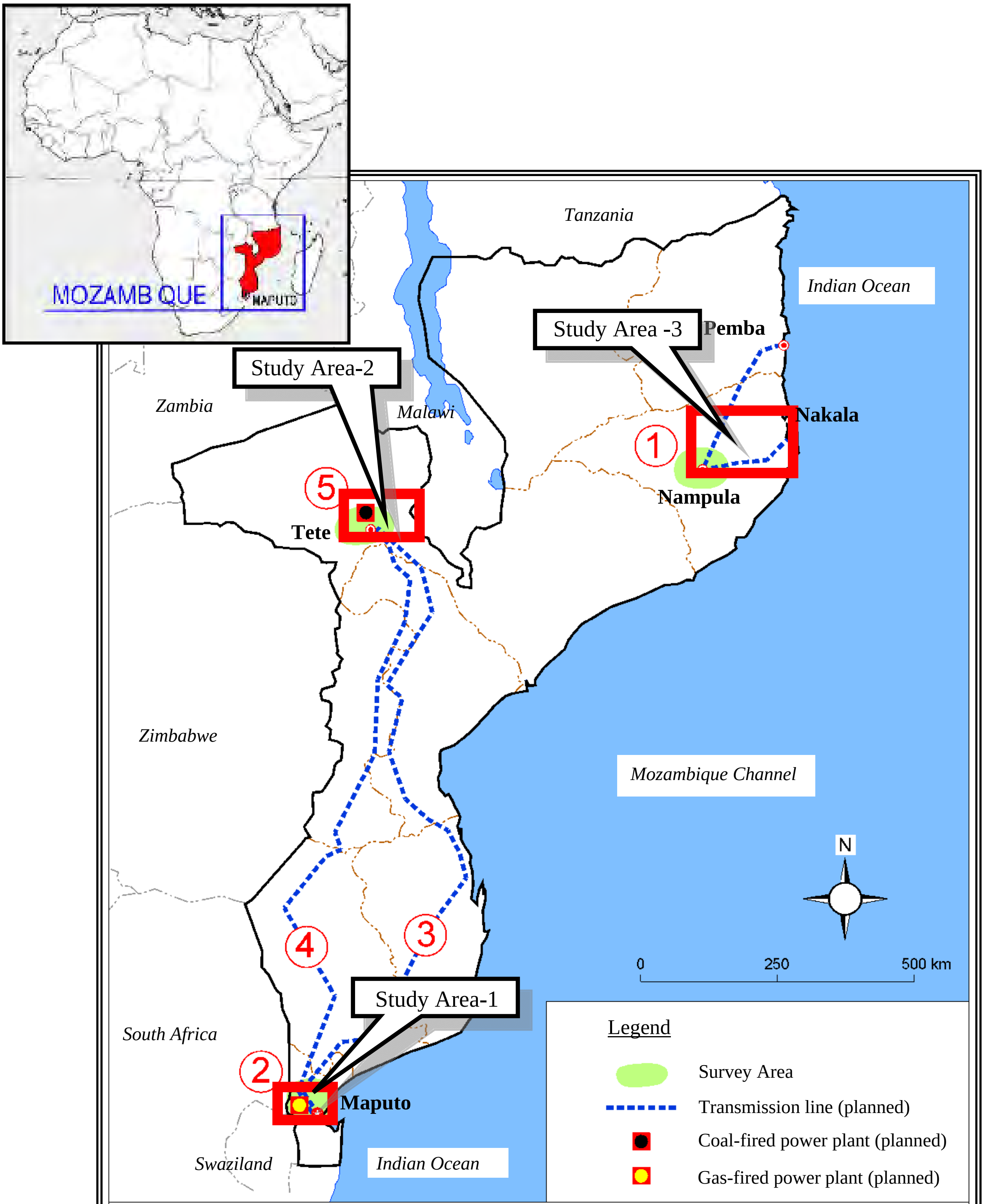
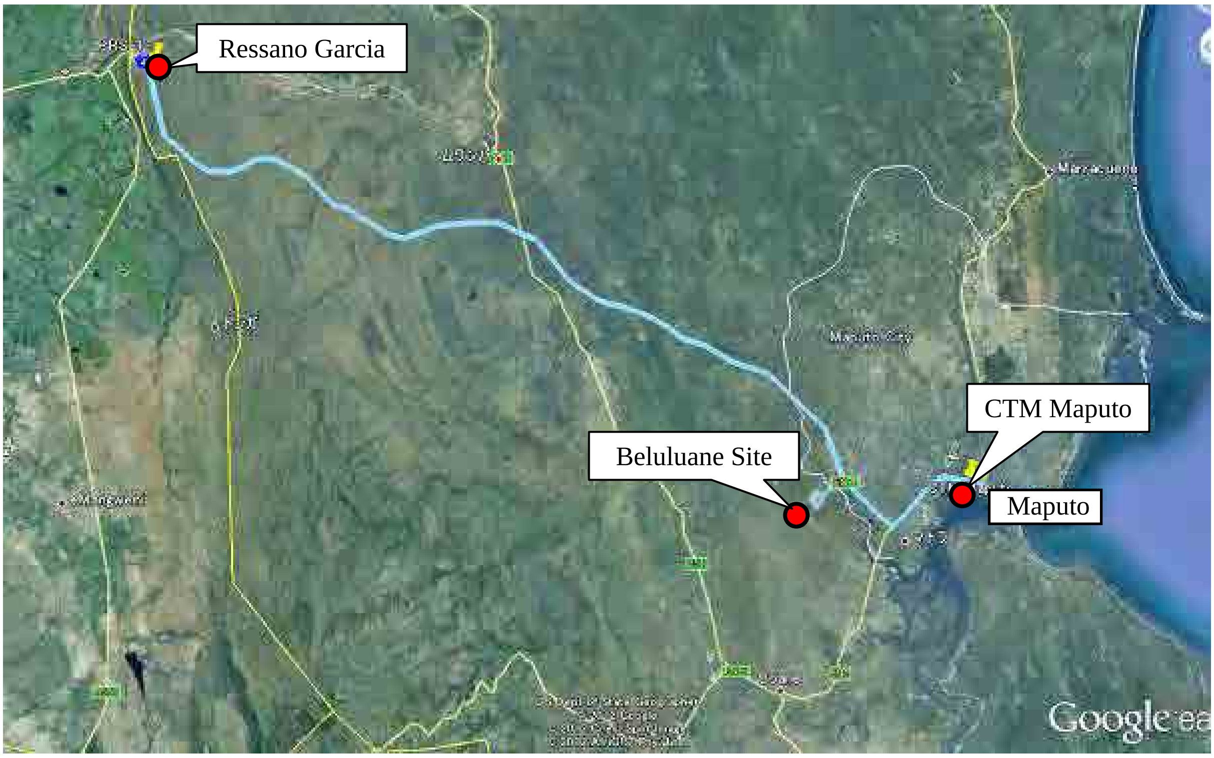
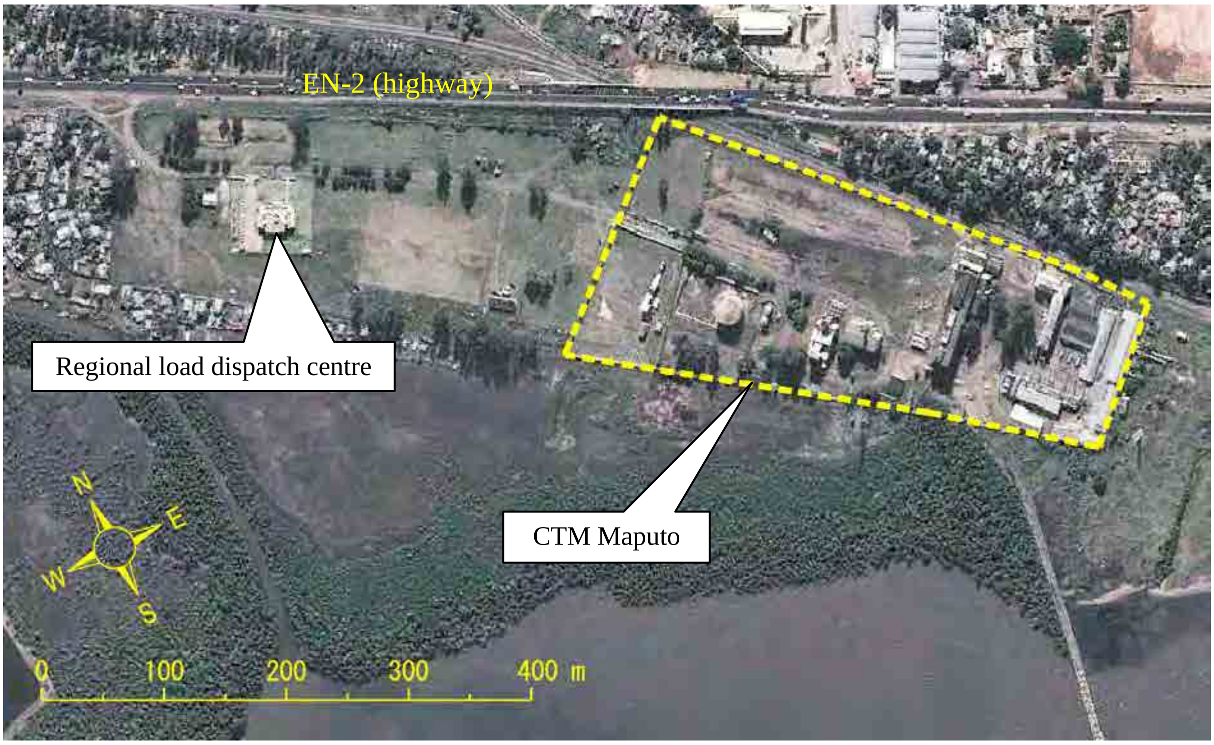


①	RECONFIGURATION OF NAMPULA - MONAPO - NACALA AND NAMPULA- METORO - PEMBA - AT NAMIALO AND BUILD NEW 40MVA, 110/33KV AT NAMIALO
②	50MW POWER PLANT AT BELULUANE
③	CESUL 400KV HVAC
④	CESUL 500KV HVDC
⑤	TETE COAL GENERATION PROJECTS (PHASE I - 500MW)

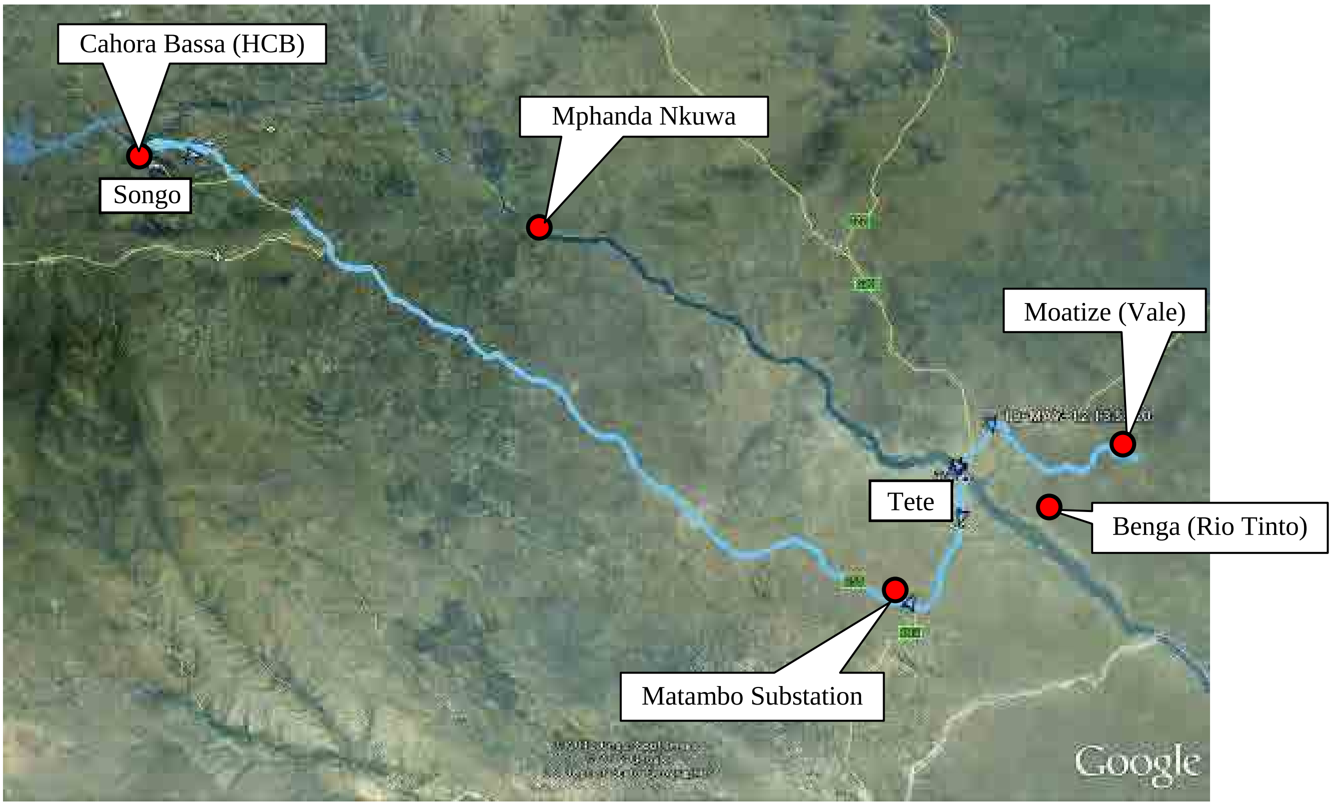
Location of Study Area



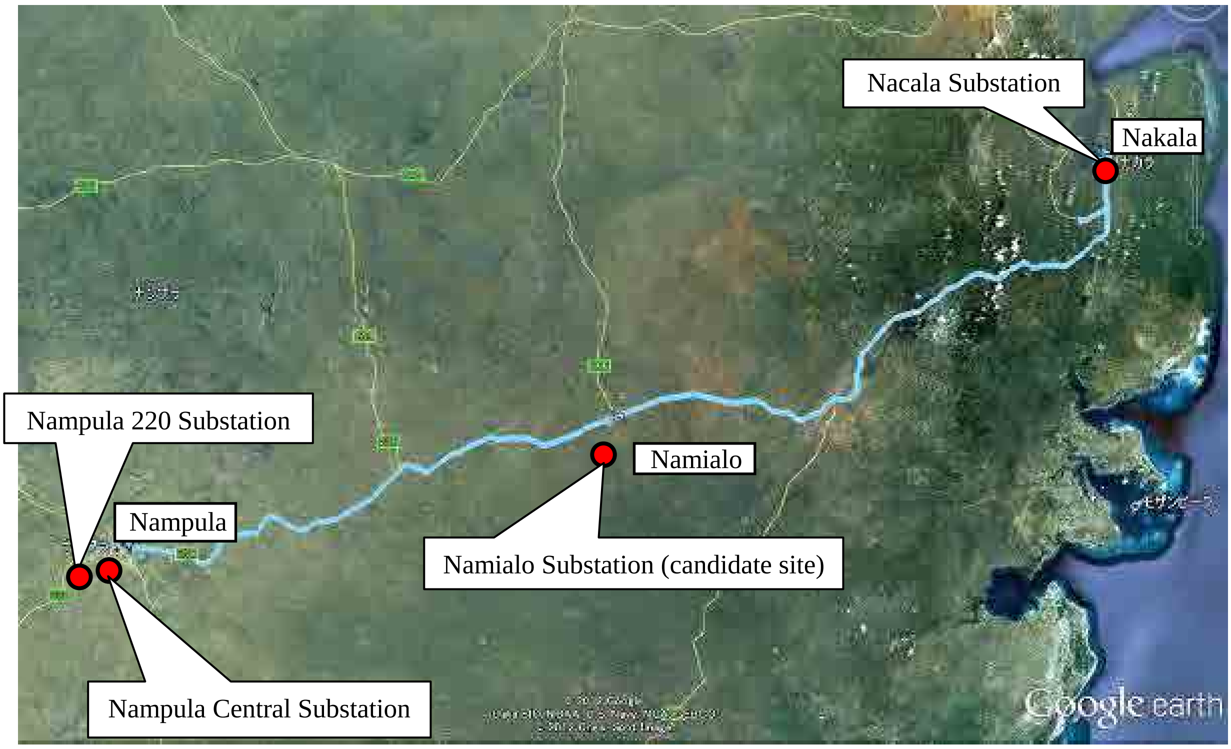
Study Area-1 (Maputo – Ressano Garcia)



Plan of CTM-Maputo (Enlarged View of "CTM Maputo" in the above Figure)



Study Area-2 (Tete – Songo)



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EXECUTIVE SUMMARY

1. Background and Objectives of the Survey

An overview of the power sector of the Republic of Mozambique (hereinafter referred to as "Mozambique") is as follows:

- Mozambique has a vast land area of 799,380 km^2 and a population of 22.4 million, resulting in a low population density of 28 persons per km^2. For this reason, it is difficult for the national power grid to reach rural regions in the county, causing a big gap in the access to electricity between the people residing in cities and those in outlying regions. This situation presents a barrier to addressing the issue of poverty reduction in the rural areas.
- The national electrification rate is very low at 18%（2011） making the increase of the rate an important issue. There is a strong need for assistance in electrification projects, which are expected to contribute to economic growth and poverty reduction.
- Per-capita power consumption per year is as low as 143 kWh, while generated power equal to the sum of power consumption and power loss) is only 4,025 GWh, with the maximum power being 610 MW. In the meantime, the average annual growth rate for power in terms of kWh and kW exceeds 10%. Responding to recent stable economic growth, power demand is expected to grow steadily for the years to come.
- The national power grid of Mozambique is interconnected with the Southern Africa Power Pool (SAPP) and operated as an integral part of the pool. Power generated at the Cahora Bassa Hydro Power Plant (rated capacity: 2,075 MW) is exported to the power pool, and the power required for Mozambique is imported from the pool. The power sector of Mozambique heavily depends on the pool.
- Eighty-eight percent of the power requirements of Mozambique come from the Cahora Bassa Hydro Power Plant, which is roughly equal to 21% of the total generated power at the power plant (the figure 21% was obtained by calculating 3,549 GWh of purchased power divided by generated power 16,600 GWh, both figures for the year 2009). Most of the remaining 12% comes from aging thermal power plants. There is a strong need for the power sector of Mozambique to promote rehabilitation and capacity enhancement of the existing thermal power plants, not just by maintaining the current capacity, but rather by increasing the capacity of a reliable supply of its own in the years ahead.
- In the regions where extension of the national power grid is not economically feasible, power generation by technologies such as photovoltaics and small-scale hydropower has been promoted. Acceleration of the introduction of such technologies is highly anticipated.

This survey, "Data Collection Survey on the Power Sector of Mozambique," is intended to collect and analyze data necessary for the strategic cooperation by the Government of Japan to the Government of Mozambique in the power sector of Mozambique. The survey was conducted during the period from February 2012 to July 2012. The JICA Survey Team collected data from the Ministry of Energy (ME) and Electricity of Mozambique (EDM), counterparts of Mozambique for this survey, on the power sector of Mozambique. Site reconnaissance was also carried out in the sites of priority projects in various parts of the country.

2. Situation of the Power Sector

The situation of the power sector of Mozambique is summarized as follows:

- The means of power supply is divided into three categories: the national grid, mini grids, and independent systems. For the national grid, EDM is responsible under the supervision of ME. For mini grids, ME is responsible through relevant offices in the provincial governments.
- EDM is a state-owned vertically integrated electric power company responsible for power generation, transmission, distribution, and sales of electricity. EDM primarily conducts the businesses of power transmission, distribution, tariff collection, etc. for the customers who receive power from the national grid. The scale of power generation is small.
- Since Mozambique has a large area extending 2,000 km in the north-south direction, the network is separated into two systems: one for the southern area and the other for the central and northern areas. These systems are independently operated, without being linked to each other.
- The Cahora Bassa Hydro Power plant (HCB) with an output of 2,075 MW, the major power source in Mozambique, is linked to the network for the central and northern areas. A part of the generated power is transmitted to the central and northern areas by means of a 220 kV AC transmission line to meet the load within the country, while some power is sent to the neighboring country, Zimbabwe, by means of a 400 kV AC transmission line. However, the majority of the power generated by HCB is sent to the Apollo substation in South Africa by a 535 kV DC transmission line and is then sent to SAPP.
- Since the system for the southern area, which covers Maputo City, the capital of Mozambique, is located over 1,000 km from HCB, power is imported from SAPP via the networks of South Africa and Swaziland by means of a 400 kV AC transmission line. As a result, more than 80 percent of domestic demand is supplied by re-imported power.
- Operation of the Cahora Bassa Hydro Power Plant has dramatically increased power supply capacity. It has brought out latent power demand, further increasing power demand due to dynamic economic activities.
- EDM has been conducting an update study to the existing study, "Electricity Master Plan Study," which was completed in 2004. The update study, “Update of Master Plan 2010-2027," is scheduled to be complete by the end of 2012. The long-term power demand forecast will also be updated. It is expected that the results of the power demand forecast will be reflected in the power facilities development plan for the coming years.

3. Power Supply and Demand

The situation of power supply and demand is summarized as follows:

- The nation-wide power demand is low: 610 MW for maximum power and 4,025 GWh for power consumption. However, annual average growth rates for the past 5 years have reached as high as 13.8% for the former and 10.6% for the latter. It is forecast that power demand will continue to increase at high rates for the years to come, owing to the active economic activities and rise in the income level.
- Region-wise, the whole southern region, which covers the Maputo metropolitan area, registers an electrification rate of 42%, much higher than the national average rate of 18%. Maputo City enjoys a high rate of 82%. In the meantime, the maximum power in the southern region alone is 369 MW, accounting for 60% of the 610 MW mentioned above, representing a steady annual average growth rate of 11.3%.
- The power demand is expected to continuously grow at a steady rate in the future. However, power purchase from the Cahora Bassa Hydro Power Plant, which accounts for 88% of power supply capacity in the county, is limited to 300 MW for firm power and 200 MW for non-firm power. Any increase from these figures is considered difficult, for the increase requires negotiations with SAPP-affiliated countries.
- A large-scale power plant development plan, using hydro and coal resources abundantly existing in the Province of Tete, and an AC-DC hybrid trunk transmission line project (called "CESUL Project" for short[1]) to transmit power generated at the power plants to the southern region are both anticipated to be implemented at an early stage. As investment financing of these mega projects remains an issue to overcome, the year of commissioning, originally scheduled in 2017, is expected to be delayed beyond 2020.
- To cope with the tight power supply and demand situation, EDM has made strenuous efforts to secure supply capacity by rehabilitating rapidly aging small-scale hydro and thermal power plants. Such efforts alone, however, cannot address the steadily increasing power demand. Thus, EDM is to purchase power from power plants under construction by independent power producers (IPPs) at Ressano Garcia in the southern region, or to jointly promote power development by equity participation in different IPPs. These measures have been deemed essential by EDM to secure a stable power supply.
- These supply capacities alone cannot meet the medium- and long-term power demand in the southern region, while the commencement and commissioning of the above CESUL Project is certain to be delayed. Under these situations, adding a new power plant to the existing and committed supply capacity, inside the Maputo metropolitan area, which is the largest load center in the country, becomes a pressing issue. A new power plant is expected to supply stable power to the Metropolitan area, accelerate economic activities, and contribute to poverty reduction.

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[1] The project name was changed by EDM to the "STE Project" in the middle of 2012, but the original name "CESUL Project" is used in this report to maintain consistency with the existing reports and documents.

4. Regional Transmission Development Project (CESUL)

- In an effort to make an effective use of the wealth of hydro-energy of the Zambezi River and coal energy in the central region of the country, two large scale hydroelectric projects: the 1,245 MW Cahora Bassa North and the 1,500 MW Mphanda Nkuwa projects, and two coal-fired power plant projects: the Moatize and the Benga coal-fired power projects with an initial capacity of 300 MW and 250 MW, respectively, are currently underway.
- When transmitting the power generated by these developed power plants (with a total installed capacity of 3,295 MW) over a long distance of approximately 1,300 km to meet the demand in the southern area centering on Maputo, the greatest problem is how to maintain system stability. To solve this problem, use of the AC/DV hybrid transmission network system has been proposed. The project cost will reach a total of 2,163.6 million US$ in the Stage 2 of Phase I where the capacity of the power sources to be developed reaches a total of 3,295 MW.
- This project was named the "Mozambique Regional Transmission Backbone Project," and the Feasibility Study of this project was submitted in March 2012.

5. Overview of Priority Projects

ME and EDM have jointly requested to the Government of Japan for assistance in the power sector of Mozambique in EDM's document, "Mozambique Electricity Sector & Power Infrastructure," in which five projects are nominated as 'Projects for Future Cooperation with Japan.'

- Reconfiguration of Nampula – Monapo – Nacala and Nampula – Metoro – Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo
- 50 MW Power Plant at Beluluane
- CESUL 400 kV HVAC
- CESUL 500 kV HVDC
- Tete Coal Generation Projects（Phase I – 500 MW）

On the other hand, an additional request was made by EDM during the discussion in fieldwork for inclusion of the following project in the priority project list:

- Caia – Nampula – Nacala 220 kV Transmission Line

As a result of the preliminary evaluation, it was found that all of the above priority projects meet requirements such as the following: importance and effect of the project, feasibility of the project and policy needs of Japan. On the other hand, the projects that EDM has given high priority and meet the requirements of the Government of Japan for rationale for implementation and expected effects are the two projects mentioned below in the order of priority.

- 50 MW Power Plant at Beluluane
- Reconfiguration of Nampula – Monapo – Nacala and Nampula – Metoro – Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo

6. New Maputo Thermal Power Plant Project

6.1 Outline of the Project

In December 2012, Mozambique officially requested Japan for yen loan assistance for a gas combined cycle power plant (50 MW) in the southern region of the country.

The JICA Study Team has collected relevant information on the Project and conducted a reconnaissance of candidate sites, and thereby has drawn up a Terms of Reference (TOR) for the detailed study for the Project. In the course of the Study, the JICA Study Team discussed the Project with ME and EDM and thence obtained their agreement on the contents of the TOR for detailed study. Finally, it was decided that the preparatory works for the detailed study shall proceed based on the following basic understandings:

- Project Site: The optimum site for the Project shall be selected from the two candidate sites: 1) the site in Beluluane Industrial Park and 2) the site in the existing CTM-Maputo based on the comparative study, and then a detailed study for the selected site shall be conducted. As the project site is not yet determined, the project shall be tentatively called "New Maputo Thermal Power Plant Project."
- Gas Supply: EDM shall secure 6.0 MGJ/y of gas, which is the sum of 2.8 MGJ/y: the amount of the gas intended for the project of upgrading of existing gas turbines (GTGs) in CTM-Maputo (e.g. conversion of open cycle to combined cycle GTG System) and 3.2 MGJ/y originally intended for a gas-fired combined cycle power plant in Beluluane Industrial Park.
- Installed Capacity: The initial request from EDM was 50MW. With 3.2 MGJ/y of natural gas, however, it is decided that a combined cycle gas turbine (CCGT) power plant with an installed capacity of around 70 MW will be investigated in the feasibility study. Thus, it is expected that the first phase 70 MW plant will be constructed using 3.2 MGJ/y with assistance of the Government of Japan, and thence to expand the plant with remaining 2.8 MGJ/y later on in the future.
- Gas Pipeline: The gas distribution concession for Maputo City and Marracuene District has been given to a joint venture between ENH and KOGAS (from South Korea) by the Government of Mozambique and it was corroborated by EDM that the first phase of pipeline construction: construction of the pipeline linking the existing PRS-2 and CTM-Maputo, is scheduled to be completed by November 2013. Thus, construction of a new gas pipeline dedicated to the Project is not required.

6.2 Expected Project Effects

The new power plant is expected to operate in middle or base load mode. While the peak power demand of the whole country increases by 50-80 MW annually, that for the southern region increases by around 40 MW. The new power plant is to supply power to the southern region, especially for the Maputo Metropolitan area. The role and expected effects of the Project are summarized as follows:

- The installed capacity of the new power plant is expected to be around 70 MW, which corresponds to an increase of peak power demand for two years in the southern region. Although the total installed capacity of the EDM thermal power plants is reportedly 92 MW, most of these thermal power plants cannot provide a stable power supply; only three gas turbine power generation systems in CTM-Maputo serve as emergency backup generation. As the public power utility in the country, it is an urgent and immediate priority for EDM to construct a new 70 MW power plant with high reliability and stability.
- Three (3) IPP projects in Ressano Garcia (i.e. Sasol + EDM IPP, Gigawatt-Mozambique IPP and Aggreko IPP) are currently underway. The installed capacity of these power plant ranges between 100 MW and 140 MW. It is necessary in the near term for EDM to purchase peak power from these IPPs at an extremely high price.
- Currently, EDM purchases peak power from SAPP on a spot basis. The SAPP electricity price for the on-peak hours costs 25 ~ 30 USc/kWh, which is three to four times higher than the EDM average sales price (7.5 USc/kWh). It is likely that this expenditure may put pressure on EDM’s corporate profit in the near future. The generation cost of the New Maputo Thermal Plant is expected to be 6.55 USc/kWh, which is lower than the electricity purchase price from Aggreko’s peaking power plant (9.0 USc/kWh). Thus, it can be said that the Project can offer power generation at a competitive price in a market. The Government of Mozambique also expects the gas-fired power plant to continuously supply power to the Maputo metropolitan area even after commissioning of the CESUL project, and surplus power from the CESUL project to be transmitted to neighboring countries.
- In addition to the above, the Project can create the following positive effects: provision of peak load capacity (short-term effect), contribution to energy security of Mozambique (mid- to long-term effects) effective utilization of existing staff of EDM, job creation and economic growth, CO_2 emission reduction, and so on.

6.3 Environmental and Social Impacts of the Project

- The proposed site inside the Beluluane Industrial Park is already cleared, leveled and was allocated as an industrial area at the time the park was developed. Therefore, impacts on the natural environment and social conditions are expected to be minimal or negligible. On the other hand, if pipelines to supply cooling water (18 km) and fuel gas (3.5 km) need to be laid in the populated areas, it would be necessary to examine the environmental and social impacts caused by these pipelines.
- The proposed CTM-Maputo site is within the plot managed by EDM and is also cleared and leveled. Therefore, impacts on the natural environment and social conditions are expected to be minimal or negligible. The discharge of heated effluent and intake of cooling water will be carried out in Maputo Bay, where the coast is covered by mangroves.

Therefore, it is necessary to consider the impact on changes in the water temperature and currents due to the project.

6.4 Key Considerations for Implementation of the Project

- Key considerations for the implementation of a target project should be identified by conducting a feasibility study under the framework of JICA’s preparatory survey, and thereby, approaches to solutions and/or mitigation strategies for the considerations should be presented. On the assumption that the priority projects are financed by yen loans, they should be implemented in accordance with general guidelines and considerations stipulated in the “the Operational Guidance for the Preparation of the Projects Financed by Japan's ODA Loans.”
- EDM has a number of employees proficient in planning, construction and operation of transmission and distribution facilities. Since large-scale generation projects have not been implemented for many decades, however, it has few personnel proficient in the field of power generation facilities. It is indispensable to identify appropriate counterparts who will be responsible for each aspect in the implementation of the project.

7. Laws and Regulations on Environmental and Social Considerations

- The Environmental Law (Lei do Ambiente), Law No. 20/97, is the foundation for the whole set of legal instruments regarding the preservation of the environment. This is an umbrella law for environmental matters and there are a number of individual regulations, rules and programs, etc. established under this law. The ambit of the Environmental Law comprises all activities public or private, which may directly or indirectly influence the environment.
- The Environmental Law states that the licensing and registration of activities that may cause a significant impact on the environment must be carried out according to the Environmental Impact Assessment (EIA) regulations and that the issuance of an Environmental License must be based upon an approved EIA of the proposed activity. The EIA process is set out in Regulations on the EIA Process, Decree No. 45 of 2004. The Regulations require carrying out a screening in order to categorize the activity into A, B or C, which will determine the depth of impact assessment related to the degree of impact, and sets out criteria for the categorization.
- Category A is defined as: projects that may cause negative impacts due to the proposed activities or due to the sensitivity of the area. This project category requires the elaboration of an environmental prefeasibility study and scoping definition, followed by execution of an EIA, which consists of an Environmental Impact Study and an Environmental Management Plan (EMP). Example of projects that basically fall under Category A are: all types of power generation including hydro, thermal (coal, gas and others) and transmission lines for which the voltage is 110 kV or more and the length is 10 km or more.

- The Categorization is decided by MICOA based on the Preliminary Environmental Information Form that is filled in/completed by the developer/proponent.

8. Conclusion and Recommendations

- Collected data and information are organized in a list (List of Collected Information), which can be easily referred to in an electronic format.
- The survey area covers the whole country and reconnaissance took place at the sites of priority projects. The results of the reconnaissance were included in the deliverables. The data and information are organized in the deliverables to enable formulation and implementation of the priority projects in the near future.
- The projects whose priority is considered high by EDM, and significance and effectiveness of aid by the Government of Japan are deemed as sufficient, are the projects listed below (the names of the projects are those at the time of request from EDM). There is a possibility that the priority of any other priority projects (particularly, Caia – Nampula – Nacala 220kV Transmission Line Project) may increase depending on the development and situation in the future. It is suggested, therefore, that continuous data collection activities should be in place.
  - 50 MW Power Plant at Beluluane
  - Reconfiguration of Nampula-Monapo-Nacala and Nampula-Metoro-Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo
- It was decided that a full-scale feasibility study on “the New Maputo Thermal Power Station Project” will be conducted to investigate the requested “50 MW Power Plant at Beluluane” with the highest priory in terms of necessity and urgency.
- Results of the updated project of the Master Plan for the power sector of Mozambique, which has been conducted under assistance from a donor country, are expected to provide valuable reference data when the Government of Japan considers extending assistance to the power sector of Mozambique. From this point of view, data collection activities on the updated project of the Master Plan should be continued.
- In order to facilitate and maximize the effectiveness of supporting the power sector of Mozambique, there is a strong need for strengthening cooperation with other donors.

List of Tables

List of Figures

Abbreviations

Abbreviation	Original Language	English	Remarks
AdeM	Águas de Moçambique	-	
AFD	L'Agence Française de Développement	French Development Agency	
AfDB	-	African Development Bank	
ASDI	-	Swedish International Development Agency	Also known as SIDA
BCF	-	billion cubic feet	
BID	-	The Inter-American Development Bank	
CCGT	-	Combined Cycle Gas Turbines	
CCPP	-	Combined Cycle Power Plant	
CESUL	Projecto Regional de Transporte de Energia, Centro-Sul	Mozambique Regional Transmission Backbone Project	
CEZA	Companhia Eléctrica do Zambeze	Zambezi Electricity Company	
CFM	Portos e Caminhos de Ferro de Moçambique	Mozambique Ports and Railways	
CNELEC	Conselho Nacional da Electricidade	National Electricity Council	
CMG	Companhia Moçambicana de Gasoduto	Mozambican Pipeline Company (no official English name)	A subsidiary of ENH
CMH	Companhia Moçambicana de Hidrocarbonetos	Mozambican Hydrocarbon Company (no official English name)	A subsidiary of ENH
CPF	-	Central Processing Facility	
CRA	Conselho de Regulação do Abastecimento de Água	Water and Sanitation Regulator	
CTM	Central Térmica de Maputo	Maputo Thermal Power Station	
DANIDA	-	Danish International Development Agency	
DNE	Direcção Nacional de Energia	National Directorate for Energy	
DNAIA	Direcção National de Avaliação do Impacto Ambiental	National. Directorate for Environmental Impact Assessments	
DPCA	Provinciais para Coordenação da Acção Ambiental	Provincial Directorate for Co-ordination of Environmental Affairs	
DWT	-	Deadweight tonnage	
EDM	Electricidade de Moçambique	Mozambican Electricity Company (no official English name)	
EIA	-	Environmental Impact Assessment	
EIRR	-	Economic Internal Rate of Return	
EIS	-	Environmental Impact Study	
EN	Estrada Nacional	National Highway	
ENH	Empresa Nacional de Hidrocarbonetos de Moçambique	Mozambican National Hydrocarbon Company	
EPC	-	Exploration and Production Agreement (contract)	
EPC	-	Engineering, Procurement and Construction (contract)	
EPDA	Estudo de Pré-Viabilidade Ambiental e Definição do Âmb	Environmental Pre-Feasibility Study and Scope Definition	
EPZ	-	Export Processing Zone	
ESIA	-	Environmental and Social Impact Assessment	
ESKOM	-	South African Power Utility	
EU	-	European Union	
FIPAG	Fundo de Investimento e Património de Abastecimento de Água	Water Supply Investment and Assets Fund	
FIRR	-	Financial Internal Rate of Return	
FTZ	-	Free Trade Zone	
FUNAE	Fundo de Energia	Mozambican National Rural Electrification Fund (no official English name)	
GAZEDA	Gabinete Das Zonas Económicas de Desenvolvimento Acelerado	Special Economic Zones Office	

Abbreviation	Original Language	English	Remarks
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit	German Agency for International Cooperation	
GoM	-	Government of Mozambique	
GSA	-	Gas Sales Agreement	
GT	-	Gas Turbine	
GTZ	Die Deutsche Gesellschaft für Internationale Zusammenarbeit	German Organization for Technical Cooperation	GTZ is now GIZ
HCB	Hidroeléctrica de Cahora Bassa	Cahora Bassa Hydroelectric	
HRS	-	Heat Recovery System	
HRSG	-	Heat Recovery Steam Generator	
ICO	Instituto de Crédito Oficial	State Credit Agency of Spain	
IDA	-	International Development Association	
IFC	-	International Financial Corporation	
INP	Institudo Nacional de Petróleos	National Petroleum Institute	
ITC	-	Independent Transmission Company	
JICA	-	Japan International Cooperation Agency	
KfW	Kreditanstalt für Wiederaufbau	-	Germany's state-owned development lender
MGC	-	Matola Gas Company	A joint venture of GoM and Gigajoule International Ltd.
MGJ	-	Million gigajoules	
MICOA	Ministério para Coordenação de Acção Ambiental	Ministry of Coordination of Environmental Affairs	
MMR	-	Ministry of Mineral Resources	
ME	-	Ministry of Energy	
MOTRACO	-	Mozambique Transmission Company	
MPDC	-	Maputo Port Development Company	
MTC	-	Ministry of Transport and Communications	
NERSA	-	National Energy Regulator of South Africa	
NGV	-	Natural Gas Vehicle	
OPEC	-	Organization of the Petroleum Exporting Countries	
PPA	-	Petroleum Production Agreement	
PPA	-	Power Purchase Agreement	
PRS	-	Pressure Reduction Station	
PSA	-	Production Sharing Agreement	
PSS/E	-	Power System Simulator for Engineering	
ROMPCO	-	Republic of Mozambique Pipeline Investments Company Ltd.	
RORO	-	Roll-on/Roll-off ship	Vessels designed to carry wheeled cargo
RSA	-	Republic of South Africa	
SADC	-	Southern African Development Community	
SAPP	-	Southern African Power Pool	
SEA	-	Simplified Environmental Assessment	
SIDA	-	Swedish International Development Cooperation Agency	Also known as ASDI
SPI	-	Sasol Petroleum International Ltd.	
SPT	Sasol Petroleum Temane Limitada	-	A subsidiary of SPI
SPV	-	Special Purpose Vehicle	
TAC	-	Technical Assessment Commission	
TCF	-	Trillion cubic feet	
TOR	-	Terms of Reference	
UTIP	Unidade Técnica de Implementação dos Projectos Hidroelétricos	Technical Unit for the Implementation of Hydroelectric Projects	
WB	-	World Bank	

Chapter 1 Introduction

This survey, “Data Collection Survey on the Power Sector of Mozambique,” is intended to collect and analyze information necessary for the strategic cooperation of the Government of Japan and the Government of the Republic of Mozambique (hereinafter referred to as ‘Mozambique’) in the power sector of Mozambique. The survey was conducted during the period from February 2012 to July 2012 in accordance with the contract signed on February 20, 2012, between Japan International Cooperation Agency (JICA) and the joint venture (JV) of Oriental Consultants Co., Ltd. (OC) and Tokyo Electric Power Services Co., Ltd. (TEPSCO).

JV dispatched the Survey Team to Mozambique three times during the period mentioned above to collect data from the Ministry of Energy (ME) and Electricity of Mozambique (EDM), counterparts of Mozambique for this survey on the power sector of Mozambique. Site reconnaissance was also carried out at the sites of priority projects in various parts of the country. Review and analysis of the data and information, made available from these activities, was conducted, and the results are described in this Draft Final Report (DF/R). When the DF/R is basically accepted by JICA and the counterparts of Mozambique, it will be issued as a Final Report (F/R) after modifications, if any, are made.

Table 1-1 shows an overview of the site work conducted in this survey. Work schedules, a list of persons whom the Survey Team met, and a list of collected data are included in Appendices 1-5, respectively.

Table 1-1 Overview of Site Work

No.	Major Tasks	Team Members	Period
1	• Explanations of Ic/R • Data collection • Site reconnaissance (Beluluane site, CTM-Maputo site)	• KASAI Takashi, Team Leader/ Power Development Expert • KINOSHITA Nobuyuki, Power System Expert • OKANO Hideyuki, Power Generation Expert • MIYASHITA Mitsuru, Economist • NIMIYA Masaki, Environmental & Social Considerations Expert	February 26, 2012 – March 28, 2012 (See Appendix-1 for details)
2	• Explanations of Pr/R • Data collection • Site reconnaissance (Beluluane site, CTM-Maputo site) • Site reconnaissance (priority project sites in the Province of Tete) • Site reconnaissance (priority project sites in the Nacala Corridor areas)	• KASAI Takashi, Team Leader/ Power Development Expert • KINOSHITA Nobuyuki, Power System Expert • OKANO Hideyuki, Power Generation Expert • MIYASHITA Mitsuru, Economist • NIMIYA Masaki, Environmental & Social Considerations Expert	May 13, 2012 – May 29, 2012 (See Appendix-2 for details)
3	• Explanations of Pr/R • Data collection	• KASAI Takashi, Team Leader/ Power Development Expert • KINOSHITA Nobuyuki, Power System Expert • OKANO Hideyuki, Power Generation Expert	July 1, 2012 – July 9, 2012 (See Appendix-3 for details)

Note: Ic/R – Inception Report, Pr/R – Progress Report, DF/R – Draft Final Report

Figure 1-1 shows the locations of the priority projects that are listed in the "Priority Projects for Future Cooperation with Japan," a document that was submitted by the counterparts of Mozambique to JICA. The Survey Team conducted collection, organization, review and analysis of the obtained data, and made recommendations for facilitation of cooperation in the power sector of Mozambique, so that these data can be utilized for consideration of future cooperation projects.

The configuration of this DF/R is as follows. The contents are described in detail in each chapter.

Chapter 1	Introduction
Chapter 2	Data Collection and Review on the Power Sector of Mozambique
Chapter 3	Data Collection and Review on the Priority Projects
Chapter 4	Data Collection and Review on the Proposed New Maputo Thermal Power Plant Project
Chapter 5	Data Collection and Review on the Environmental and Social Considerations
Chapter 6	Data Collection and Review on Energy Resources Development
Chapter 7	Conclusion and Recommendations

Chapter 2 Data Collection and Review on the Power Sector of Mozambique

2.1 Outline of the Power Sector of Mozambique

2.1.1 Overview of Current Situation of the Power Sector

An overview of the power sector of Mozambique is as follows:

- The Republic of Mozambique (hereinafter referred to as "Mozambique") has a vast land area of 799,380 km^2 and a population of 22.4 million resulting in a low population density of 28 persons per km^2. For this reason, it is difficult for the national power grid to reach rural regions in the county, causing a big gap in the access to electricity between the people residing in cities and those in outlying regions. This situation presents a barrier to addressing the issue of poverty reduction in the rural areas.
- The national electrification rate is very low at 18% making the increase of the rate an important issue. There is a strong need for assistance in the electrification projects, which are expected to contribute to economic growth and poverty reduction.
- Per-capita power consumption per year is as low as 143 kWh, while generated power (equal to the sum of power consumption and power loss) is only 4,025 GWh, with the maximum power being 610 MW. In the meantime, the average annual growth rate for power in terms of kWh and kW exceeds 10%. Responding to recent stable economic growth, power demand is expected to grow steadily for the years to come.
- The Government of Japan has been concentrating on providing assistance to Mozambique for the Maputo and Nacala economic corridor program and the enhancement of power facilities has become an urgent issue for the acceleration of the corridor programs.
- The national power grid of Mozambique is interconnected with the Southern Africa Power Pool (SAPP) and operated as an integral part of the pool. Power generated at the Cahora Bassa Hydroelectric Power Plant (rated capacity: 2,075 MW) is exported to the power pool, and the power required for Mozambique is imported from the pool. The power sector of Mozambique heavily depends on the pool.
- Eighty-eight percent of the power requirements of Mozambique come from the Cahora Bassa Hydroelectric Power Plant, which is roughly equal to 21% of the total generated power at the power plant (the figure 21% was obtained by calculating 3,549 GWh of purchased power divided by generated power 16,600 GWh, both figures for the year 2009). Most of the remaining 12% comes from aging thermal power plants. There is a strong need for the power sector of Mozambique to promote rehabilitation and capacity enhancement of the existing thermal power plants, not just by maintaining the current capacity but rather by increasing the capacity of a reliable supply of its own in the years ahead.

- In the regions where extension of the national power grid is not economically feasible, power generation by such technologies as photovoltaics and small-scale hydropower has been promoted. Acceleration of the introduction of such technologies is highly anticipated.

2.1.2 Outline of the Energy Policy

The electricity sector of Mozambique has undergone a major change as a result of economic structural reforms in the country as a whole with an emphasis on a market-oriented economy. This results from the energy policy of the country that has ensured that rural electrification will be built into the national-level electrification program and that private investment will be used to promote development of large-scale energy projects.

The energy policy, which was formulated in 1997, has been maintained in its original form up to today. The energy policy puts emphasis on the following points:

- To ensure a reliable energy supply at the lowest possible cost to satisfy current levels of consumption and the needs of economic development.
- To increase the availability of energy for the domestic sector, particularly coal, kerosene, gas and electricity.
- To promote reforestation in order to increase the availability of firewood and charcoal.
- To strengthen the institutional capacity of the main agencies that supply energy in order to improve their performance.
- To promote economically viable investment programs with a view on the development of energy resources (hydroelectricity, forests, coal and natural gas).
- To increase exports of energy products.
- To increase efficiency in the use of energy.
- To promote the development of conversion technologies and environmentally benign energy uses (solar power, wind power and biomass).
- To promote a more efficient, dynamic and competitive business sector.

2.1.3 Principles on Energy Management Strategy

The GoM-approved "Energy Management Strategy for the Energy Sector (2008-2012)" establishes policy guidelines and relevant measures based on the following principles:

- Increased sustainable access to electricity and liquid fuels
- The sustainable utilization of wood fuel
- The promotion of new and renewable sources of energy
- Diversification of the energy matrix
- The joint planning and integration of energy initiatives with development plans and programs of other sectors
- Sustainable development and environmental protection
- Tariffs reflecting real costs and the incorporation of mitigation measures to protect the environment

- The efficient use of energy
- Institutional coordination and consultation with relevant stakeholders for better development of the energy sector
- Active participation in international cooperation forums, including the Southern African Development Community (SADC).

The first item, “increased sustainable access to electricity and liquid fuels,” and the third item, "the promotion of new and renewable sources of energy,” closely relate to the "Poverty Reduction Action Plan (PARP) 2011-2014," which is one of the priority measures of the country. PARP 2011-2014 requires that the energy supply system plays a significant role in poverty reduction, setting the following guidelines for such action.

- Access to electrical energy: expand access to energy at the lowest possible cost by broadening the geographic coverage of energy supply infrastructure and services.
- Renewable energy and new energy sources: create the capacity to use new and renewable energy sources in the country, encourage the development of technologies for producing and installing solar, wind and small-scale hydropower systems, and prioritize their installation and use in health centers and schools.

2.1.4 Legislation in the Electricity Sector

In order to implement the energy policy, the following laws and regulations have been issued.

(1) Ministerial Decree No. 20/97

This provides the basis for the establishment of the National Directorate for Energy (DNE) and was promulgated in 1997. DNE is the technology council established in the Ministry of Energy, conducting analysis, recommendations and planning on energy policy.

(2) Electricity Act No. 2197

This act was approved by parliament and promulgated in 1997, providing general policy on the administrative organization of the energy sector and stipulating the legal framework for power generation, transmission, distribution, and electricity sales, import and export of power, and concessions for power supply.

(3) Municipal Legislation

This was legislated in 1997, stipulating that certain powers are given to local governments for investment planning and operation of the power supply service.

(4) Decree No. 42/2005 of 29 of November 2005

The decree not only stipulates that planning should be undertaken for power generation, transmission, distribution, and electricity sales planning, financing, construction, ownership, operation and maintenance, but also provides the rules and required procedures for operation and maintenance of the national grid and its development.

(5) Decree No. 43/2005 of 29 of November 2005

This decree gives the legal framework for establishing EDM as the corporation that manages transmission and dispatching nationwide.

2.1.5 Plans Related to Implementation of Power Projects

Plans relating to the implementation of power projects include those at national and provincial levels, the roles of which are defined between the organizations at each level. The energy strategy, “Programado Governo, Estrategia de Energia,” was created by ME as a national level planning guide and was issued after evaluation by National Electricity Council (CNELEC). Plans related to the energy strategy are the following:

- Business plan and its budget
- Electrification Master Plan (2005-2019)
- Strategic Plan (2006-2009)
- Contracts for business promotion

CNELEC is a regulatory agency that was established by the Electricity Act and promulgated in 1997. CNELEC has the roles of implementing policy advice and arbitration.

2.2 Structure, Organization and Operation of the Power Sector

2.2.1 Organizations Relating to Implementation of Power Projects

The means of power supply is divided into three categories: the national grid, mini grids, and independent systems. For the national grid, EDM is responsible under the supervision of ME. For mini grids, ME is responsible through relevant offices in the provincial governments.

Important organizations involved in the power sector are EDM, Fundo de Energia (FUNAE), which is responsible for providing funds to promote renewable energy projects (especially rural electrification projects), and the Technical Unit for the Implementation of Hydroelectric Projects (UTIP), responsible for promoting large-scale hydropower projects. These organizations are shown in Figure 2.2-1.

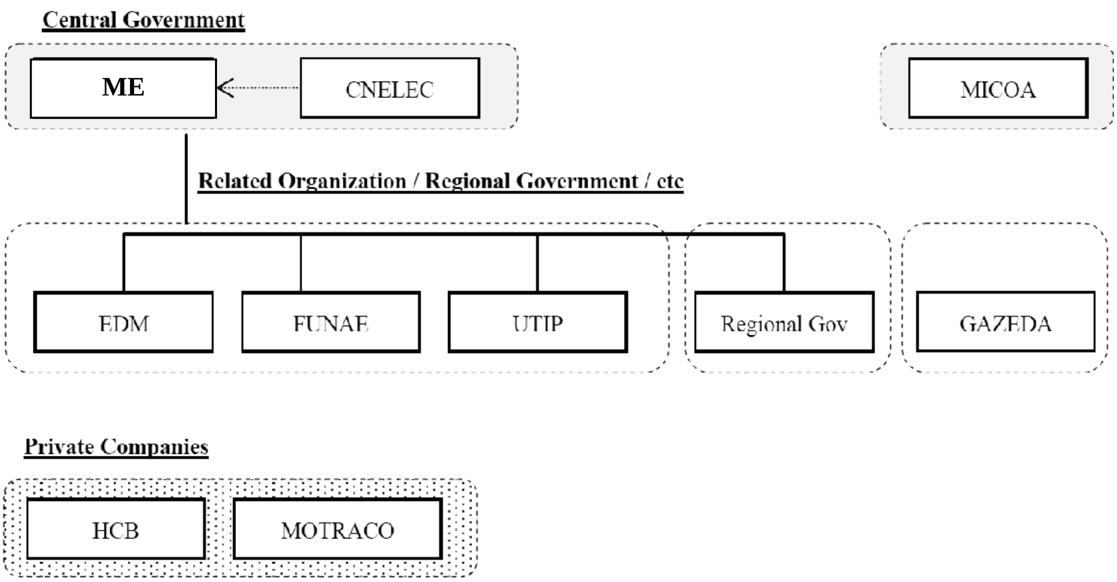
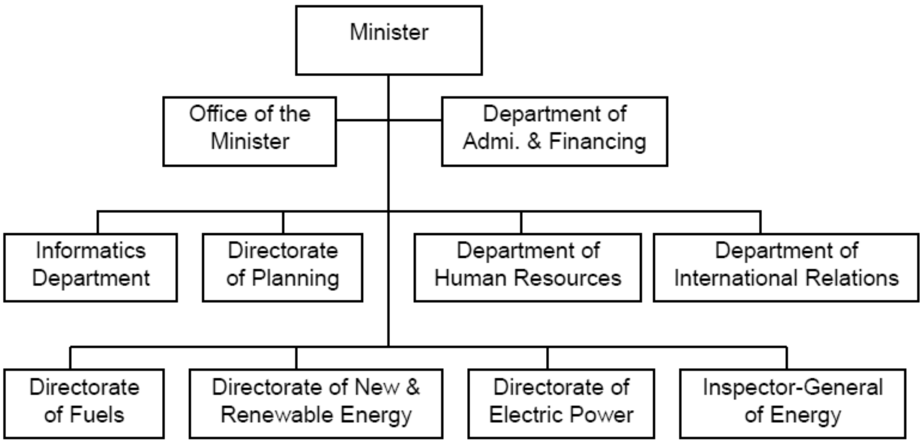


Figure 2.2-1 Organizations Related to the Power Sector

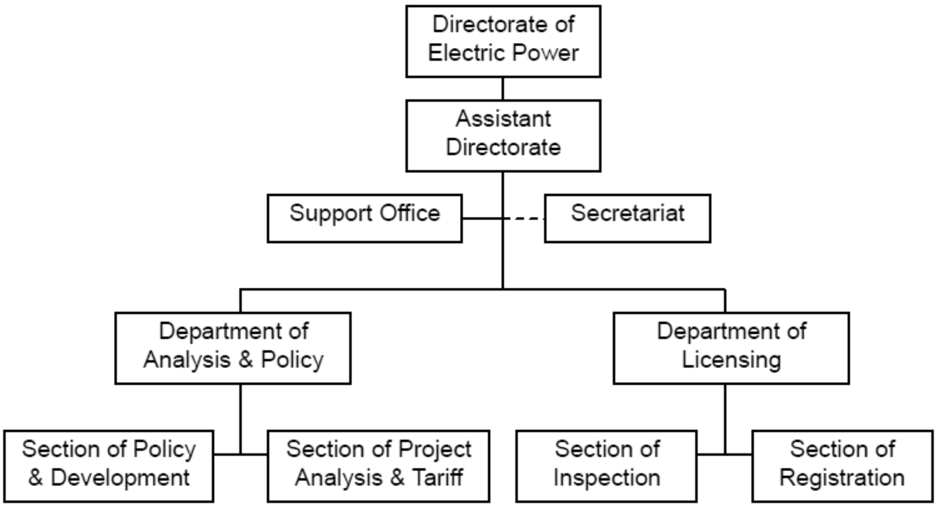
2.2.2 Organization and Roles of ME

The ME, established in 2000, is the ministry that has overall jurisdiction in the energy sector. Figure 2.2-2 shows the organization of the ME. The total number of employees is about 160. The department called "Direccao Nacional de Energia Electrica (Directorate of Electric Power)" is directly involved in the power sector and its organization is shown in Figure 2.2-3.



(Source: ME)

Figure 2.2-2 Organization of ME



(Source: ME)

Figure 2.2-3 Organization of Directorate of Electric Power

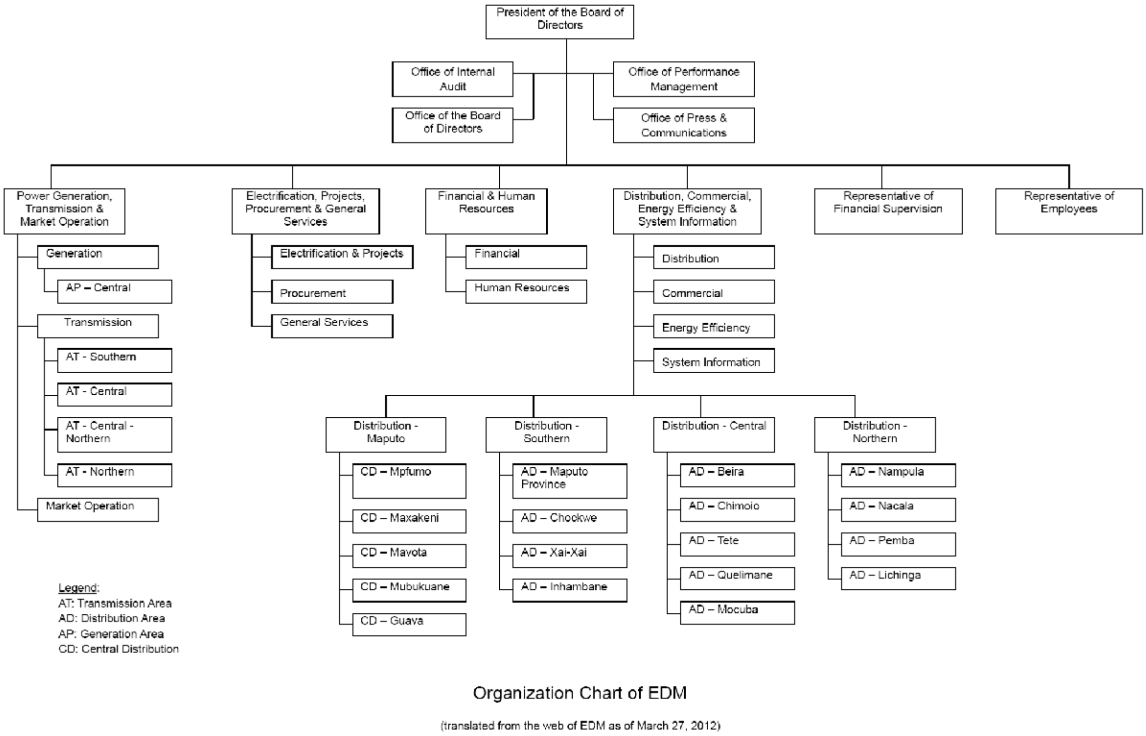
The ME is given the following roles:

- To promote public relations activities related to domestic power resources.
- To develop domestic power resources and to promote their use.
- To promote the increase of power demand, particularly in rural areas.
- To promote efficient power generation, particularly in rural areas for economic and social growth and development.
- To promote private participation in the development of power infrastructure.
- To secure storage, transportation, supply, and commercialization of natural gas and petroleum products in a stable and sustainable manner.
- To reduce environmental impact in electricity supply and use.
- To ensure appropriate setting of the prices of petroleum and related products.
- To generate electricity to meet the needs of urban and rural users.
- To provide petroleum products on a national level with an emphasis on rural areas.

2.2.3 Roles and Organization of EDM

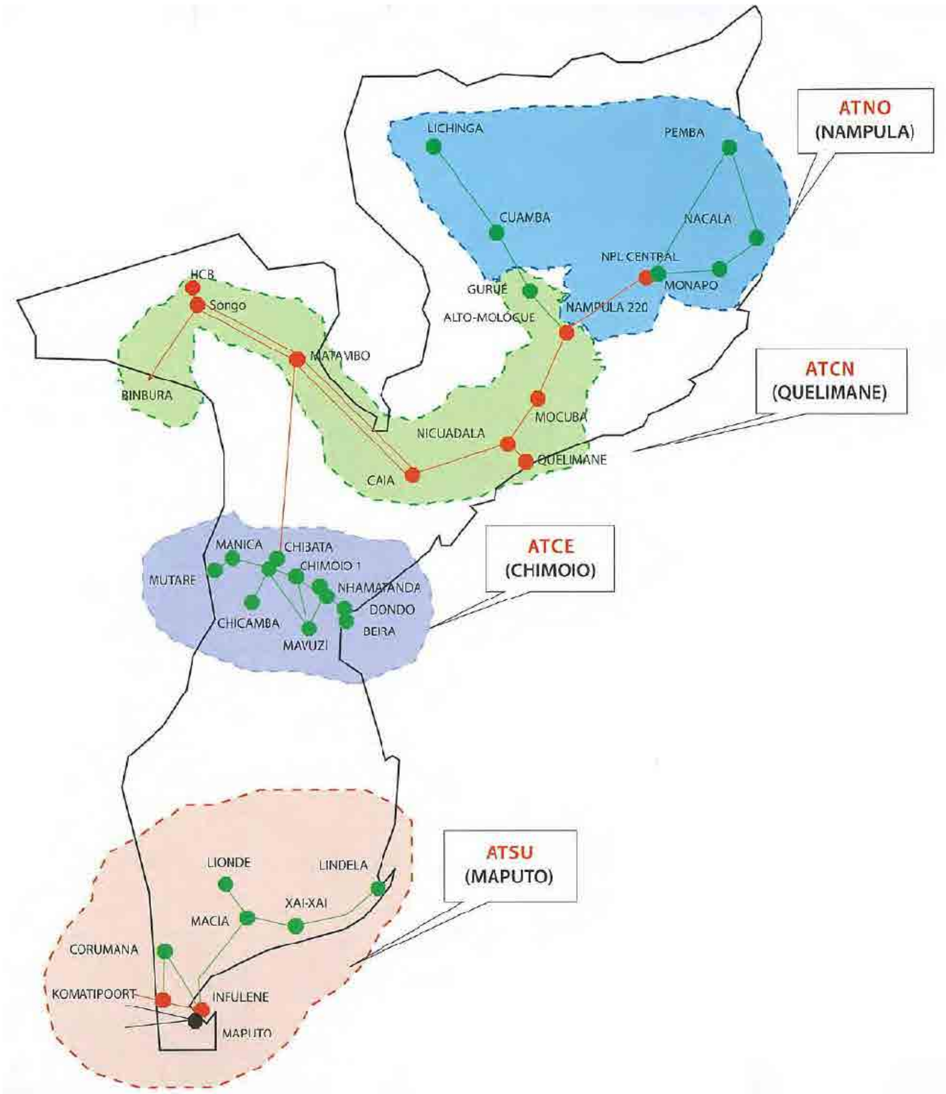
EDM is a state-owned vertically integrated electric power company responsible for power generation, transmission, distribution, and sales of electricity. EDM primarily conducts the businesses of power transmission, distribution, tariff collection, etc. for the customers who receive power from the national grid. EDM operates small-scale power generation at their five power plants. In addition, they operate a number of off-grid and backup generators in rural areas. Power generators, which are aging, have been progressively retired. This situation has led to an increased dependence on purchasing power from Cahora Bassa Hydroelectric (HCB).

The organization of EDM is shown in Figure 2.2-4. The total number of staff is about 3,500. Departments involved in this survey are Electrification & Projects, Generation, and Transmission. Transmission and distribution networks are operated by the jurisdiction of the regional division as shown in Figure 2.2-5. ATSU (Southern Transmission Area), which is based in Maputo city, has jurisdiction over the grid in the southern region, while the power distribution network in Maputo province is the responsibility of the distribution organizations in the southern region. The distribution organization in the Maputo metropolitan area has jurisdiction over the power distribution network of Maputo city.



(Source: EDM)

Figure 2.2-4 Organization of EDM



(Source: EDM)

Figure 2.2-5 Jurisdiction of Regional Division of EDM

2.2.4 Private Organizations Related to the Power Sector

The power sector includes some private organizations that play an important role in the operation of the sector. Leading organizations are as follows:

a) Hidroelectrica de Cahora Bassa (HCB):

HCB is an independent power producer (IPP) that owns Cahora Bass Hydropower Station. GoM owns 85% of the shares of HCB, with the rest (15%) owned by Portugal. Inside Mozambique, EDM directly controls HCB. Cahora Bassa Hydropower Station is the largest in terms of generation capacity in the southern African region.

b) Mozambique Transmission Company (MOTRACO):

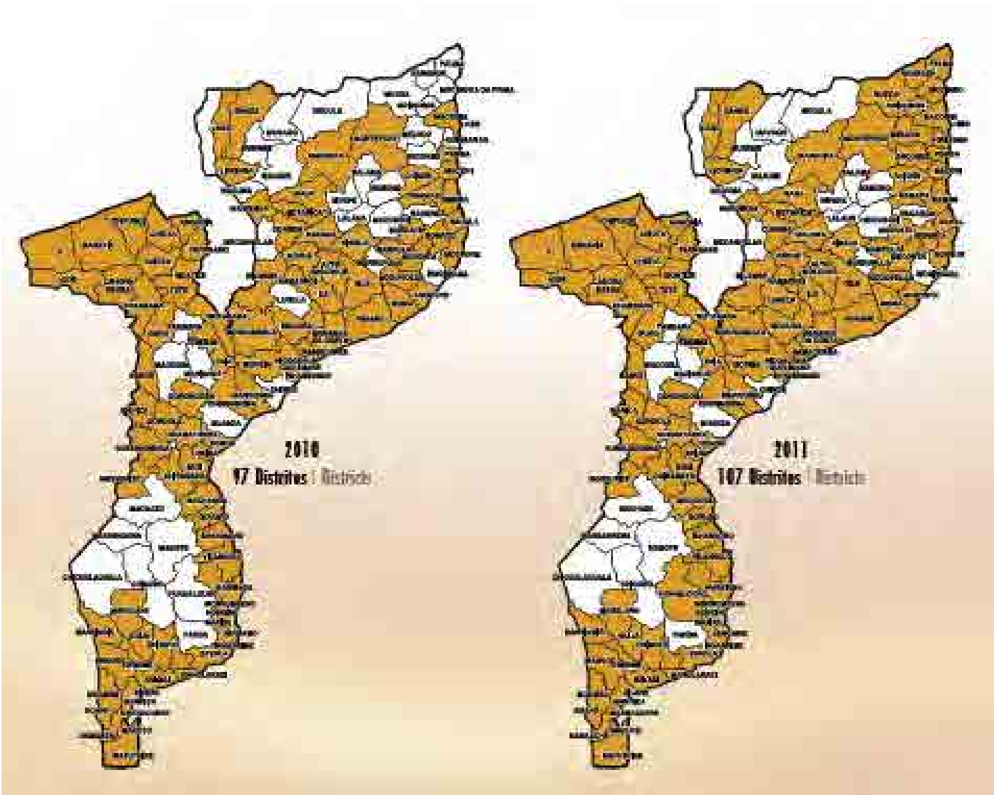
MOTRACO is an independent transmission company (ITC) jointly owned by EDM (investment ratio: 33.3%), South African Power Utility (ESKOM, 33.3%), and Swaziland

Electricity Board (33%). It supplies electricity to the Mozal aluminum smelter through a dedicated transmission line.

2.3 Electrification Plan and Situation of Electrification

EDM has been promoting a nation-wide electrification plan on the basis of the Master Plan for the power sector, which was created in 2004. According to the EDM document, "Projectos em Curso para Electrificacao das Sedes Distritais ate 2013," the accumulated number of electrified districts is targeted at 104 in 2010, 107 in 2011, and 125 in 2014, for a total of 128 districts in the whole country. Aiming towards this goal, 97 districts were electrified in 2010 with the number reaching 107 in 2011.

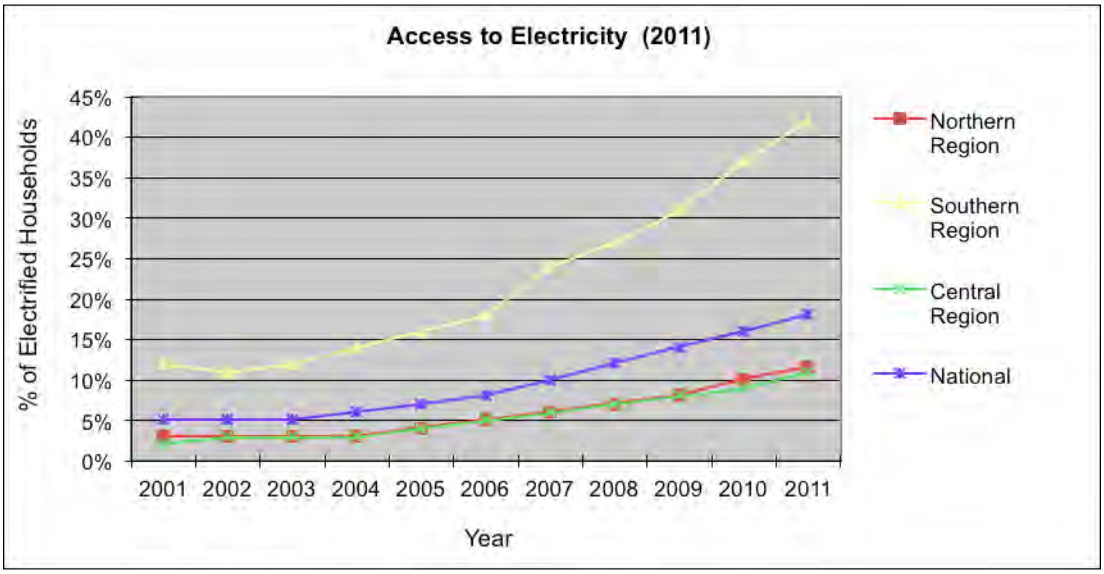
Shown in Figure 2-3-1 is the evolution of the electrified districts from 2010 to 2011. As is evident in this figure, electrification has been advancing throughout the nation.



(Source: Statistical Summary 2011, EDM)

Figure 2.3-1 Evolution of Nation-wide Electrification

Figure 2.3-2 is an illustration of the transition of the electrification rate at a national level and in individual regions. The nation-wide average electrification rate has grown steadily from 5% to 18% in the 11 years from 2001 to 2011. On the other hand, the electrification rate in the southern region has shown dramatic growth from 12% and 42% while the rates in the northern and central regions have remained at a level considerably lower than the national average.



(Source: Statistical Summary 2011, EDM)

Figure 2.3-2 Evolution in Electrification Rate (2001 -2011)

EDM calculates electrification rates in individual provinces using the number of households in each province. The number of electrified households and the calculated electrification rate of each province are provided in Table 2.3-1. Although the electrification rate in the city of Maputo reached as high as 82% in 2011, there are provinces with an electrification rate of less than 10%, such as Tete and Niassa. This suggests that a large disparity exists between cities and rural areas in the country.

Table 2.3-1 Electrification Rates by Province (2011)

Province	No. of Households	Access (%)
Cabo Delgado	31,385	8.2
Niassa	27,535	9
Nampula	134,140	13
Total - Northern	193,060	11.5
Zambezia	69,184	7.3
Tete	46,372	10
Manica	41,540	11
Sofala	83,131	20
Total - Central	240,227	11
Inhambane	36,323	12
Gaza	77,829	27
Maputo Province	171,507	54
Maputo City	216,049	82
Total - Southern	501,708	42
Total	934,995	18

(Source: EDM)

EDM assumes the number of people with access to electricity (i.e. electrification rate) by multiplying the number of electrified households by 4.4, which is the average number of persons per household in the country. When the number of electrified households (934,995) in Table 2.3-1 is multiplied by 4.4, the electrified population comes to 4.1 million, which is equivalent to about 18% of the total population of the country in 2011 (22.89 million).

2.4 Electricity Tariff and Payment

General consumers receiving electricity from the EDM grid at low voltage (LV) are required to pay an electricity tariff according to the tariff table shown in Table 2.4-1. Both LV consumers with large consumption of electricity and medium voltage (MV) / high voltage (HV) consumers pay tariff according to those listed in Table 2.4-2.

General consumers must pay a tariff that is the sum of the tariff for monthly electricity consumption (kWh) and a monthly flat rate. General consumers are classified into four categories: social, household, farming and commercial. A progressive payment method is applied, where as more electricity is consumed, more payment is required.

Large consumers need to pay a tariff calculated by multiplying the contracted power (kW) by a certain rate, in addition to the sum of the tariff for monthly electricity consumption (kWh) and the monthly flat rate, which are applied to general consumers. Large consumers are classified into three categories: LV, MV, and HV.

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. To enable the prepaid system to work properly, watt-hour meters called CREDELEC are installed at each consumer’s location. CREDELEC makes it possible for consumers to preset any amount of electricity consumption for a certain period, thus managing their electricity consumption for each month. Using this system, consumers can easily monitor their electricity consumption for a certain period. When CREDELEC is introduced, the electricity tariff rate is fixed, regardless of the amount of consumption.

The current electricity tariff is applied nationwide to any type of consumer, considering the payment capabilities of low-income consumers; thus, the power supply business in rural areas seems to be unprofitable. A tariff increase has been discussed but has not yet been put in place due to strong objections from the public.

Table 2.4-1 Electricity Tariff for LV Consumers

Social Tariff, Household, Agriculture and General (Low Voltage)

Recorded Consumption (kWh)	Sale Price				Flat Rate (Mt)
	Social Tariff (Mt/kWh)	Household Tariff (Mt/kWh)	Farming Tariff (Mt/kWh)	General Tariff (Mt/kWh)	
From 0 to 100	1.07				
From 101 to 200		2.34	2.36	2.61	75.26
From 201 to 500		3.11	3.36	3.74	75.26
Above 500		3.27	3.68	4.09	75.26
Pre-payment	1.07	2.98	3.27	3.75	

(Source: EDM)

Table 2.4-2 Electricity Tariff for Consumers of Large Consumption

Major Consumers of Low, Medium and High Voltage

Class of Consumers	Sale Price		Flat Rate (Mt)
	(Mt/kWh)	(Mt/kW)	
Major Cons. LV	1.47	112.65	220.37
Medium Voltage	1.21	126.09	1,034.38
High Voltage	1.08	138.88	1,034.38

(Source: EDM)

Electricity consumption of domestic customers in 2011 was 1,052.3 GWh. The number of electrified households was 934,995 for the same year. The amount of electricity consumed by an average household per year is calculated to be 1,125 kWh. When multiplied by 2.98 Mt/kWh, which is applied to prepaid consumers, the annual electricity charge comes to 3,353 Mt. By applying the current exchange rate of 28 Mt/USD, for example, the above charge comes to 0.106 USD/kWh. As the annual income level for general consumers is low, the burden of electricity charge to households is considerably large. There is a possibility that the power demand is significantly suppressed.

In the economic analysis by EDM for rural electrification projects, the cost of energy is assumed to be 0.028 USD/kWh, with the sale price of energy being 0.06 USD/kWh.

2.5 Current Situation of Power Generation Facilities

Table 2.5-1 illustrates the current situation of the power generation facilities (owned by EDM) in Mozambique.

The overall installed capacity of the hydro power plants and thermal power plants amount to 207.6 MW. Of this amount, the installed capacity of hydro power plants accounts for 108.85 MW with an actual available capacity of 61.10 MW, while the installed capacity of the thermal power plants is 98.75 MW with an available capacity of 69.35 MW.

At present, maximum power is 610MW in Mozambique, and power which Mozambique can generate is 130.45MW (=61.10MW + 69.35MW). That is, it is only around 2% (=130.45MW/610MW) of the required power

Table 2.5-1 List of Hydro Power Plants and Thermal Power Plants in Mozambique

Power Station	Unit	Turbine/ Generator Manufacturer	Year Installed	Nominal Cap. (MW)	Available Capacity (MW)	Comments
1. Hydropower						
Mavuzi	1	Charmilles/BBC	1955	5	4.5	Operational
	2	Charmilles/BBC	1955	5	0	Out-of-order
	3	Neyrpic/SIEMENS	1967	14	12	Operational
	4	Neyrpic/SIEMENS	1957	14	12	Operational
	5	Neyrpic/SIEMENS	1957	14	0	Out-of-order
Chicamba	1	Voith/SECRON	1968	19.2	0	Operational
	2	Voith/SECRON	1968	19.2	17	Operational
Corumana	1	Undenas/ABB	1990	8.3	7.0	Operational
	2	Undenas/ABB	1990	8.3	7.0	Operational
Cuamba	1	Soerumsand/NEBB	1989	0.55	0.5	Operational
	2	Soerumsand/NEBB	1989	0.55	0.5	Operational
Lichinga	1	Soerumsand/NEBB	1983	0.75	0.6	Operational
Total Hydro				**108.85**	**61.10**	
2. Thermal						
Beira	1-Gas	ABB Stal	1988	14.0	12.0	Operational
Maputo	1-Gas	Rolls Royce	1968	17.0	0	Out-of-order
	2-Gas	BBC	1973	38.0	30.0	Operational
	3-Gas	Alsthom	1991	24.0	22.0	Operational
Temane	1-Gas			5.2	4.8	
Nova Mambone	1-Gas			0.55	0.55	
Total Thermal				**98.75**	**69.35**	
Total Hydro + Thermal				**207.60**	**130.45**	

(Source: Prepared by JICA Study Team based on information presented on the EDM web site as of July 2012.)

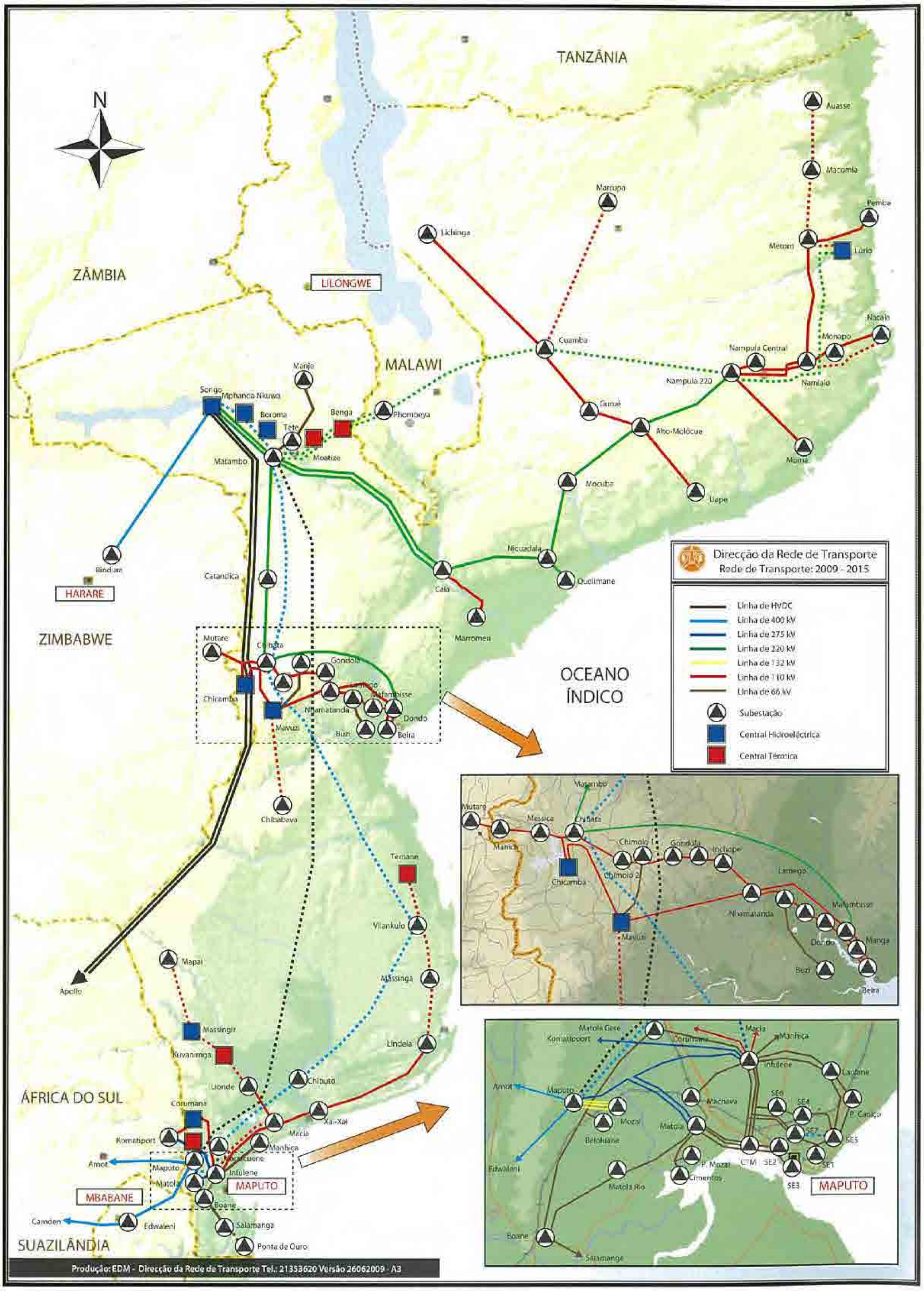
2.6 Current Situation of Power Transmission and Transformation Facilities

2.6.1 Overview of Network System

Figure 2.6-1 is a diagram of the network system in Mozambique. Since Mozambique has a large area extending 2,000 km north to south, the network system is separated into two systems: one for the southern area and the other for the central and northern areas. These systems are independently operated, without being linked to each other.

The Cahora Bassa Hydroelectric Power Plant (HCB) with an output of 2,075 MW, the major power source in Mozambique, is linked to the network for the central and northern areas. A part of the generated power is transmitted to the central and northern areas by means of a 220 kV AC transmission line and is supplied to meet the load within the country. It is also sent to the neighboring country, Zimbabwe, by means of a 400 kV AC transmission line. However, the majority of the power generated by HCB is sent to the Apollo substation in South Africa by a 535 kV DC transmission line and is then sent to the Southern African Power Pool (SAPP).

Since the system for the southern area, which covers Maputo, the capital of Mozambique, is located over 1,000 km from HCB, power is imported from SAPP via the network of South Africa and the network of Swaziland by means of the 400 kV AC transmission line. As a result, more than 80 percent of domestic demand is supplied by re-imported power.



(Source: Characterization of the transmission network 2010 (EDM))

Figure 2.6-1 Network System Diagram

2.6.2 Power Transmission and Transformation Facilities

Table 2.6-1 illustrates power transmission facilities by design voltage, and Table 2.6-2 shows the details of the power transmission facilities. The 400 kV transmission lines are employed as the international interconnection lines between South Africa, Swaziland and Zimbabwe. The 275 kV transmission lines are employed for the southern area. The 220 kV transmission lines are utilized for the central and northern areas. The 110 kV transmission lines are used as supply lines from the base substations of the system for the southern area and for the central and northern areas. The length of the 110 kV transmission lines amounts to 2,530 km, serving 50 percent of the total capacity of the system. Furthermore, the 66 kV transmission lines are utilized as local supply lines to meet local demand.

Table 2.6-1 Power Transmission Facilities by Design Voltage (by Extended Circuit)

Design Voltage (kV)	400	275	220	110	66	**Total**
Length (km)	233	127.5	1,756	2,530	481	**5,127.5**

(Source: Created by the JICA Study Team based on Characterization of the transmission network 2010 (EDM))

Table 2.6-3 shows the details of the substation facilities. A 400 kV transformer is employed by EDM in the Maputo substation of the network for the southern area to transform the receiving voltage from South Africa and Swaziland down into 275 kV or 132 kV for domestic use. Further, the majority of the transformers having a primary voltage of 220 kV or less have a secondary voltage of 33 kV. These transformers are utilized to supply power to the power distribution system from the power transmission system.

Table 2.6-2 Details of Power Transmission Facilities

From	To	Voltage [kV]	Length [km]	Completion Year	Capacity [MVA]
Songo	Bindura	400 (330)	125	1997	1,041
Arnout	Maputo	400	49.9	2000	1,293
Edwalene	Maputo	400	58.1	2000	1,293
Matambo	Chibata	220	320	1983	247
Songo	Matambo	220	120	1984	247
Songo	Matambo	220	115	1984	477
Matambo	Chimuara	220	294	1983	477
Matambo	Chimuara	220	291	1983	477
Chimuara	Mocuba	220	262	1984	477
Mocuba	Alto Molocue	220	151	1986	239
Alto Molocue	Nampula 220	220	183	1986	239
Nicuadala	Quelimane	220	20	1986	239
SE Matola	Infulene	275	16	2000	479
Komatipoort	Infulene	275	85	1972	479
SE Maputo	Matola	275	16	2004	479
Motraco	Mozal	275 (132)	3.5	2000	1,293
Motraco	Mozal	275 (132)	3.5	2000	1,293
Motraco	Mozal	275 (132)	3.5	2000	1,293
Alto Molocue	Gurue	110	75.7	2000	99
Gurue	Cuamba	110	100.0	2004	70
Cuamba	Lichinga	110	235.0	2005	70

From	To	Voltage [kV]	Length [km]	Completion Year	Capacity [MVA]
Nampula 220	Nampula Central	110	4.0	1984/04	99
Nampula Central	Monapo	110	131.0	1984/04	84
Monapo	Nacala	110	64.0	1984/04	84
Nampula 220	Moma	110	170.0	2007	77
Nampula 220	Pemba	110	375.0	2005	70
lnfulene	Macia	110	125.0	1983	99
Macia	Chicumbane	110	49.0	1983	99
Chimuara	Marromeu	110	90.0	2008	63
Macia	Lionde	110	53.0	1983	99
Infulene	Corumana	110	92.0	1984	99
Komatipoort	Corumana	110	40.0	1990	99
Mavuzi	Nhamatanda	110	80.0	1973	77
Nhamatanda	Beira	110	91.0	1973	77
Mavuzi	Chicamba	110	72.0	1957	77
Chicamba	Xigodora	110	11.0	1957	77
Xigodora	E.Chicamba	110	5.0	1957	77
E.Chicamba	Machipanda	110	50.0	1957	77
Machipanda	Mutare	110	7.5	1957	77
Mavuzi	Beira	110	171.0	1955	70
Nhamatanda	Gondola	110	78.0	1987	99
Gondola	Xigodora	110	37.0	1987	99
Chicumbane	Lindela	110	233.8	2002	68
Alto Molocue	Uape	110	90.0	2008	77
Infulene	Boane	66	30.0	1982	38
Infulene	2M	66	4.5	2003	50
Infulene	CTM	66	7.5	2004	38
Infulene	CTM	66	7.5	2004	38
Infulene	Manhica	66	62.0	1975/88/04	38
Infulene	Machava	66	7.5	1991	38
Infulene	SE5 (Compone)	66	15.1	1990	38
CTM	Matola	66	4.9	1998	60
Mavuzi	Chimoio 1	66	46.0	1953	38
CTM	SE6	66	3.8	1992	38
CTM	Matola	66	4.9	1998	60
CTM	Matola	66	4.9	1998	60
Matola	Machava	66	2.5	1998	50
Matola	Boane	66	21.9	1998	50
Matola	Cimentos	66	2.7	1998	50
SE6	SE4	66	2.4	1998	38
SE4	SE5	66	4.8	1996	38
CTM	SE3	66	5.4	2001	50
CTM	SE2/3	66	5.4	2001	50
Boane	Salamanga	66	76.7	2002	50
2M	SE7	66	7.9	2004	50
2M	SE7	66	7.9	2004	50
SE7	SE5	66	4.0	2004	88
SE3	SE1	66	2.1	2004	55
SE3	SE7	66	2.2	2005	77
Matambo	Tete	66	20.0	2009	60
Tete	Manje	66	109.0	2009	50
Infulene	CTM	66	7.5	1972	38

(Source: Characterization of the transmission network 2010 (EDM))

Table 2.6-3 Details of Substation Facilities

Name	Year	Voltage	kV							Total Capa-city (MVA)
			400	330	275	220	132	110	66	
Alto Molocue	1984	220/110/33/7.7	-	-	-	4	-	4	-	151
Beira	1966	110/22/6.6	-	-	-	-	-	5	-	80
Beluluane	1998	66/11	-	-	-	-	-	-	1	20
Boane	1980	66/33	-	-	-	-	-	-	3	30
Chimuara	2003	220/110/33	-	-	-	5	-	1	-	56
Catandica	2004	220/33	-	-	-	1	-	-	-	25
Central Termica	1972	66/33	-	-	-	-	-	-	14	60
Chibata	2003	220/110	-	-	-	1	-	3	-	84
Chicamba	1967	110/22	-	-	-	-	-	4	-	48
Chicumbane	2004	110/33	-	-	-	-	-	2	-	16
Chimoio 1	1950	66/22/6.6	-	-	-	-	-	4		18
Chimoio 2	1964	110/22/6.6	-	-	-	-	-	1	-	27.5
Cuamba	2004	110/33	-	-	-	-	-	3	-	16
Dondo	1972	110/22	-	-	-	-	-	1		20
Gondola	1998	110/22	-	-	-	-	-	1	-	10
Gurue	2002	110/33	-	-	-	-	-	3	-	16
Inchope	2005	110/33	-	-	-	-	-	1	-	10
Infulene	1972	275/110/66	-	-	6	-	-	5	7	372
Lamego	1973	110/66/22	-	-	-	-	-	1	1	18.8
Lichinga	2005	110/33	-	-	-	-	-	1	-	16
Lindela	2002	110/33	-	-	-	-	-	1	-	10
Lionde	1985	110/33	-	-	-	-	-	5	-	16
Machava	2004	66/33	-	-	-	-	-	-	3	30
Macia	2002	110/33	-	-	-	-	-	4	-	10
Mafambisse	1985	110/22	-	-	-	-	-	1	-	12.5
Manhica	2000	66/33	-	-	-	-	-	-	1	30
Manica	1972	110/33	-	-	-	-	-	1		6.3
Maputo (MOTRACO)	2000	400/275/132	3	-	1	-	3	-	-	1500
Maputo (EDM)	2000	400/275	1	-	1	-	-	-	-	400
Matambo	1982	220/66/33	-	-	-	8	-	-	-	44
Matola 275	2006	275/66	-	-	1	-	-	-	7	320
Matola Rio	2003	66/33	-	-	-	-	-	-	1	10
Matola Gare	2004	66/33	-	-	-	-	-	-	3	30
Mavita	1978	110/22	-	-	-	-	-	1	-	12.5
Mavuzi	1949	110/66/6.6								73.9
Messica	1979	110/22/6.6	-	-	-	-		1		12.5
Mocuba	1984	220/110/33	-	-	-	4		2	-	280
Monapo	1981	110/33	-	-	-	-		3	-	16
Moma	2007	110/33/11	-	-	-	-		3	-	50
Nacala	1981	110/33	-	-	-	-		3	-	70
Nampula 220	1988	220/110/33	-	-	-	3		5	-	200
Nampula Central	1981	110/33	-	-	-	-		3	-	35
Pemba	2005	110/33	-	-	-	-		1	-	16
Riopele	1982	60/30	-	-	-	-		-	1	10
Ceramica	2002	220/33/33	-	-	-	1		-	-	50
Salamanga	2002	66/33	-	-	-	-		-	1	10
SE Movel 0 (Xinavane)	1997	110/33/22						1		10
SE Movel 1 (Metoro)	2004	110/33	-	-	-	-		1	-	10
SE Movel 2	2004	110/33	-	-	-	-		1	-	10
SE Movel 3 (SE5)	2004	66/33	-	-	-	-		-	1	20

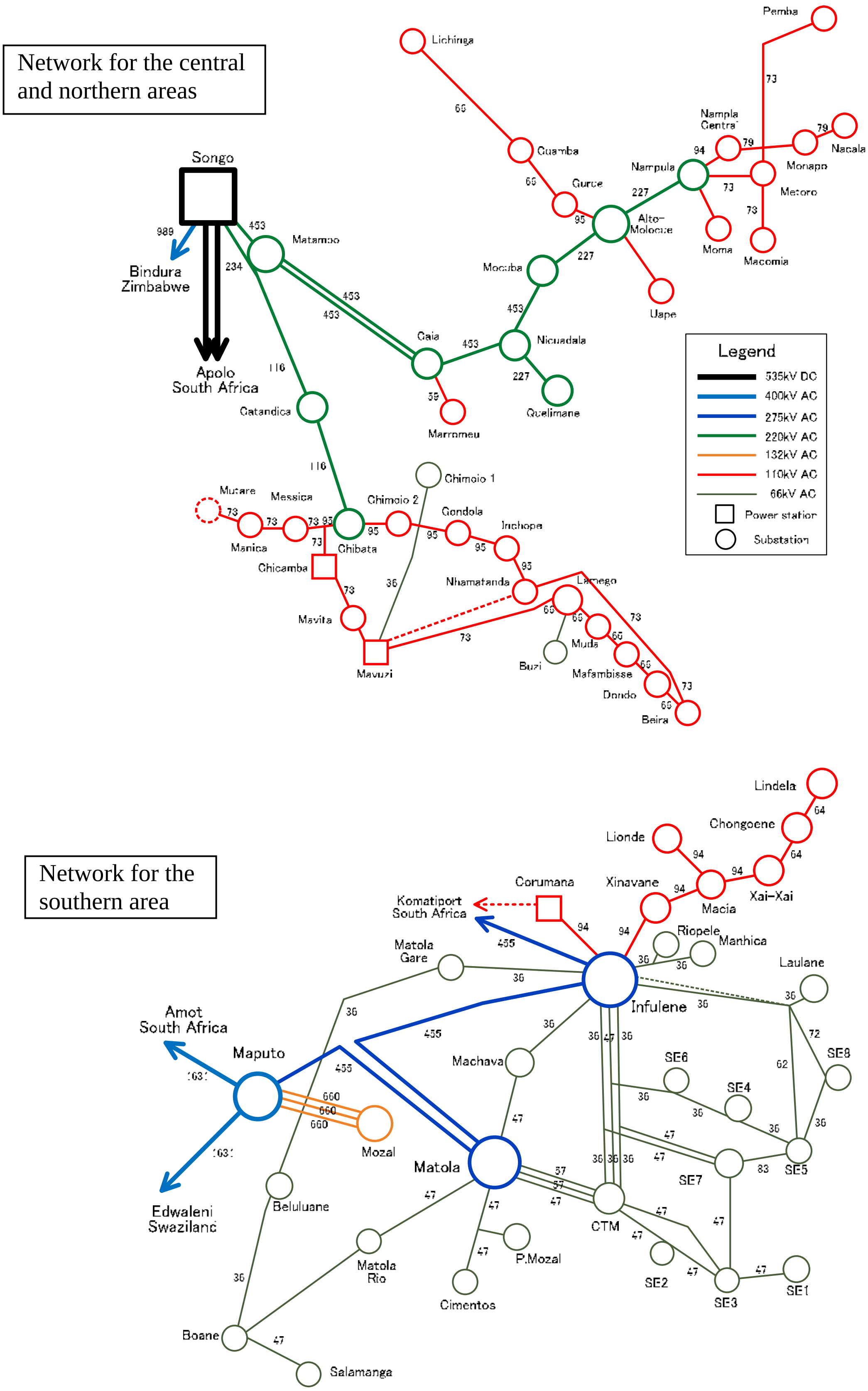
Name	Year	Voltage	kV							Total Capacity (MVA)
			400	330	275	220	132	110	66	
SE1	2003	66/11	-	-	-	-		-	1	30
SE2	2003	66/11	-	-	-	-		-	1	30
SE3	2001	66/11	-	-	-	-		-	4	60
SE4	1994	66/11	-	-	-	-		-	1	30
SE5	1990	66/11	-	-	-	-		-	5	20
SE6	1994	66/33/11	-	-	-	-		-	1	20
SE7	2004	66/11	-	-	-	-		-	4	30
SE8	2005	66/11	-	-	-	-		-	2	30
Manje	2009	66/33	-	-	-	-	-	-	1	10
Uape	2009	110/36(33)	-	-	-	-	-	1	-	16
SE9	2005	66/11	-	-	-	-		-	2	60
Songo	1982	330/220	-	2	-	3		-	-	665
			4	**2**	**9**	**30**	**3**	**78**	**66**	**5,400**

(Source: Characterization of the transmission network 2010 (EDM))

2.6.3 Transmitting Capacity of Transmission Lines

Figure 2.6-2 shows the transmitting capacity of the transmission lines when the power factor is assumed at 0.95. The transmitting capacity of different lines is as follows:

- 400 kV lines: 1,631 MW (989 MW for the line designed for 400 kV but operated at 330 kV)
- 275 kV lines: 455 MW
- 220 kV lines: 116 to 453 MW
- 132 kV lines: 660 MW
- 110 kV lines: 59 to 95 MW
- 66 kV lines: 36 to 83 MW



(Source: Created with reference to PSS/E network analysis data provided by EDM)

Figure 2.6-2 Transmitting Capacity of Transmission Lines (unit: MW)

2.6.4 Demand by Network

Table 2.6-4 illustrates the power demand by network in 2011: the network for the central and northern areas and that for the southern area. The total power demand of Mozambique amounts to 1,426.6 MW. Almost 60 percent of the demand comes from an aluminum smelter plant, Mozal. The demand from the other consumers accounts for only about 40 percent of the total. The network for the southern area including the capital Maputo, the demand center, and Mozal creates demand amounting to 86 percent of the total demand of the country, while the network for the central and northern areas meets the demand of only 14 percent.

Table 2.6-4 Demand by Network (2011)

Network		Demand (MW)	Share (%)
Central · North		193.4	14
South	Mozal	850.0	59
	excluding Mozal	383.2	27
Total		1426.6	100

(Source: Analysis result using PSS/E network data provided by EDM)

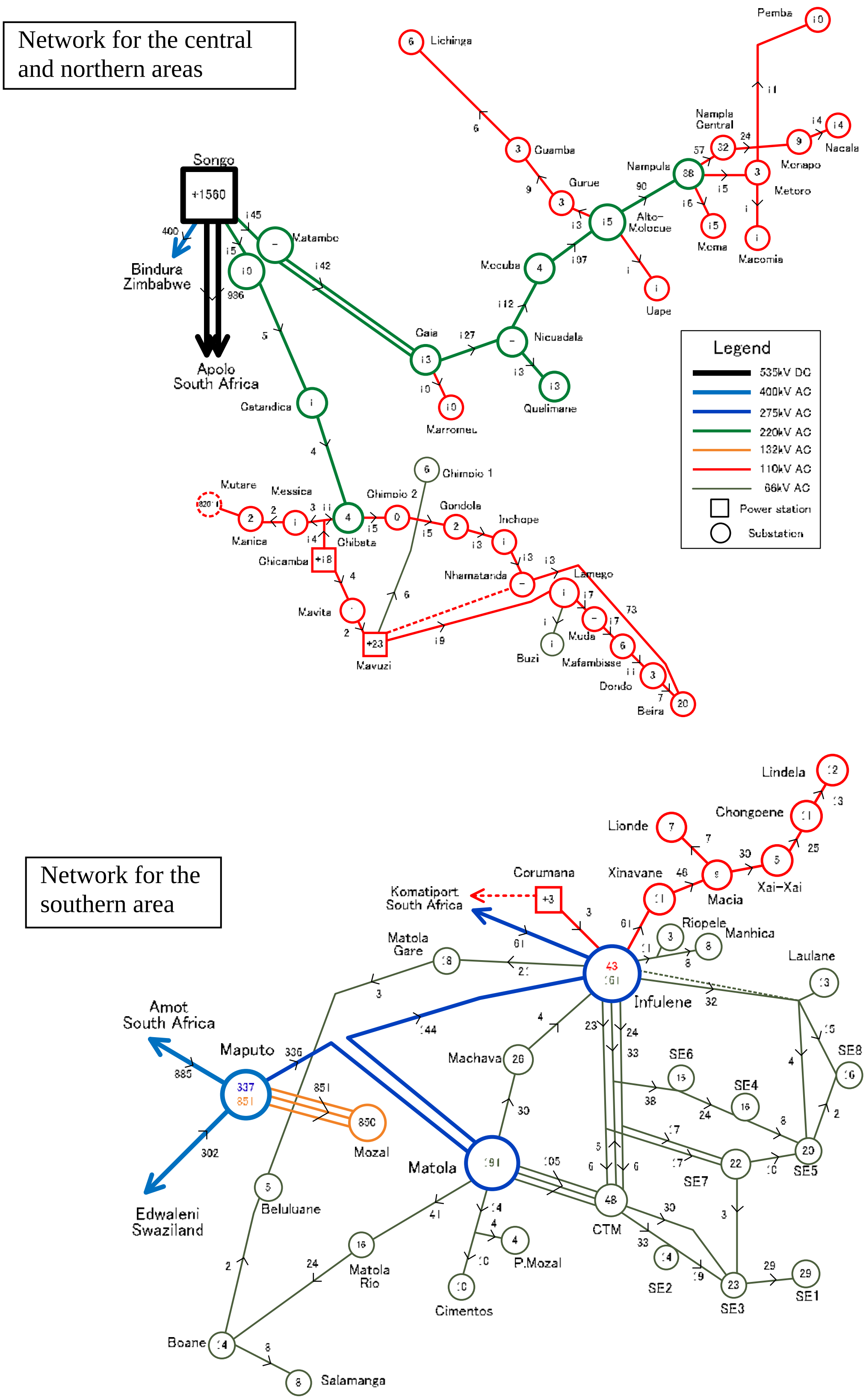
2.6.5 Power Flow

The power flow has been analyzed using the 2011 network data provided by EDM. The analysis result is shown in Figure 2.6-3. The maximum power flow by voltage class is given in Table 2.6-5. The maximum power flow of the 400 kV transmission line is 885 MW on the Maputo-Amot line of the interconnected line with South Africa. This allows a sufficient margin to meet the transmitting capacity of 1,631 MW. The maximum power flow on the 275 kV transmission line is 336 MW of the Maputo-Matola line and the utilization rate is 74 percent. Similarly, all of the 220 kV, 132 kV and 110 kV transmission lines have a sufficient margin for the transmitting capacity, and any overload or other problems are not anticipated. In the 66 kV transmission lines, on the other hand, the utilization rate of the facilities tends to be higher on the transmission lines where the power transmission capacity is as small as 36 MW (power factor assumed at 0.95). Above all, the power flow of the transmission line branching off at the Infulene-CTM line and leading to the SE6 substation is 38 MW, which is slightly higher than the transmitting capacity. However, power flow exceeding the capacity is found only in this transmission line.

Table 2.6-5 Maximum Power Flow by Voltage Class

Voltage (kV)	Line Section	A. Power Flow (MW)	B. Capacity (MW)	Utilization Rate (%) (= A/B)
400	Maputo−Amot	885	1631	54
275	Maputo−Matola	336	455	74
220	Caia−Nicuadala	127	453	28
132	Maputo−Mozal	284	660	43
110	Infulene−Xinavane	61	94	65
66	Branching point−SE6	38	36	106

(Source: Analysis result using PSS/E network data provided by EDM)



(Source: Analysis result using PSS/E network data provided by EDM)

Figure 2.6-3 2011 Power Flow (unit: MW)

2.6.6 Fault Current

Fault current analysis has been done using the 2011 network data provided by EDM. The result of the analysis is given in Figure 2.6-4 and the maximum fault current by voltage class is illustrated in Table 2.6-6.

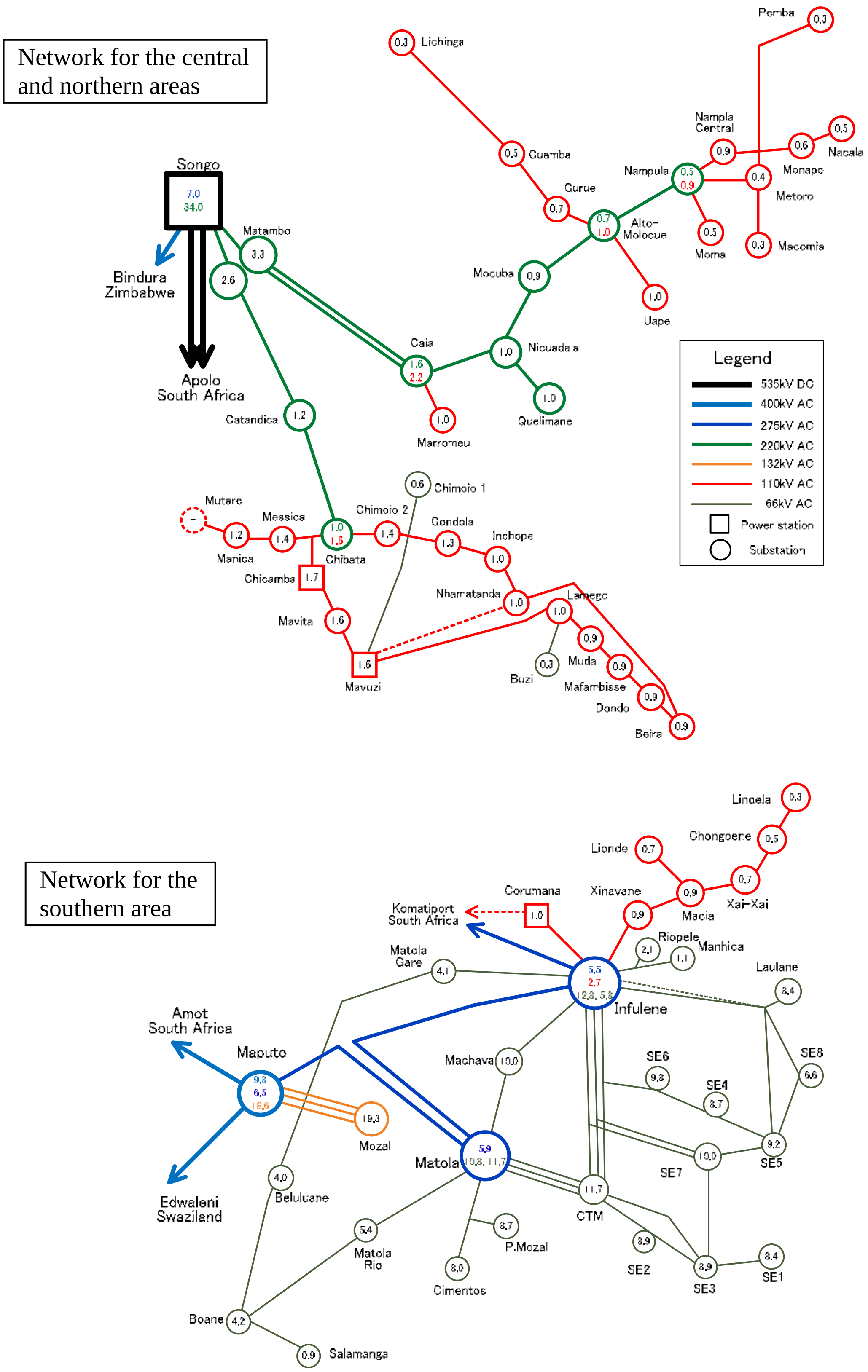
The power system of the country is small-scaled and separated into a network for the central and northern areas and a network for the southern area. Since it covers a large expanse of the country, the power is transmitted over long distances. For these reasons, the fault current is as small as about 10 kA for each voltage class, except on the Songo 220 kV bus and Mozal 132 kV bus. Thus, there will be no problem, such as excess in the current breaking capacity of the circuit breaker.

The village of Songo has a power plant that is connected with several generators of large capacity, so the fault current of the 220 kV bus is as large as 34 kA. Further, Mozal is located close to the 400 kV Maputo substation and is connected with three separate transmission lines. For this reason, Mozal is expected to produce a fault current as large as 19.3 kA when faults occur.

Table 2.6-6 Maximum Fault Current by Voltage Class

Voltage (kV)	Station	Fault current (kA)	Remarks
400	Maputo	9.8	
275	Maputo	6.5	
220	Songo Matambo	34.0 3.3	
132	Mozal	19.3	
110	Chicamba	1.7	
66	Infulene	12.8	

(Source: Analysis result using PSS/E network data provided by EDM)



(Source: Analysis result using PSS/E network data provided by EDM)

Figure 2.6-4 Fault Current in 2011 (unit: kA)

2.7 Status of Power Supply and Demand

2.7.1 Power Supply and Demand

Operation of the Cahora Bassa Hydroelectric Power Plant, the major power source in Mozambique, has dramatically increased the power supply capacity. It has also made latent power demand tangible, resulting in a steadily increasing power demand hand-in-hand with dynamic economic activities. Table 2.7-1 shows the national energy balance for 2009 and 2010. In 2011, the total energy production (gross electricity production in Mozambique plus imports from neighboring countries (including South Africa)[2]) was 4,025 GWh, with the breakdown is shown in Figure 2.7-1. While the electricity production by HCB accounts for 88% of the total energy production, the electricity production by EDM constitutes only 10% of the total.

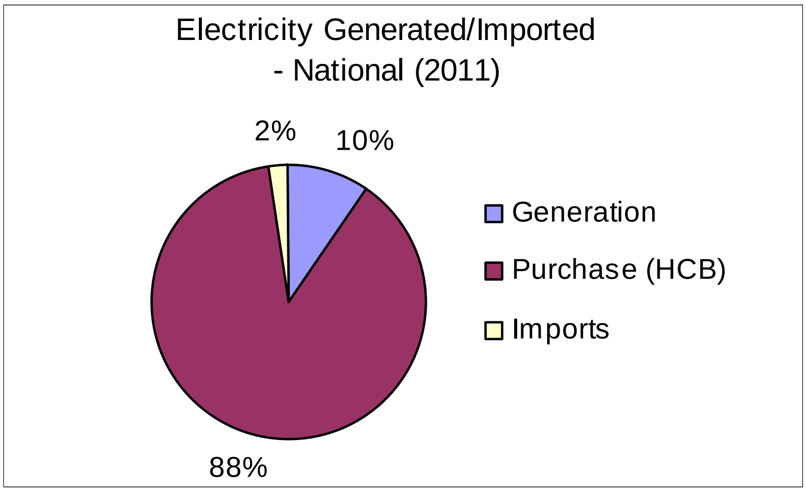
Table 2.7-1 Energy Balance in 2011

(Unit: GEh)

Description	2011	Weight	2010	Weight
(1) Generation	389	10%	368	10%
(2) Purchase (HCB)	3,549	88%	3,118	88%
(3) Imports	86.5	2%	67.4	2%
(4) Total Energy = (1)+(2)+(3)	4,025	100%	3,553	100%
(5) Exports	669	17%	580	22%
(6) Gross Available = (4)-(5)	3,356	83%	2,973	78%
(7) Transmission Losses	159	5%	137	7%
(8) P. Station Losses	31	1%	27	1%
(9) Special Customers	122	4%	96	2%
(10) Distribution = (6)-(7)-(8)-(9)	3,044	91%	2,713	90%
(11) Public Lighting	50	2%	45	2%
(12) EDM's Consumption	6	0%	6	0%
(13) Distribution Losses	649	19%	611	19%
(14) Invoicing = (10)-(13)	2,395	71%	2,102	71%
(15) Invoicing Including Special Customers	2,517	75%	2,101	73%
(16) Total Losses = (7)+(8)+(13)	839	25%	775	27%

(Source: Statistical Summary 2011, EDM)

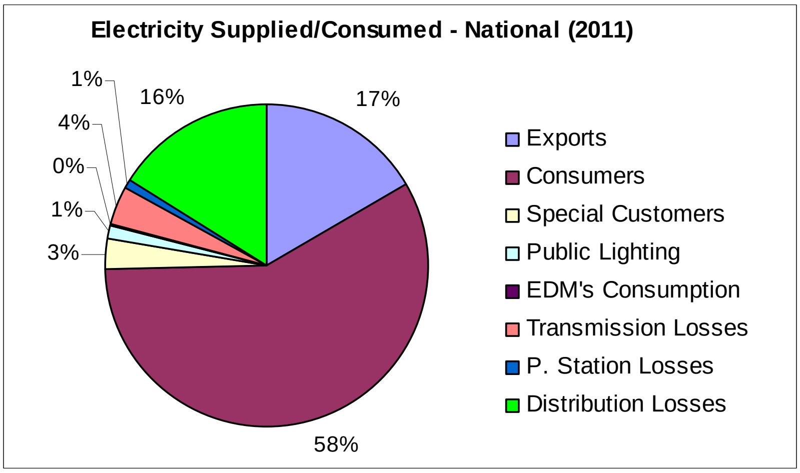
[2] EDM had to purchase power from neighboring countries, as power distribution networks of EDM are not provided in some remote areas, which accounted for 2% of the total.



(Source: Statistical Summary 2011, EDM)

Figure 2.7-1 Breakdown of Generated Power in 2011

Figure 2.7-2 shows a breakdown of the gross energy available in Mozambique, which corresponds to "(6) Gross Available" in Table 2.7-1. It should be noted that exports of electricity accounted for 17% and total power loss reached the high level of 25%. Distribution losses alone accounted for 19%.



(Source: Statistical Summary 2011, EDM)

Figure 2.7-2 Breakdown of Power Consumption in 2011

The values in Table 2.7-1 represent only power generation connected to the national grid operated by EDM. Power generation in rural areas by stand-alone diesel generators, solar plants, and small hydro plants, which are off-grid power sources, is not included in the table.

Table 2.7-2 shows the power consumption by region in 2011. The Maputo metropolitan area alone constitutes a major load center, accounting for 32.6% of the nation.

Table 2.7-2 Power Consumption by Region in 2011

Distribution	GWh	Share 1	Share 2
Northern	428	10.6%	13.2%
Central	739	18.4%	22.9%
Southern	1,012	25.1%	31.3%
Maputo City	1,055	26.2%	32.6%
Sub-Total	3,234	80.3%	100.0%
Export	669	16.6%	
Special customers	122	3.0%	
Total	4,025	100.0%	

(Source: EDM)

2.7.2 Annual Evolution of Power Supply and Demand

Table 2.7-3 shows the annual evolution of power supply and demand as well as basic parameters for the past six years from 2006 to 2011. The amount of generated power has steadily increased, with export of power evolving at a certain level. The number of new customers (connections) has been growing with each passing year, increasing the national electrification rate accordingly. The collection rate of electricity tariffs is as high as 97%. On the other hand, the power loss ratio has been continuously at a high level of 21-23%.

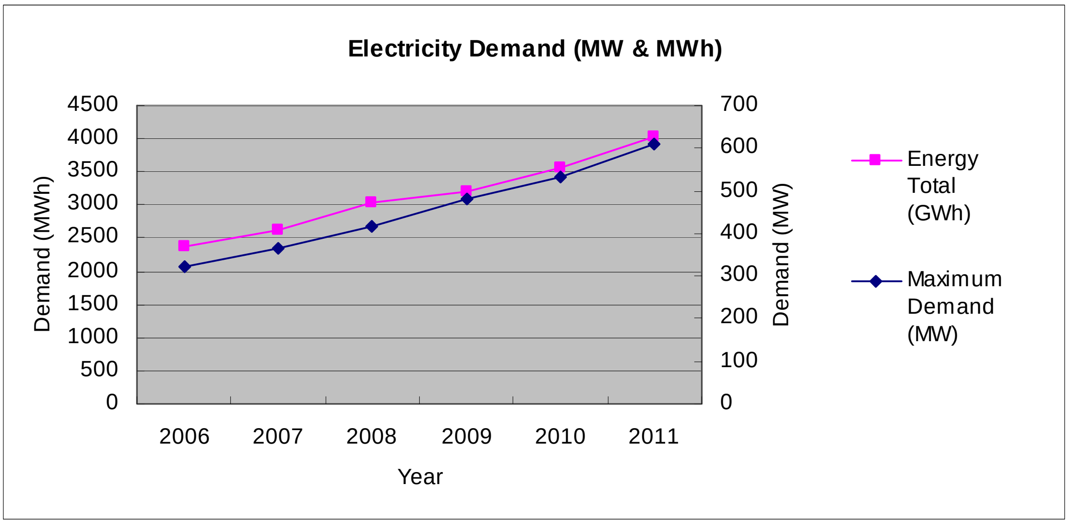
Table 2.7-3 Annual Evolution of Power Supply and Demand (2006 -2011)

Description	2006	2007	2008	2009	2010	2011
Energy Total (GWh)	2,382	2,622	3,032	3,193	3,553	4,025
Public Lighting (GWh)	42	39	38	42	45	50
EDM's Consumption (Buildings & Offices) (GWh)	10	6	6	6	6	6
Total Losses (Technical + Non Technical Losses)	21%	23%	21%	23%	22%	21%
Total Billed Energy (GWh)	1,873	2,029	2,404	2,449	2,777	3,185
Total Billed Energy	79%	77%	79%	77%	78%	79%
Billed Energy (National Territory) (GWh)	1,375	1,506	1,734	1,934	2,197	2,517
Billed Energy (National Territory)	58%	57%	57%	61%	62%	63%
Billed Energy (Export) (GWh)	498	523	670	514	580	669
Billed Energy (Export)	21%	20%	22%	16%	16%	17%
Collection Rate	95%	95%	96%	97%	97%	97%
Average Period for Receiving (days)	53	33	42	45	45	45
Maximum Demand (MW)	320	364	416	481	534	610
Number of Employees	3,233	3,323	3,532	3,735	3,511	3,402
Number of Customers	415,667	510,848	614,731	736,085	858,108	1,010,780
Prepayment Coverage	46%	58%	64%	73%	78%	81%
Number of New People Connected to the Grid	357,651	400,827	440,206	531,907	576,127	719,004
New Connections	85,155	95,435	104,811	120,888	130,938	163,410
Customers per Employee	129	154	174	197	244	297
National Access to Electricity	8%	10%	12%	14.3%	16%	18%

(Source: Statistical Summary 2011, EDM)

2.7.3 Annual Evolution of Generated Power and Maximum Power

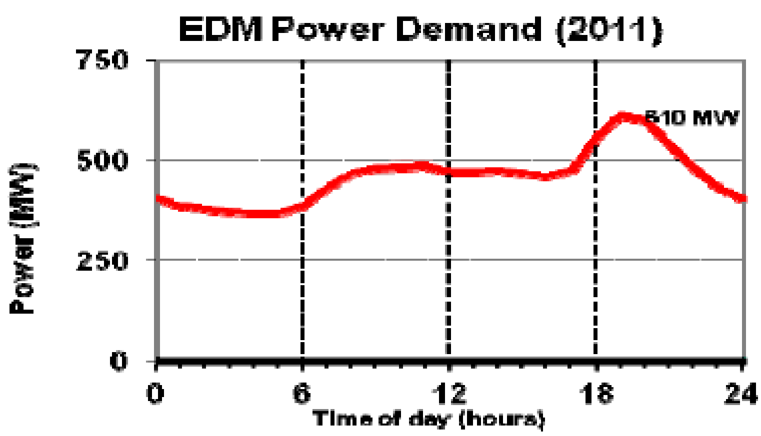
The generated power and maximum power values from Table 2.7-3 are illustrated in Figure 2.7-3. The annual average growth rate of the amount of power generation reached 111.1%. At the same time, the maximum power has also been increasing. The maximum power demand in 2011 was 610 MW.



(Source: Statistical Summary 2011, EDM)

Figure 2.7-3 Annul Evolution of Generated Power and Maximum Power (2006 -2011)

The maximum power demand of 610 MW was recorded at 8 p.m. on November 16, 2011. The daily load curve for the same day is illustrated in Figure 2.7-4. There is a tendency that the power demand for household lighting starts to increase in the early evening and reach a maximum in the mid-evening (at around 7 p.m.). Although November corresponds to the high-temperature period in Mozambique, it seems that the power demand for room cooling (air-conditioning) is not high enough to increase the power demand during daytime hours.



(Source: EDM)

Figure 2.7-4 Daily Load Curve for the Day on Which the Maximum Power Demand was Recorded

2.7.4 Structure of Power Supply and Demand

(1) Overview of Power Purchase

EDM relies on imports for almost 90 percent of its electricity demand, purchasing from HCB and power utilities in the neighboring countries. The breakdown of the electricity imports is shown in Table 2.7-4. The electricity purchased from HCB, at the extremely low unit price of 0.0136 USD/kWh, accounts for the majority of the electricity imports so the electricity purchased at a higher price of 0.175 USD/kWh from neighboring countries is limited to a very small amount, enabling a relatively low overall average purchase price of 0.0175 USD/kWh.

Table 2.7-4 Electricity Purchase Status of EDM (2011)

Supplier of Energy	Amount (USD)	Share (%)	Energy (MWh)	Share (%)	Purchase Price (USD/kWh)
ZESCO	930,951	1.5%	86,500	2.4%	0.175
Border towns	706,169	1.1%			
Motraco	4,411,906	7.0%			
ESKOM	9,082,320	14.3%			
Sub-total	15,131,346	23.8%			
HCB	48,342,860	76.2%	3,549,000	97.6%	0.0136
Total	63,474,206	100.0%	3,635,500	100.0%	0.0175

(Source: EDM)

(2) Overview of PPA between EDM and HCB

In 2011, EDM purchased 3,549 GWh of electricity from HCB. This figure corresponds to 88.2 percent of the total demand on the EDM Grid (4,025 GWh). At present, Mozambique's share of the 2,075 MW power generation in HCB is 300 MW of firm and 200 MW of non-firm power. With a substantial annual load growth this capacity will be insufficient and new capacity is needed.

It is possible to increase the amount of electricity purchased from HCB, but it is limited to the additional power. It is most probable that the Power Purchase Agreement (PPA) between EDM and HCB will be renewed after 2015 when the PPA for the additional power between HCB and ESKOM expires. The additional power for EDM on the renewed contract is expected to be between 200 MW and 400 MW. The adjustment to the allocation of the firm power is subject to negotiations between Mozambique and RSA at the government level.

Table 2.7-5 Annual Electricity Purchased from HCB

Year	Firm Power [MW]	Additional Power [MW]	Energy [GWh]
2008	300	90	2,635
2009	300	100	2,775
2010	300	100	3,022
2011	300	200	3,549

(Source: EDM)

(3) Overview of PPA between EDM and SAPP

EDM has been purchasing electricity from SAPP under the current PPA as shown in Table 2.7-6. The electricity purchased from SAPP for 2011 amounts to 86.47 GWh, which corresponds to 2.1 percent of EDM's total electricity demand of 4,025 GWh. The electricity purchased from SAPP has increased year by year in accordance with the ever-increasing electricity demand in the country. Although the amount of electricity purchased from SAPP is relatively small, it serves as an important supplemental capacity.

The PPA between EDM and SAPP is not a Firm Agreement; the transactions are subject to the availability of and necessity for electricity and the price is determined by the interaction of supply and demand. Since countries in the Southern African Region are currently suffering from power shortages, there are uncertainties regarding purchasing power (MW/MWh) from SAPP in the future.

Table 2.7-6 Electricity Purchased from SAPP

Year	Energy [GWh]
2008	27.38
2009	31.90
2010	67.44
2011	86.47

(Source: EDM)

2.7.5 Sales Price of Electricity

The average sales price of electricity of EDM, calculated from electricity sold to customers and the sales revenue, was 0.091 USD/kWh in 2009 (see Table 2.7-7). The EDM 2009 annual report states that the sales average price (SAP) is 0.084 USD/kWh.

Table 2.7-7 Unit Electricity Price (2009)

Description	Value	Unit
Sales of electricity in 2009*	4,367,273,080	MZM
Electricity invoiced in 2009**	1,934	GWh
Electricity sales rate	2.3	MZM/kWh
Exchange rate	25.25	MZM/USD
Electricity sales rate	0.091	USD/kWh
* excludes exported energy ** includes special customers and represents 72% of total energy		
Sales average price (SAP)	0.084	USD/kWh

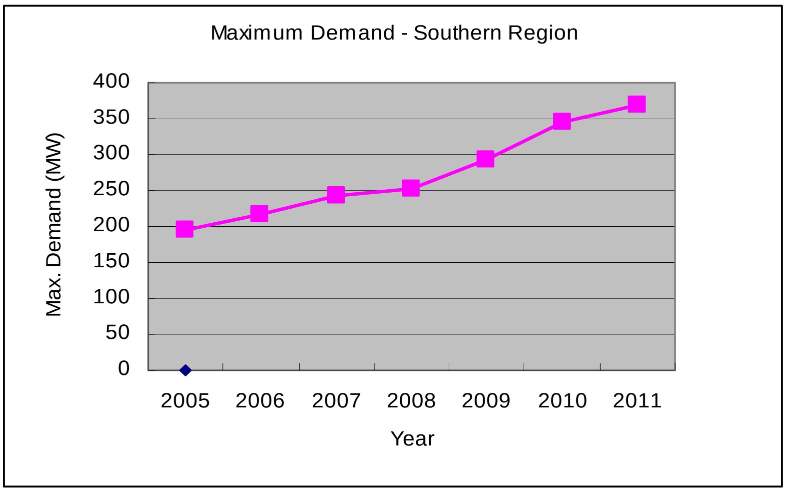
(Source: EDM)

2.8 Power Demand Forecast

EDM, with the assistance of Norway, conducted the "Electricity Master Plan Study" (M/P) in 2004. The M/P covers a survey of the entire power sector development for the years 2005-2019, including a long-term power demand forecast. After the study, EDM felt the need to update the M/P considering the changes in the circumstances surrounding the power sector. The preparation for the updating work started in 2008 and has resulted in the on-going study “Update of Master Plan 2010-2027" with the assistance of the French Development Agency (AFD). The M/P is to be completed by the end of 2012. The long-term power demand forecast is also to be updated. It is expected that the results of the power demand forecast will be reflected in the power facilities development plan for the coming years.

In the meantime, EDM has independently conducted a power demand forecast and written a power facilities development plan without waiting for the results of the M/P update. The demand forecast and development plan are summarized in the "Expansion Plan and Strengthening of Power Transmission Grid 2012-2021" (Issue: September 2011).

EDM Southern Region (the distribution service area), which covers the Maputo metropolitan area, is the largest load center in the country. The evolution of maximum demand in the region for the period of 2005-2011 is shown in Figure 2.8-1. The annual average growth rate of the maximum demand for this period was 11.3%. The maximum demand for 2011 was recorded in July at 369.1 MW.



(Source: EDM)

Figure 2.8-1 Evolution of Maximum Demand for the Southern Region (2005 -2011)

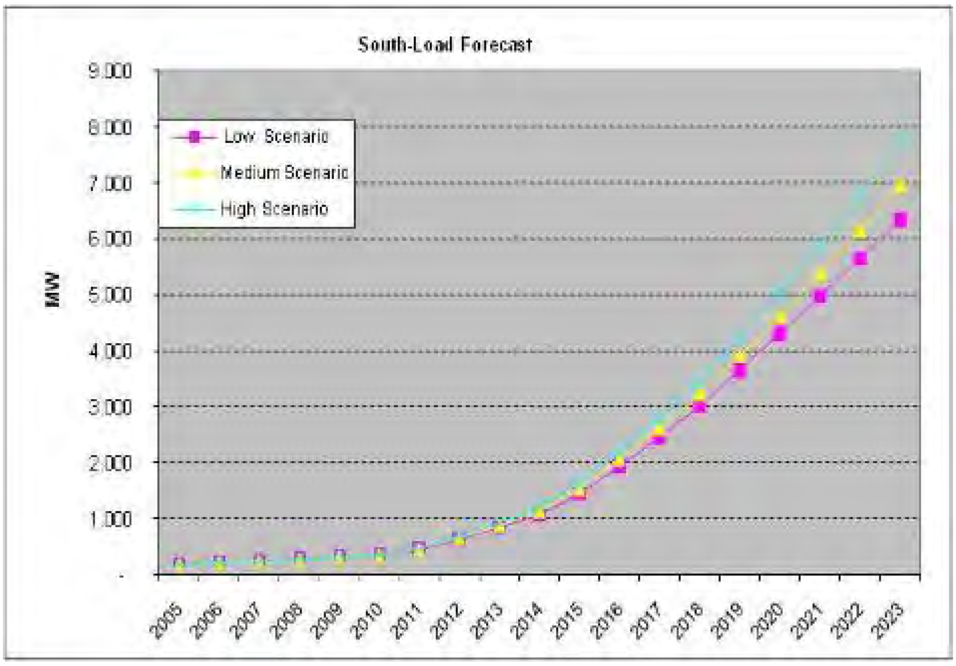
To estimate future electric power demand, EDM has identified the projects with large power consumption as shown in Table 2.8-1, assuming that future power demand will increase in a manner similar to the recent evolution. The power demand forecast until 2023, based on this assumption, is indicated in Figure 2.8-2. EDM assumes three growth scenarios (high/ medium/ low) for the forecast, which considers the progressive implementation of large-scale projects starting in 2015, thus estimating the growing power demand accordingly.

Power demand of the Mozal aluminum smelter is currently 950 MW. Future expansion plans for the smelter additionally consider a larger power demand of 920-1,320 MW. Industries with large power consumption, such as cement and metal industries, will become a driving force for increasing power demand in the future.

Table 2.8-1 Projects with Large Power Demand in the Southern Region

No.	Project / Customer	Location	Demand [MW]
1	CIMPOR - expansion	Maputo	10
2	Mozal - expansion	Maputo	120
3	Arcelor Mittal	Maputo	20
4	Corridor Sands	Xai - Xai	40
5	Corridor sabds	Maputo - Beloluane	`80
6	Ferro Chrome	Maputo	100
7	Tongat Hullet - Sugar	Maputo	6
8	Ilovo - Sugar	Maputo	5
9	KCI - Cement Project	Maputo	15
10	GS Cimentos	Maputo	15
11	NAGE - Steel	Maputo	37
12	Chrome Tech Holdings - Steel	Maputo	26
13	Mozal III	Maputo	200 - 600
14	Mozal IV	Maputo	600
15	Various projects	Maputo	30
16	Limestones	Inhambane	40
17	Cement Factory	Inhambane	50
18	Various Consulting Projects	Inhambane	0 - 16

(Source: EDM)



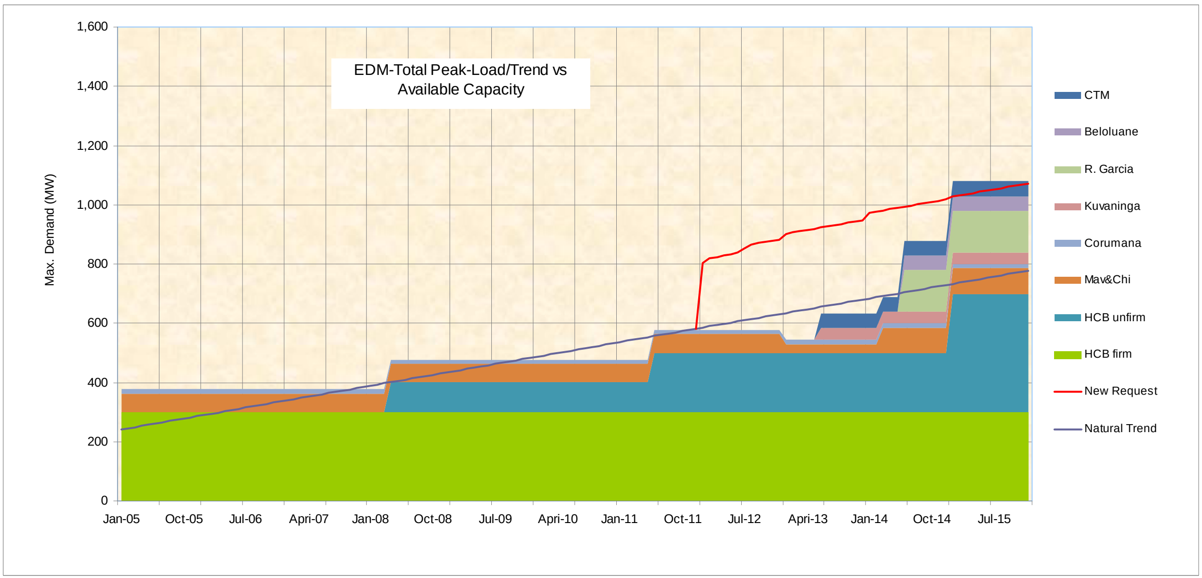
(Source: EDM)

Figure 2.8-2 Evolution of Maximum Demand and Demand Forecast for the Southern Region (2005-2023)

For power demand at national and regional levels, EDM has reviewed actual values for the years 2005-2010 and created a power demand forecast for the years up to 2015. The power demand forecast at the national level is indicated in Figure 2.8-3, while the power demand outlook for the southern region is shown in Figure 2.8-4.

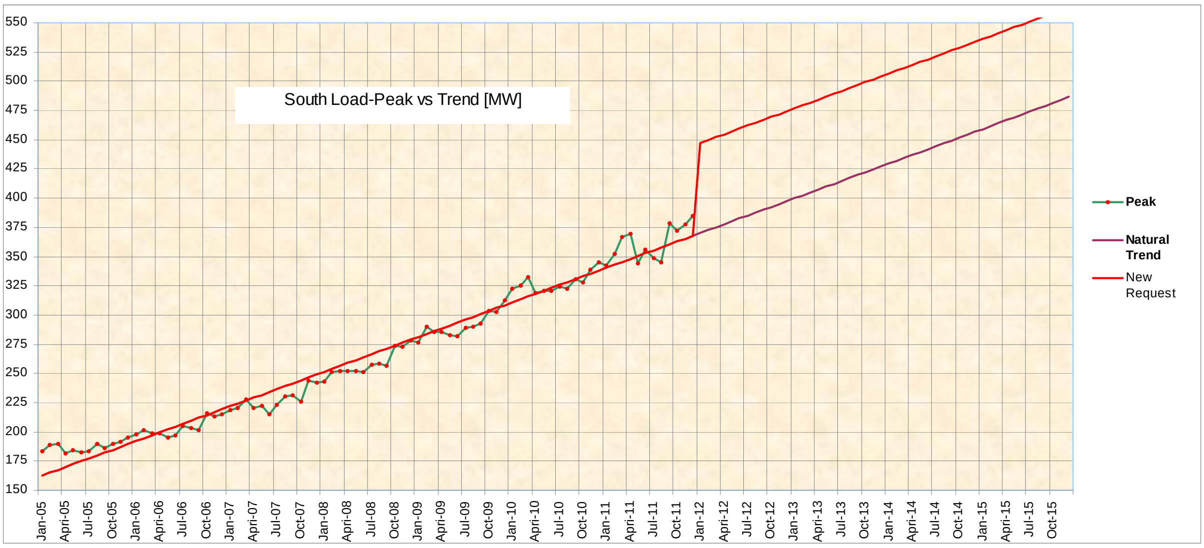
The power demand forecast is drawn up to the year 2015 on the basis of the sum of incremental demand growth by regression analysis and additional power demand by customers with large power consumption. To meet the demand, the existing and future power plants are considered as power supply sources. Power demand is expected to grow at a comparatively slow speed. In the meantime, a number of additional power plants are planned to be put into operation to meet additional power demand so that customers with large power consumption can apply to receive power from 2012.

According to the power supply plan of EDM, the proposed combined cycle power plant at Beluluane with capacity of 50 MW should start operation in June 2014 and CTM-Maputo power station will start in June 2013 after completing its rehabilitation. However, as of June 2012, no implementation plan has been established for either project. In addition, it takes three years or more to start operation after an implementation plan is developed and put into practice. For this reason, it is not considered practical to expect power supply capacity by either project to meet the short- or medium-term power demand. Therefore, it is necessary that practical planning for power supply and demand be developed.



(Source: EDM)

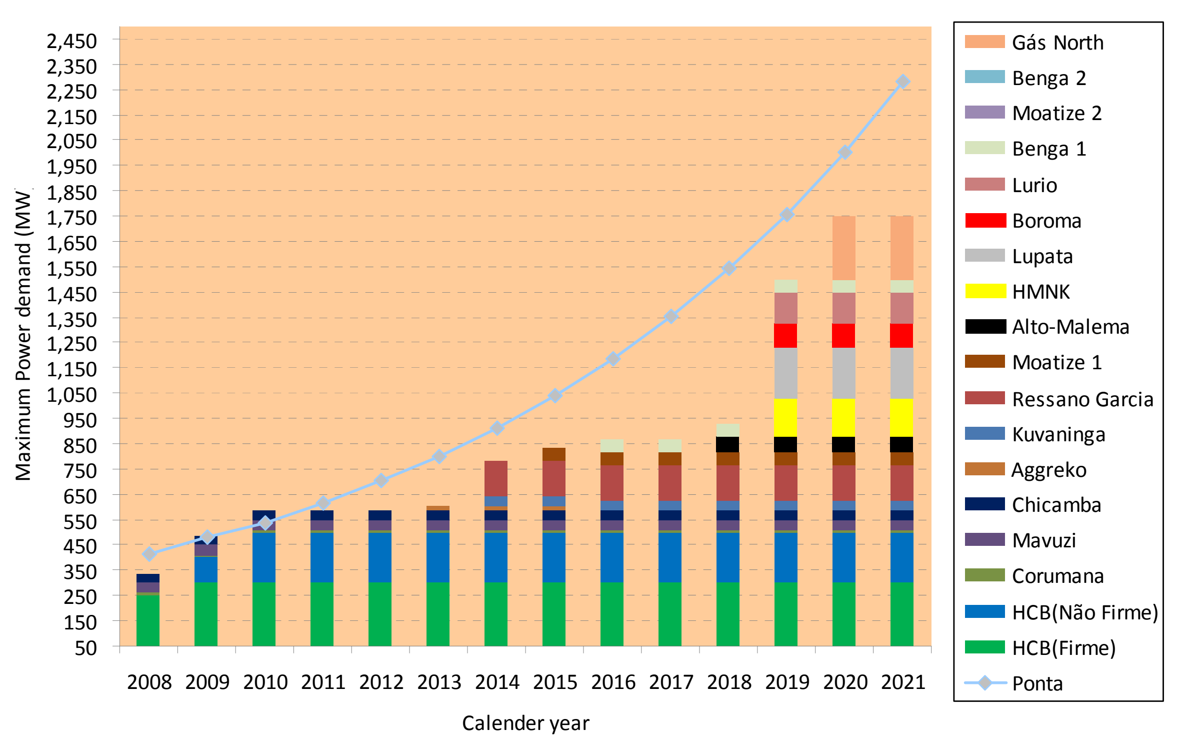
Figure 2.8-3 Evolution of Power Demand Nationwide and Demand Forecast (2005-2015)



(Source: EDM)

Figure 2.8-4 Evolution of Power Demand in the Southern Region and Demand Forecast (2005-2015)

Apart from the demand forecast in the Electricity Master Plan Study now underway, EDM is conducting a separate demand-supply analysis. As shown in Figure 2.8-5, the average annual growth rate of the maximum power for the past few years has been 14% and this growth rate is expected to continue until 2021, due to the strong economic growth and electricity demand. In order to meet this demand, although power purchase from HCB will be secured in the future, EDM needs to rehabilitate its own existing power generation facilities and procure electricity from new IPPs, such as gas-fired thermal power plants in Ressano Garcia, new hydro power plants and coal-fired thermal power plants in Tete province. Even if all these power supplies are secured, there is still a risk of power shortage in the future. If this is the case, expansion of the said projects and/or power purchase from SAPP is inevitable. Accordingly, it is necessary to scrutinize the power supply capacity of individual power generation projects and thereby elaborate the middle- and long-term power demand and supply plan.



(Source: EDM)

Figure 2.8-5 Result of Power Demand and Supply Analysis (2012-2021)

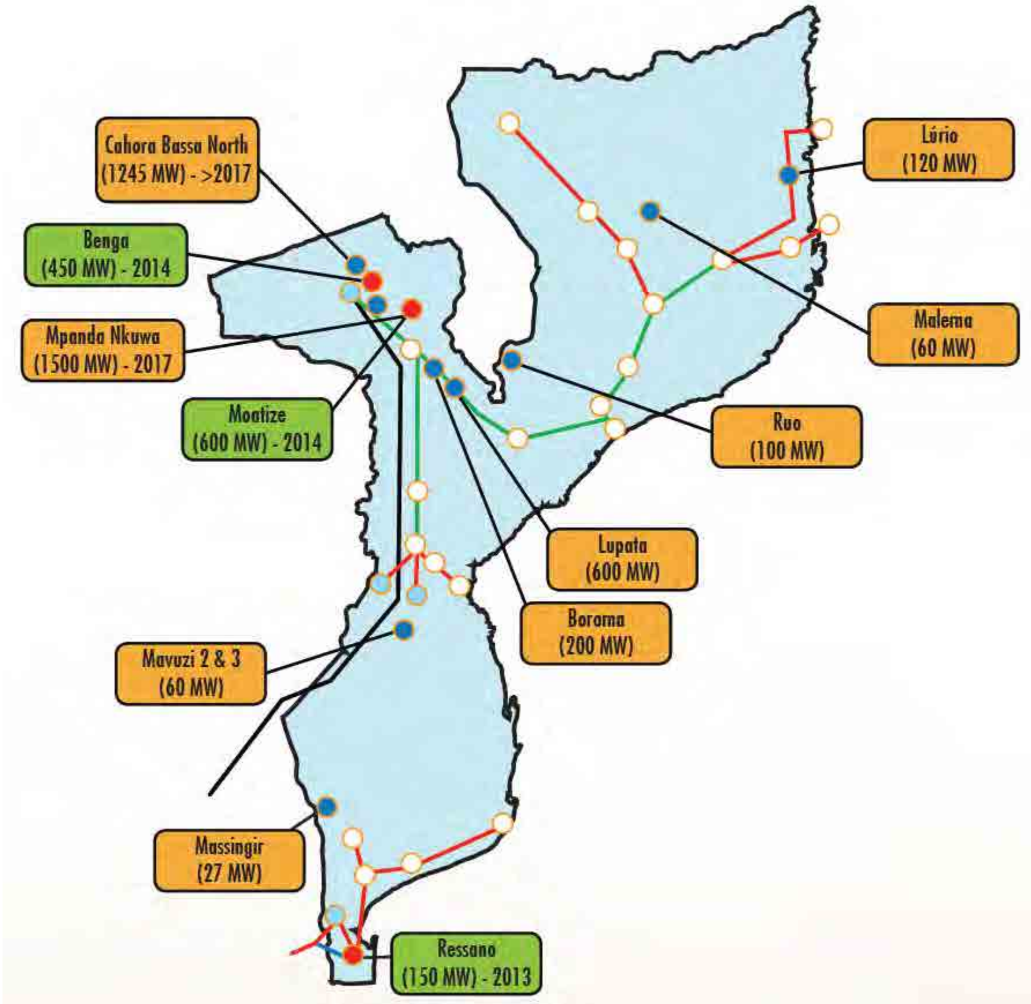
2.9 Power Development Plan

As power demand is steadily increasing in Mozambique, a number of power development projects are planned. Presented in this section is an overview of power generation, transmission and substation projects, which are expected to involve large-scale investment.

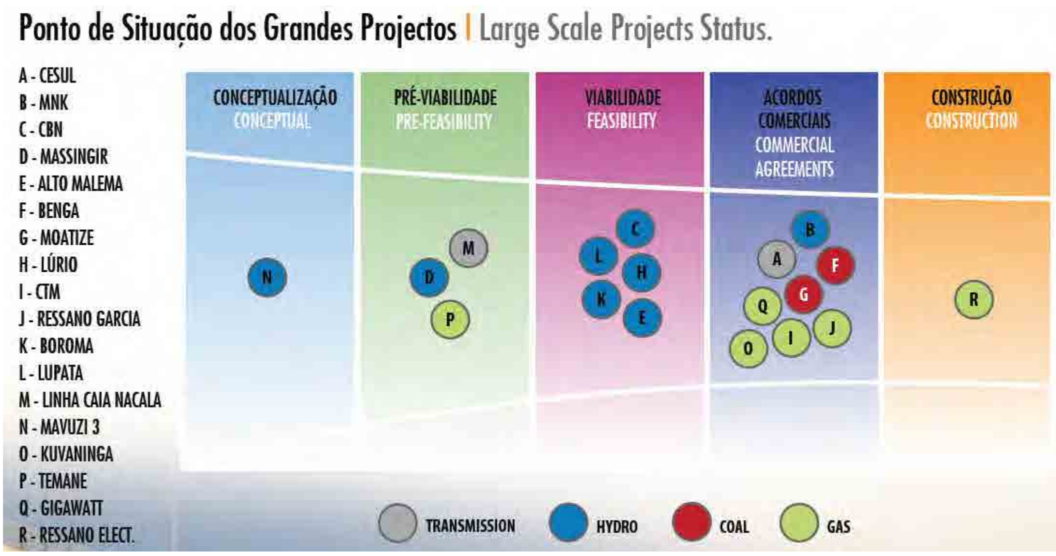
2.9.1 Power Generation Projects

Locations of large-scale power generation projects that relate to EDM are indicated in Figure 2.9-1. An overview of power generation projects announced by EDM is shown in Table 2.9-1. There are six projects with a total installed capacity of 4,005 MW with a total investment cost reaching USD 6,540 million.

(1) Location of Power Generation Projects under Planning



(2) Current Status



(Source: Statistical Summary 2011, EDM)

Figure 2.9-1 Power Generation Projects under Planning

Table 2.9-1 Overview of Power Generation Projects under Planning

No.	Project	Capacity (MW)	Investment (MUSD)	Status	Year of Comm.
1	Moatize Thermal Power Plant (IPP, Vale)	600	1,400	Power purchase agreement under negotiation (supply to EDM & export). Design, ESIA, & funding in progress.	2014/2015
2	Benga Thermal Power Plant (IPP Rio Tinto)	450	1,100	Power purchase agreement under negotiation (supply to EDM & export). Design, ESIA, & funding in progress.	2014/2015
3	Malema Hydropower Plant (EDM - IPP)	60	120	Pre-F/S	2015
4	Mphanda Nkuwa Hydropower Plant (Campbell & Correia)	1,500	2,900	Power purchase agreement under negotiation (supply to EDM & export). Design, ESIA, & funding in progress. Concession contract at final stage.	2017
5	Cahora Bassa North Hydropower Plant (HCB and CEZA)	1,245	800	Pre-F/S	2017
6	Moamba / Ressano Garcia Thermal Power Plant (EDM + SASOL)	140	220	Pre-F/S	2013
	Total	**4,005**	**6,540**		

(Source: EDM)

Apart from the above-mentioned large-scale power generation projects to be developed in accordance with the mid- and long-term development plans, in order to bridge the gap in power balance especially in the southern region, it is necessary for EDM to acquire power from gas-fired thermal plants being developed in Ressano Garcia in the near term. The outline of these gas-fired plants are summarized as follows:

(1) Sasol + EDM IPP

This is an IPP project being developed by a joint venture between EDM and Sasol (RSA). The plant houses 16 gas engine generators each with an installed capacity of about 9 MW, with a total installed capacity of 140 MW. EDM is planning to purchase 100 MW of power from this IPP.

(2) Gigawatt-Mozambique IPP

This is an IPP project being developed by Gigawatt-Mozambique: a joint venture between Gigajoule of RSA and some private enterprises based in Mozambique with a share ratio of 40/60, based on a 25-year concession for electricity generation granted by the Mozambican government. The plant, estimated to cost $230 million, has an installed capacity of 100 MW, of which approximately 40 MW is to be sold to EDM based on a long-term PPA. The remaining capacity is to be utilized to feed electricity to RSA through the South Africa Power Pool (SAPP). The plant is expected to start commercial operation by the end of 2013.

(3) Aggreko IPP

This is an IPP project being developed by Aggreko, which is the world's biggest temporary power provider. Aggreko has signed a Power Purchase Agreement (PPA) with Eskom, the South African power utility, and agreed on PPA terms with EDM to provide a 107 MW power plant that will supply base load and peak power to both companies. The output of the plant will be split between the two companies, with EDM utilizing 15 MW and Eskom 92 MW. The gas used in the plant is part of the gas given to Mozambique as a royalty by Sasol, which is operating the onshore Pande/Temane gas fields. The plant is scheduled to start operations by the end of 2012 and supply power until July 2014. Aggreko is responsible for building gas interconnections, a substation and 1.5 kilometers of a 275 kV transmission line. The total value of the project is likely to be in the order of $250 million over two years, including fuel costs.

2.9.2 Transmission and Substation Projects

An overview of the transmission and substation projects announced by EDM is presented in Table 2.9-2. There are eight projects totaling a USD 287.5 million investment cost.

Among these, the priority project of EDM is the project listed as “220 kV Line Caia – Nacala (800 km).” This project is intended to supply electric power to the Nacala district, where power demand has been significantly increasing in recent years, by constructing ultra-high voltage transmission lines of 220 kV from Caia substation to Nacala substation. If the project is realized, power supply facilities will be reinforced to supply power to the Nacala corridor area for the years to come. The investment cost is estimated at USD 224 million.

Table 2.9-2 Overview of Power Transmission Projects

Project Description	Purpose / Impact	Amount [MUSD]	Status	Year of implem.
Transformer Installation in central Nampula 110/33 kV, 35 MVA	Increased capacity in distribution in Nampula and Nacala	2.5	Mix of credit financing from Danida. Ongoing development of the specifications	2014
Installation of the system SVC North	Increased capacity to transfer the North Central Line at X MW, the system stabilizes the North Central Line	45	Launch of a university for the project planned for July 2011	2015
Strengthening 220/110 kV Substation, System Center in North	Increased availability of power to the central and northern areas	21	Ongoing development of the feasibility study	2015
220 kV Line Caia - Nacala (800 km)	Increased carrying capacity of 100 MW / power redundancy to the central and northern areas	224	Ongoing feasibility study	2016
Improvement and expansion of the Nacala port and Nacala-a-Velha	Improved quality of supply and expansion of the network for resettlement, etc.	20	Ongoing fund raising	2016
Strengthening of the transmission of the Nacala corridor, construction of a substation 110/33kV 40MVA in Namialo	Increased availability of energy	16	Ongoing fund raising	2016
Installation of the regional dispatch center for Central and Northern areas	Operation and monitoring of the transmission system	18	In the mobilization phase of funding	2016
Strengthening of the system of the distribution of Nampula and Nacala	Improved quality of supply to the city of Nampula and Nacala and peri-urban areas	15	Being implemented and funded by the EXIM Bank of India	2012
Total [MUSD]		**361.5**		

(Source: EDM)

2.9.3 CESUL Project

EDM has created an implementation plan for the "Mozambique Regional Transmission Backbone Project" (also known as the "CESUL[3]" project), with the assistance of aid organizations in Europe, in order to meet the increasing power demand of the Maputo metropolitan area and southern African countries.

In the CESUL Project, as a prerequisite for transmission planning, the power supply and demand of the SAPP member countries is estimated to provide a long-term power supply and demand outlook. The current status of electricity supply and demand in each country is shown in Table 2.9-3, where the power generation capacity and the maximum demand are also presented. It can be readily understood that the power demand in South Africa is prominently large and because the power supply capacity in Mozambique is significantly larger than the power demand, the country is able to export the surplus power to the SAPP.

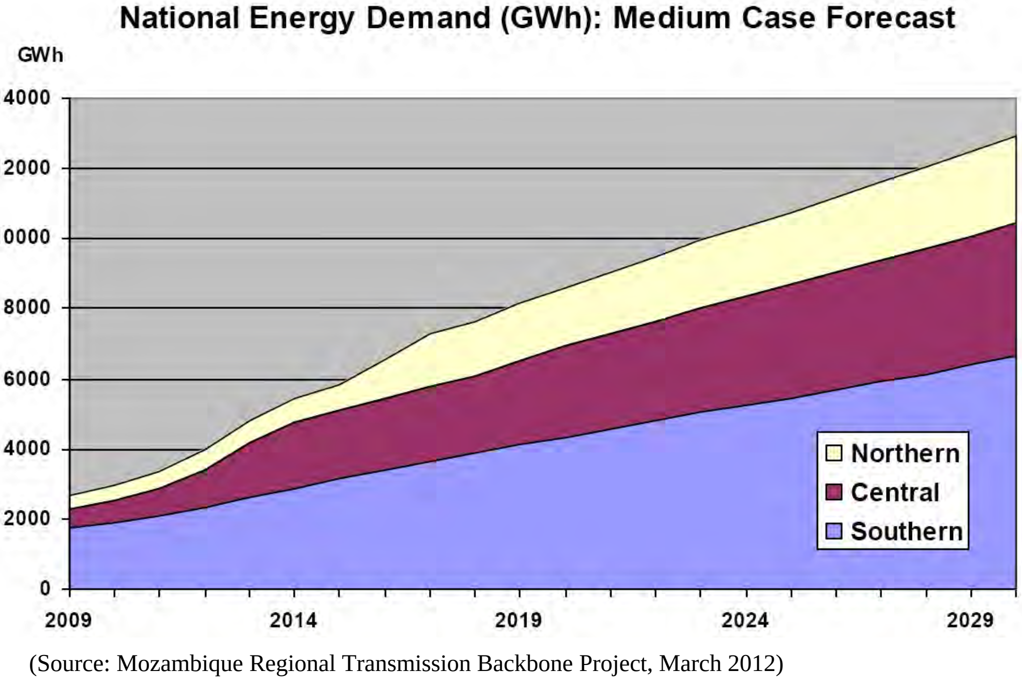
[3] The CESUL project was renamed the "STE" project in the middle of 2012. In this report, however, the project is still referred to as the former name (CESUL) in order to avoid confusion.

Table 2.9-3 Power Supply and Demand of the SAPP Member Countries

No.	Country	Utility	Installed Capacity (MW)	Available Capacity (MW)	2010 Peak Demand (MW)
1	Angola	ENE	1,187	990	1,100
2	Botswana	BPC	202	190	553
3	DRC	SNEL	2,442	1,170	1,081
4	Lesotho	LEC	72	72	121
5	Malawi	ESCOM	287	287	300
6	Mozambique	EDM	233	174	534
		HCB	2,075	2,075	
7	Namibia	NamPower	393	360	564
8	South Africa	Eskom	44,170	41,074	36,705
9	Swaziland	SEC	70	70	204
10	Tanzania	TANESCO	1,008	780	833
11	Zambia	ZESCO	1,812	1,215	1,600
12	Zimbabwe	ZESA	2,045	1,320	2,100
Total SAPP			55,996	49,777	45,695
Total Interconnected SAPP			53,514	47,720	43,462

(Source: Mozambique Regional Transmission Backbone Project, March 2012)

Figure 2.9-2 shows a long-term power demand forecast for Mozambique. Power supply and demand is forecast to grow five-fold from 2009 to 2030, recording an annual growth rate of a little over 8%. The power demand in the southern region is projected to account for half of the total in the year 2030.



(Source: Mozambique Regional Transmission Backbone Project, March 2012)

Figure 2.9-2 Long-Term Power Demand Forecast of Mozambique

In the CESUL Project, it is assumed that the power generation projects shown in Table 2.9-4 will be implemented. Power generation capacity for both thermal power plants at Benga and Moatize and hydropower plants at MPNK and CBNB account for 82% of the total capacity so the progress of these projects will have a major impact on the overall CESUL Project. Gas-fired power plants with a total capacity of 600 MW include 70 MW from the rehabilitation project at CTM Maputo power station.

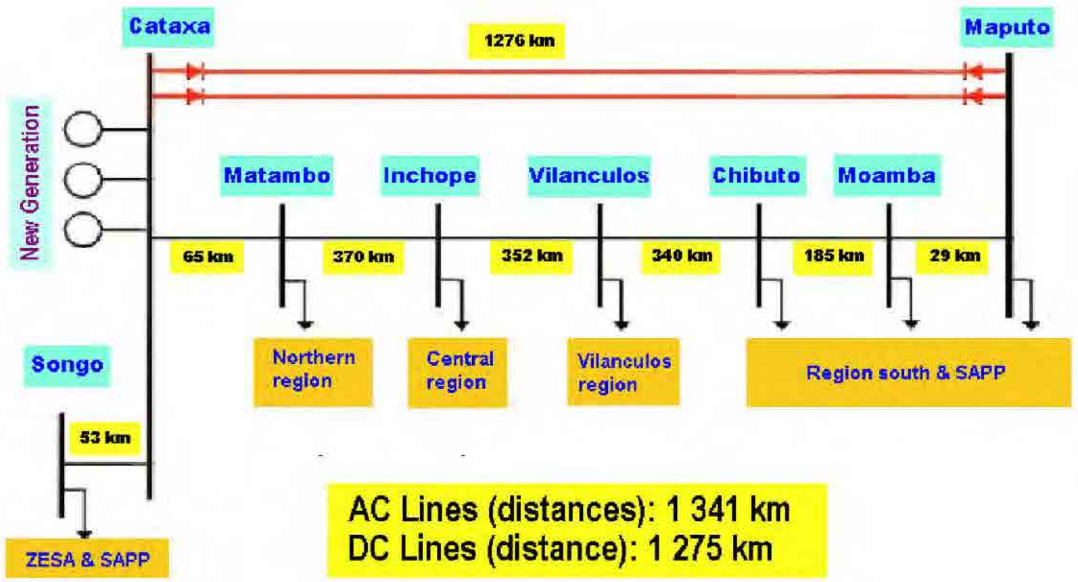
Table 2.9-4 Power Generation Projects Considered for the CESUL Project

Energy	New Projects	Comm. Yr	Cap. (MW)
Thermal-Gas	CTM-conversion to gas	2013	70
	Kuvaninga gas	2013	40
	Ressano Garcia (RG) gas	2014	140
	Electrotec gas - near RG	2015	250
	Gigawatt gas - near RG	2014	100
	Sub-total		600
Thermal-Coal	Benga coal fired plant	2014	2,000
	Moatize coal fired plant	2014	2,400
	Sub-total		4,400
Hydropower	Mphanda Nkuwa (MPNK)	2017	1,500
	MPNK Extension	2020	750
	Cahora Bassa North Bank (CBNB)	2017	1,245
	Massingir	2014	40
	Boroma	2017	200
	Pavua	2015	60
	Lupata	2017	600
	Muenezi	2014	21
	Alto Malema	2014	60
	Tsate	2014	50
	Sub-total		4,526
Renewables	Wind - Ponto D'Ouro	2013	10
	Wind - Inhambane	2013	10
	Biomass	2014	50
	Solar	2013	10
	Sub-total		80
Total			9,606

Note: Comm. Yr: Earliest commissioning year, Cap.: Installed capacity at the final development stage

(Source: Mozambique Regional Transmission Backbone Project, March 2012)

An overview of the transmission lines for the CESUL Project is shown in Figure 2.9-3. The AC system has a transmission capacity of 900 MW and is operated at 400 kV. The DC power transmission system with a voltage of ± 500 kV has a transmission capacity of 2,650 MW. The converters are commissioned in two stages: 1,325 MW for Stage 1 and 1,325 MW for Stage 2. The entire project will be implemented in seven separate packages for tendering and construction.



(Source: Mozambique Regional Transmission Backbone Project, March 2012)

Figure 2.9-3 Transmission System of CESUL Project

The scope of work covering the AC system and Stage 1 of the DC system is referred to as the Phase 1 project. For this scope of work, implementation is estimated to take as long as 59 months, covering design, tendering, procurement, construction, etc. The total project cost is estimated to be 1,800 million USD.

A construction project of this kind and size presents a big challenge, requiring funding and public-private partnerships. It has been decided, therefore, that a project finance-based special-purpose entity (special purpose vehicle: SPV) will be created and operated for the CESUL Project. It is planned that EDM will own 51% of the SPV shares, with the remaining 49% going to other public and private sectors, who will jointly invest in the SPV.

2.10 Outline of Cooperation Projects Implemented by Other Donors

The Ministry of Energy (ME), which holds jurisdiction over the power sector in Mozambique, and Electricidade de Moçambique (EDM), which is the publicly-owned electricity company under jurisdiction of the ME, with support from foreign countries, have engaged in human capacity building, establishment of policy and regulatory framework of the Mozambican power sector, and development and operation of the power equipment and facilities. This chapter provides an outline of power projects implemented (or to be implemented) in cooperation with other donors.

2.10.1 On-going Power Projects

Table 2.10-1 shows the on-going power projects in Mozambique, which are classified into three categories: technical cooperation projects, transmission projects, and rural electrification projects, with a total project cost amounting to USD 669.19 million.

The technical cooperation projects are supported by aid agencies such as World Bank (WB), International Development Association (IDA), L'Agence Française de Développement (AFD), the Government of Norway (through the Agency for Development Cooperation: NORAD) and the Government of Sweden (through the Swedish International Development Cooperation Agency: SIDA). The technical cooperation projects for the power sector are characterized by the wide range of aid agencies and countries involved.

The Mozambique Electricity Master Plan was prepared with the assistance of NORAD in 2004. In 2008, however, the need to upgrade the Master Plan was recognized so terms of reference (TOR) for an update of the previous Master Plan were prepared. Currently, the update of the Master Plan is underway and is to be completed by the end of 2012. Sub-Item 1.1.3: "Update of Master Plan 2010-2027" in Table 2.10-1 corresponds to this project.

Table 2.10-1 On-going Power Projects

Item	Name of the Project	Cost [MUSD]	Funder
1. Ongoing projects			
1.1 Feasibility Study and Technical Assistance			
1	Feasibility Study of Second Line Caia - Nampula	1.80	IDA
2	Integrated Management System (Sigem)	6.74	IDA
3	Update of Master Plan 2010-2027	1.30	AFD
4	Capacity Building	4.00	Swedish
5	Feasibility Study for Electrification of Vilanculos (OHL 110 kV Chibabava - Vilankulos)	0.05	Swedish
	Sub Total - Item 1.1	**13.84**	
1.2 Transmission Projects			
1	Rehabilitation and Reinforcement of Distribution network. Maputo City (Lot 1)	33.35	Portugal
2	Rehabilitation and Reinforcement of distribution network. Maputo City (Lot 2)	31.90	Portugal
3	Mobil Substation	6.09	Reino Belga
4	66kV Lines in Maputo	6.65	EDM
5	Mixed credit	150.00	Danida
6	Assembly of the Second Transformer in Matambo SS	13.00	World Bank
7	110kV Transmission Line Mavuzi - Chibabava	19.50	EU
8	SVC in Mocuba	10.03	GdM
9	Rehabilitation Chimoio SS and Acquisition of Mobile SS 110/33/22 kV 10 MVA	6.30	Kingdom of Belgium
10	Electricity II (Line DL8)	0.40	EDM
11	Electricity IV (Chibata - Dondo 220kV)	55.00	ADB/OPEC
12	Rural Electrification of North area of Gaza Province (110kV Lionde - Mapai)	54.00	Korean Exim Bamk
13	Transmission line 275 KV Corumana - Lionde	25.30	Danida
	Sub Total - Item 1.2	**386.22**	
1.3 Rural Electrification Projects			
1	LCREP of Niassa	11.40	IDB
2	EDAP (Expansion MV Network in Maputo, Manica, Tete, Nampula and Cabo Delgado)	147.70	BM/Afund/OFID/AFD/EIB
3	Rural Electrification Sofala, Manica and Tete Provinces (Lot B)	15.80	Suecia/Noroega
4	Rehabilitation of Bilene SS	1.90	EDM
5	Rural Electrification of Inhambane, Zambezia and Nampula Provinces	30.00	EXIM BANK/INDIA
6	Rural Electrification of Niassa, Cabo Delgado and Manica Provinces	25.00	EXIM BANK/INDIA
7	Electricity III	19.33	ADB/OPEC
8	Rural Electrification of Cabo Delgado Phase III - Addendum (Ibo)	13.00	NORWAY
9	Rural Electrification of Pande	3.00	GoM
10	Rural Electrification of Chimbonila	2.00	Norway
	Sub Total - Item 1.3	**269.13**	
	TOTAL - Item 1	**669.19**	

(Source: EDM, 2012)

2.10.2 Priority Projects without Funding

Table 2.10-2 shows the priority power projects to be implemented in accordance with the power development plan for which the funding source has not been determined. This table shows only the projects to be implemented over the period 2010 - 2015. The projects are divided into four categories: transmission projects, rural electrification projects, distribution & rehabilitation projects and generation projects with a total project cost expected to amount to USD 2,906.07 million. Although some transmission projects have already gained financial commitment, most of the projects still need a large amount of funds for implementation, thus requiring financial support from developed countries.

The Beluluane Gas-Fired Power Plant Project requested by the Government of Mozambique through ME and EDM corresponds to Sub-Item 2.10.2: “50 MW gas-fired power plant: 75 MUSD.” In addition, the Project for Rehabilitation of the existing Maputo Thermal Power Plant corresponds to Sub-Item 2.10.2 “10. Expansion of gas turbine HRSG coupled to existing plant: 70 MUSD.” Both are designated as priority projects to be implemented.

Table 2.10-2 Priority Projects Without Funding

Item	Name of the Project	Cost [MUSD]	Remarks
2. . Priority Projects Without Funding			
2.1 Transmission Projects (2010 - 2015)			
1	Rehabilitation and Reinforcement of Infulene SS	32.00	
2	Rehabilitation and Reinforcement of Transmission Net grid in Maputo	4.70	
3	Transmission line 275 kV Infulene - Maputo	50.80	
4	Rehabilitation and Reinforcement of Maputo SS and Power Transfer to South Area	96.68	
5	Transmission line 275 kV Maputo - Salamanga and Salamanga 66/33 kV SS Extension	48.59	committed
6	Transmission Line 66kV Salamanga - Catembe	24.12	
7	Reinforcement of Maputo Transmission Capacity (SS Costa do Sol)	47.70	
8	Interconnection of Moamba Gas Plant (750 MW) to 275 kV Network	750.00	
9	Reinforcement of Chicumbane SS and Interconnection of 275 KV Lionde SS	35.40	
10	Reinforcement the Network of Major Corridors 66 kV of Maputo	30.00	
11	Interconnection SE1, 3, 5 and Facim - to 66 kV SE5	9.55	
12	Construction of FACIM SE and interconnection CTM, SE and SE1	20.00	
13	Rural Electrification of Vilanculos (OHL 110 kV Chibabava - Vilankulos)	42.10	committed
14	110 kV Transmission Line Vilankulos - Massinga	32.80	
15	Manga Substation	21.17	
16	Reinforcement of Chimoio substation	20.17	
17	Reinforcement the Network of Tete	38.40	
18	SVC North System	19.00	committed
19	Reinforcement of Caia - Nampula - Nacala 220 kV	312.20	
20	Reinforcement of Nampula Transmission System (Namialo SS)	12.05	
21	Reinforcement of 220/110 kV Substation (System Center - North)	21.00	committed
22	Central Dispatch Center / North	30.09	committed
	Sub Total - Item 2.1	**1,698.52**	
2.2 Rural Electrification Projects (2010-2015)			
1	Rural Electrification of Niassa province - Phase III (Mecula and Nipepe)	36.90	
2	Electrification of Border Villages of Niassa, Zambezia, Tete, Manica and Maputo Provinces	49.30	
3	Rural Electrification and Urban Maputo Province	63.04	
4	Rural Electrification of Vilanculos	39.34	
5	Rural Electrification of Sofala North Administrative Posts	11.03	
6	Rural Electrification of Balama, Namuno and Machaze	25.00	
7	Agricultural Areas Electrification in Mozambique	128.30	
	Sub Total - Item 2.2	**352.91**	
2.3 Distribution & Rehabilitation Projects (2010-2015)			
1	Rehabilitation of Lichinga Distribution Network - Niassa Province	14.60	
2	Rehabilitation of Nampula Distribution Network - Nampula	16.34	
3	Reinforcement and Expansion of Nacala Distribution Grid	20.02	
4	Rehabilitation of Beira Electrical Network	8.08	
5	Rehabilitation of Xai-Xai Distribution Networks - Gaza Province	11.97	
6	Reinforcement of Matola Network	31.44	
7	Rehabilitation and Reinforcement of Maputo Distribution Network	30.00	
8	Reinforcement the surrounding Maputo Network Package 2	39.72	
9	Reinforcement end Extension of Maputo Netgrid Phase I 2011	17.51	
10	Reinforcement end Extension of Maputo Netgrid Phase II 2011	21.67	
11	Loss Reduction Project in Maputo Distribution Area (Guava)	21.77	
12	Ring Fance Project in Matola Area	10.02	
	Sub Total - Item 2.3	**243.14**	
2.4 Generation Projects			
1	Beluluane 50MW Gas Fired Power Plant	75.0	
2	Moamba 120MW Gas Fired Power Plant	150.0	
3	Mocimboa da Praia 50 MW Gas fired power plant	90.0	
4	Kuvaninga 50MW Gas Fired Power Plant	75.0	
5	Temane 10MW Gas Fired Power Plant	15.0	
6	Feasibility Study for Revue Basin (Tsate, Mueneze, Mavuzi II & III)	1.5	
7	Feasibility Study of Pavue at Pungue River	1.5	
8	Feasibility Study Mutelele at Ligonha River	0.7	
9	Conversion of Diesel Generator to Gas Turbine	12.0	
10	Expansion of Gas Turbine HRSG Coupled to Existing Plant	70.0	
11	Feasibility Study for Buzi Gas usage for Electricity Generation	0.2	
12	Feasibility Study for *Condensates* Usage from Natural Gas for Electricity Generation	0.2	
13	Feasibility Study for Corrumana Hydropower Rehabilitation	0.2	
14	Feasibility Study for Expansion of Temane Gas Power Plant	0.2	
15	Alto Malema Basin	120.0	
	Sub Total - Item 2.4	**611.50**	
	Total - Item 2	**2,906.07**	

(Source: EDM, 2012)

2.10.3 Recently Completed Projects

Table 2.10-3 shows recently completed power projects, which are separated into two categories: transmission projects and rural electrification & distribution projects. The total project cost amounts to USD 385.51 million.

Similar to the case for on-going transmission and rural electrification projects described in Subsection 2.10.1, the projects have been implemented with support from a wide range of foreign countries and aid agencies.

Table 2.10-3 Recently Completed Projects

Item	Name of the Project	Cost [MUSD]	Funder
3. Recently Concluded Projects			
3.1 Transmission Projects Recently Completed			
1	Feasibility Study of the Central - South Line (CESUL)	6.00	IDA/Noroega
2	Paiol Explosion – Supply Transformer For Chicumbane	0.78	Dinamarca
3	Matola Substation 275/66kV	18.50	KUWAIT/OPEC
4	National Dispatch Center	5.10	DANIDA
5	Commissioning of 2º Transformer at Machava Substation	0.38	BDSA
6	Creation of the Environmental Unit	0.54	DANIDA
7	Rural Electrification of Marromeu	9.60	KfW/EdM
8	Project of the 110kV Transmission Line Nampula - Pemba	6.80	BADEA/ IDB/ EDM
9	Rural Electrification of Cabo Delgado Phase II	10.25	BADEA/BID
10	Gurue - Cuamba - Lichinga - 110kV Transmission Line	46.43	Suecia/Noroega
11	Feasibility Study for Electrification of Niassa (Cuamba - Marrupa 110kV Line)	0.40	BADEA
12	Rural Electrification of Cabo Delgado Phase III	53.00	NORWAY/BADEA/BID/EU
13	Alto Molocue - Uape - 110kV Transmission Line	9.96	EXIM BANK - India
	Sub Total - Item 3.1	**167.74**	
3.2 Rural Electrification & Distribution Projects Recently Completed			
1	ERAP Package I, II and III, Extension of Distribution Networks	14.91	BAD
2	Rehabilitation of Maputo and Matola	7.77	ICO/SPAIN
3	Service connection in Matola City	3.00	GTZ
4	Connection of 12,000 consumers in the area of Maputo and Matola	3.00	GTZ
5	Increasing Number of Consumers in Matola Area	10.50	Elswedy-Egipto
6	Rehabilitation and Reinforcement of Infra infrastructures Damaged by Paiol Explosion	4.30	DANIDA
7	Rehabilitation and Reinforcement of Maputo Distribution Net Work	23.50	DANIDA
8	Rural Electrification of Gaza Province	19.95	EXIM BANK - India
9	Rural Electrification of Morrumbene and Massinga	1.60	Dinamarca
10	LCREP of Inhambane (Massinga - Morrungulo)	11.40	Dinamarca
11	Rural Electrification of Gorongosa	4.34	KFW
12	Rural Electrification of Sofala, Manica and Tete Provinces	15.80	Suecia/Noroega
13	Rural Electrification of Chibabava and Buzi Districts, Sofala Province	9.67	Suecia / Dinamarca
14	Rural Electrification of Tete Districts	32.00	GoM
15	Rural Electrification of Tete Districts - Addenda 1 & 2	10.56	EU
16	Rural Electrification of Namacurra	8.76	NORAD
17	Rural Electrification of Namacurra Pebane Extension	6.00	NORAD
18	Rehabilitation and Reiforcement of Distribution Network of Beira City	15.50	DSBA
19	Rural Electrification of Mecanhelas, Maua, Metarica and Marrupa, Niassa Province	14.00	Suecia/Noroega
20	Rural Electrification of Sanga - Niassa Province	1.21	GoM
	Sub Total - Item 3.2	**217.77**	
	Total - Item 3	**385.51**	

(Source: EDM, 2012)

2.10.4 Scale of Project Costs

A simple sum of all project costs listed in Subsections 2.10.1, 2.20.2 and 2.10.3 adds up to USD 3,800 million as shown in Table 2.10-4. The sum of the cost of the on-going projects and the recently completed projects accounts for only 27.8% of the total project cost. The projects to be implemented by 2015 (listed in Section 4.2) still require a large amount of investment. For the recently completed projects, the project cost incurred by ME and EDM accounts for 10.1% of the total amount with the rest depending on foreign aid from other countries. As this trend continues, both government-based support from other countries and private investment are considered essential for the power sector of Mozambique in the future.

Table 2.10-4 Total Investment Amount in Power Sector

Category	Amount (MUSD)	%
On-going projects	669.2	17.6%
Priority projects without funding	2,745.3	72.2%
Recently completed projects	385.5	10.1%
Total	3,800.0	100.0%

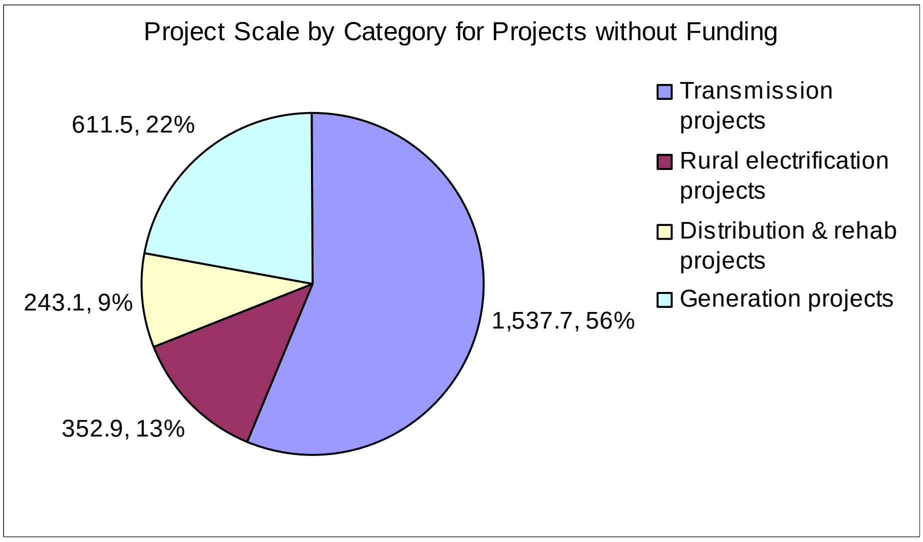
(Source: EDM, 2012)

As mentioned in Subsection 2.10.2, the total project cost for priority power projects without funding amounts to USD 2,745.3 million with the breakdown shown in Table 2.10-5 and Figure 2.10-1. The cost of transmission projects accounts for the largest share (56.0%), followed by generation projects (22.3%). However, sources of funding necessary to implement these projects have still not been identified.

Table 2.10-5 Priority Power Projects without Funds

Category	Amount (MUSD)	%
Transmission projects	1,537.7	56.0%
Rural electrification projects	352.9	12.9%
Distribution & rehab projects	243.1	8.9%
Generation projects	611.5	22.3%
Total	2,745.3	100.0%

(Source: EDM, 2012)



(Source: EDM, 2012)

Figure 2.10-1 Breakdown of Priority Power Projects without Funding

2.10.5 Assistance to Mozambican Power Sector by International Aid Agencies

The World Bank, in cooperation with IDA, has provided assistance to the Mozambican power sector. The most recent case is the "Energy Development and Access Project (EDAP APL-2)," which primarily aims at improving the access rate to electricity and the quality of power supply in rural and peri-urban areas. The project extends for the 5 years from 2010 to 2015 and the total project cost is expected to reach USD 80 million. The project has the following three components:

- Reinforcement of the Primary Networks and Grid Extension Component (US $50.0 million)
- Investments on Rural and Renewable Energy Component (US $18.0 million)
- Energy Sector Planning, Policy and Institutional Development Component (US $10.2 million)

The World Bank is also providing support for "Mozambique Regional Transmission Backbone Project (CESUL)" in collaboration with NORAD.

Figure 4-2 shows the locations of the above-mentioned World Bank assisted projects as well as other major power projects. The project information on the above-mentioned "EDAP APL-2" and information on the World Bank's assistance program for the Mozambican power sector are detailed in the following document:

- Project Appraisal Document on a Proposed Credit in the Amount Of SDR 49.7 Million (US $80 Million Equivalent) to the Republic of Mozambique for an Energy Development and Access Project (APL-2) (January 6, 2010)

2.10.6 Assistance to Mozambican Power Sector by Norway

Norway is one of the developed countries that are most actively involved in assistance to the Mozambican power sector, and it currently provides support to the following six projects:

- Institutional Capacity Building in the Ministry of Energy, 2007–2010, NOK 41 million
- Technical Assistance to Electricidade de Moçambique, 2008–2010, NOK 13 million
- Cabo Delgado Electrification Project, 2006–2013, NOK 342 million
- Marrupa-Cuamba-Mecanhelas Electrification Project, 2007–2012, NOK 41 million
- Chimbonila Electrification Project, 2011–2012, NOK 11 million
- Support to the National Energy Fund (FUNAE), 2010–2011, NOK 3 million

As a member of the International Cooperation Partner (ICP) countries, Norway has taken a leading role in dealing with common issues shared by the Southern African Development Community (SADC), which Mozambique is affiliated with. Projects that Norway is currently involved in are as follows:

- Support to the SADC Secretariat on Energy Related Issues
- Mozambican Regional Transmission Backbone Project (CESUL)

- Electricity Regulators’ Peer Review Network
- The Southern African Power Pool – Regional Electricity Market

2.10.7 Assistance to Mozambican Power Sector by Germany

Germany has often provided both grant and loan assistance for the Mozambican power sector. Among the most significant projects is the project for construction of a database regarding the energy sector. This database is intended to capture, store and sort all the literature on the energy sector published in the past 15 years, and the results are expected to be incorporated into the survey. The project is being implemented by the German Agency for International Cooperation (GIZ) in collaboration with Universidad Pedagogica (Pedagogica University) and is now underway. It is necessary to maintain contact with GIZ, in order to obtain this database once it is completed.

Chapter 3 Data Collection and Review on the Priority Projects

3.1 Overview of Priority Projects

ME and EDM have jointly made a request to the Government of Japan for assistance in the power sector of Mozambique in EDM’s document, “Mozambique Electricity Sector & Power Infrastructure,” in which five projects are nominated as ‘Projects for Future Cooperation with Japan.’

① Reconfiguration of Nampula-Monapo-Nacala and Nampula-Metoro-Pemba at Namialo and Build New 40MVA, 110/33kV at Namialo

② 50 MW Power Plant at Beluluane

③ CESUL 400 kV HVAC

④ CESUL 500 kV HVDC

⑤ Tete Coal Generation Projects (Phase I -500 MW)

In addition, a request has been made by EDM during the discussion on fieldwork to include the following project in the priority project list:

⑥ Caia - Nampula - Nacala 220 kV Transmission Line

An overview of each priority project is described below (items ① to ⑥ above and below correspond with each other):

① This project is intended to increase power supply reliability and stability in the Nacala corridor area, which is expected to go through overload, by construction of a substation at Namialo and connecting two existing 110kV transmission lines at the substation to operate these lines in parallel. A request for Grant Aid assistance has been made to Japan, and the project proposal that describes the project summary is available. EDM has been preparing for development of a basic plan for completion of the project by 2015.

② EDM has requested assistance in this project from Japan in their project proposal "Beluluane Power Plant 50MW CCGT Power Plant." For this project, the JICA Survey Team has reported the results of data collection and analysis in the Progress Report. The proposed TOR for implementation of a feasibility study was also provided in the report. The contents of the Progress Report on this project are described in Chapter 4 of this Draft Final Report.

③ The project is the AC transmission part of the "Mozambique Regional Transmission Backbone Project" (also known, simply, as the transmission backbone project or CESUL Project), which is to transmit power generated by hydro and thermal power, abundantly available in the Province of Tete, to load centers in the Maputo metropolitan area and Southern African Power Pool (SAPP), where a large amount of electricity is required for consumption. The final version of the feasibility study of the CESUL Project was issued in March 2012, and the project has entered the stage of project preparation.

④ The DC transmission line part of the preceding CESUL Project. Current status is the same as ③ above.

⑤ This project is originally planned for EDM to transmit power generated at the coal-fired power plant developed by the private Brazilian company Vale at Moatize in Tete. Construction of the power plant itself is to be implemented by Vale. The project is in the stage of EPC tendering.

⑥ The project is to set up a new 220 kV transmission line between Nacala - Nampula - Caia in order to ensure stable power supply to the Nacala corridor region. The project proposal was issued in March 2011 and the feasibility study will commence in a few months with the support of Norway.

3.2 Positioning of the Priority Project in the Power Generation and Electrification Policies and Adequacy of Selection

3.2.1 Adequacy of Priority Projects

The following describes the results of studying the positioning and adequacy of the priority projects discussed above:

(1) ① Reconfiguration of Nampula–Monapo–Nacala and Nampula–Metoro–Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo: This project is intended to use the marginal transmission capacity of the existing transmission line to provide to the transmission line anticipated to be overloaded in the very near future. This project is characterized by both technological feasibility and high cost-performance. However, there is no change in the current situation where power is transmitted from the power source over a long distance of about 1,000 km where for most of the distance, the power is transmitted by a single-circuit line. Thus, a great improvement in supply reliability cannot be hoped for.

(2) ② 50 MW Power Plant at Beluluane: This project (temporarily called the "New Maputo Thermal Power Plant Project") has a high priority because it is expected to contribute to the improvement of the stringent demand-supply situation in the southern area where there is a drastic growth in power demand. The construction site will be either Beluluane or CTM Maputo. If the CESUL Project is achieved, the demand-supply situation of the southern area will be improved immediately. However, the commencement of commercial operation of the Cahora Bassa North and Mphanda Nkuwa Power Plant scheduled to start operations in 2017 is now expected to take place in 2020 or later. If the commercial operation of New Maputo Thermal Power Plant Project starts in 2015 as expected, there will be five or more years before the CESUL Project is completed. This New Maputo Project is considered to be essential as a supply source during this time.

(3) ③CESUL 400 kV HVAC, ④CESUL 500 kV HVDC: This project is a power transmission project related to large-sized power development. Since the generation cost is lower, this project can be evaluated as a more effective project than other power development projects, even if the long-distance transmission cost is taken into account. Further, when the project has been completed, the tight demand-supply problem will be solved immediately. Further, a contribution to a drastic reduction in carbon dioxide gas will be achieved. However, the project cost in Phase 1 alone will reach a huge total amount of 2,164 million US$.

(4) ⑤Tete Coal Generation Projects (Phase I: 500 MW): This project covers the IPP or PPS power source to be developed by private companies. In this project, Vale Company, as a developer, will construct the power plant and the transmission line at its own expense. The yen credits will not be included in the scope of this project. This is not considered as a priority project.

(5) ⑥Caia–Nampula–Nacala 220 kV Transmission Line: This project is assumed to be an effective project that immediately solves the restriction problems discussed with reference to the above project (1). However, the construction cost amounts to a high 223.7 million US$. Accordingly, this project should be started when the industries in the Nacala corridor area have developed and there is an acute need for improvement of the supply reliability. It is advisable to focus on the implementation of (1) for the time being. When the time comes to implement this project in future, the facility reinforcement performed in (1) can be put into effective use.

3.2.2 Preliminary Evaluation of Priority Projects

Preliminary evaluations are summarized in Table 3.2-1 for the priority projects set forth in the preceding section (Nos. ①~ ⑥ in the table correspond to those in the preceding section).

Table 3.2-1 Preliminary Evaluation of Priority Projects

No.	Status	Budget (MUSD)	EDM' Priority	Effectiveness of Assistance
①	New substation at Namialo and operating 2existing transmission lines in parallel between Nampula 220 and Namialo substations. Request was made by EDM for Grant Aid from Japan. Project proposal issued.	12	Assistance from other donors is possible, but preferably from Japan. Priority is less than ⑥.	The project is expected to greatly contribute to infrastructure building for economic development of the Nacala corridor.
②	The project site was originally planned inside Beluluane Industrial Park, but the CTM-Maputo site has been added as an alternative. The two sites will be compared and narrowed down to one, which will eventually be subject to a feasibility study. Project proposal has been issued by EDM. The draft TOR has been proposed by the JICA survey team.	75	EDM intends early construction of the power plant to meet the increasingly tight power supply and demand in the southern region. Priority of this project is the highest among the projects ①-⑥. EDM anticipates early realization of the project.	None of other donor countries have committed to the financing of this thermal power plant project. Implementation of the project by Japan's yen loan is considered significant.
③ ④	To meet the power demand in the southern region of Mozambique and in the courtiers affiliated with SAPP, power is to be developed in the range of 3,295 MW, which is to be transmitted through AC 400 kV and DC 500 kV long-distance transmission lines over two separate routes. The final feasibility report was issued in March 2012. The Government of Mozambique is to conduct an appraisal of the project by the end of 2012.	2,164	EDM is intent on concluding the financial aspects by mid-2012 to harmonize with the implementation schedule of power generation projects. EDM expects assistance from the Government of Japan.	EDM expects assistance from Japan mostly in the financial aspect of project implementation. Contribution to the project by Japanese companies needs to be reviewed.
⑤	It was confirmed by EDM that this project relates to the power transmission lines for a power plant being developed by Vale on an IPP basis. A project proposal has not been issued.	950	Contents of the transmission project are not specific, and EDM has not taken any concrete action.	Vale intends to construct the transmission lines through its own financing arrangement. There is no rationale for the Government of Japan to assist with the project implementation.
⑥	The project is to construct new 220 kV transmission lines between Caia – Nampula – Nacala for a reliable and stable power supply to the Nacala corridor area. Four substations are constructed in-between. The project proposal has been issued. The feasibility study will start in two months by Norconsult under assistance from Norad. The study is to be completed within 10 months.	224	EDM places this project after the project ② in terms of priory for projects to be assisted by the Government of Japan, even eliminating project ① from the list, if necessary.	This project needs to be reviewed under the framework of strategic assistance for the Nacala corridor, which is given high priority in the area of cooperation by Japan. Urgency of the project, however, is not high.

(Source: JICA Study Team)

Each of the projects meets the following requirements, to varying degrees:

- Importance and effects of the project
- Feasibility of the project
- Policy needs of Japan

On the other hand, the projects that EDM has designated as high priority and have met the requirements of the Government of Japan for rationale for implementation and expected effects are the two projects mentioned below in the order of priority. Necessity and urgency are high for both projects. For other projects, their priority may become higher depending on the development and situation in the future. In this regard, it is necessary to continue collecting information from EDM.

- ② 50 MW Power Plant at Beluluane
- ① Reconfiguration of Nampula-Monapo-Nacala and Nampula-Metoro-Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo

3.2.3 Concrete Actions taken on Priority Projects

Based on the recognition that the New Maputo Thermal Power Plant Project has the highest priority among the priority projects presented by EDM and is in urgent need for implementation, the Study Team has collected relevant information on the project and conducted a reconnaissance of candidate sites, and thereby has drawn up the Progress Report, which includes a Terms of Reference (TOR) for the detailed study for the project.

During the Second Site Survey, the Study Team discussed the project with ME and EDM and thence obtained their agreement on the contents of the TOR for the detailed study. As a result, it was decided that the preparatory works for the detailed study shall proceed based on the following basic understandings:

(1) Project Sites

The Study Team shall initially select an optimum project site from two candidate sites: 1) the site in Beluluane Industrial Park, which was originally set forth in the project proposal prepared by EDM and 2) the site in the existing CTM Maputo based on the comparative study. The site shall be determined through consultation with related parties on both Mozambican and Japanese sides, and then the detailed study for the selected site shall be conducted. As the project site has not been determined yet, the project shall be tentatively called the “New Maputo Thermal Power Plant Project.”

(2) Gas Supply Volume

EDM intends to secure 6.0 MGJ/y of the gas, which is the sum of 2.8 MGJ/y – the amount of the gas originally intended for the project of upgrading the existing GTGs in CTM-Maputo (e.g., conversion of open cycle to combined cycle GTG System) and 3.2 MGJ/y – equivalent to the gas volume required for a gas-fired combined cycle power plant with an installed capacity of 70 MW.

EDM is expecting to implement the first phase 70 MW plant by using 3.2 MGJ/y with assistance from the Government of Japan, then proceeding with an expansion of the plant with the remaining 2.8 MGJ/y, if possible.

(3) Gas Pipeline

EDM requested that the gas pipeline linking the existing PRR-2 and the power plant site should be included in the scope of the detailed study. However, through discussion with ENH, it was found that the gas distribution concession has been awarded to a joint venture between ENH and KOGAS (South Korea) by the Government of Mozambique and construction of the pipeline is scheduled to be completed by November 2013. If this is true, the detailed study of the said pipeline is not required in the scope of the project (70 MW power plant).

3.2.4 Other Priority Projects

Other priority projects envisaged by EDM are presented in Section 2.10, "Outline of Cooperation Projects Implemented by Other Donors." Among these priority projects, EDM expects the Government of Japan to support the projects for which the funding source has not yet been determined.

In Mozambique, although no road map has been prepared by the government for the development plan of the power sector of Mozambique, the Electricity Master Plan (2004) can serve this purpose. Currently, "Technical Assistance to Strengthen EDM's Capacity for Investment and Network Development Planning – Master Plan Update Project" is underway with Norwegian assistance, and is scheduled to be completed by the end of 2012. For this project, a presentation and workshop regarding "System Analysis & Load Forecast" was held in May 2012.

The project comprises the following phases:

- Inception Phase – Nov 2011
- Phase I
    - ✓ System Review - Feb 2012
    - ✓ Load Forecast - May 2012
- Phase II – Oct 2012
    - ✓ Supply Analysis
    - ✓ Transmission Projects
    - ✓ Distribution Projects
    - ✓ Investment Scheduling and Economic Analysis
- Phase III – Dec 2012
    - ✓ Social and Environmental Considerations
    - ✓ Tariff review
    - ✓ Financial Analysis

- ✓ Updated Load Forecast Report (updated with projects)

The project is not only to update the existing Master Plan, but also to identify priority projects coupled with action plans thereof.

Since the revised Master Plan will be an important reference in formulating Japan's assistance policies for the power sector of Mozambique, it is necessary to keep updated information on the Master Plan.

3.3 Basic Information about Priority Projects

In this section, general considerations common among the six priority projects and basic information about each project are described.

3.3.1 General Considerations

(1) Electrification Plan around the Project Site

Each of the six priority projects is intended to enhance the power supply capacity for delivery to remotely located large load centers, and does not aim at contributing to the electrification plan around the project site.

(2) Situation of Electrification

The priority projects are planned to supply power to large load centers, where electrification is expanding at a rate larger than the nation-wide average of 18% (as of the end of 2011). There are still many low-income households living in electrified areas that do not receive an affordable amount of electricity due to the high cost of electricity compared to their income. For this reason, the electrification rate may not increase straightforwardly as expected, even with the implementation of the New Maputo Thermal Power Plant Project that will result in enhancement of power supply capacity for the Maputo metropolitan area. Nevertheless, it can be easily surmised that the power supply capacity increase will become a contributing cause for the electrification rate increase.

(3) Power Usage

The total of electricity consumption of consumers who receive power from the grid of EDM was 2,395 GWh in 2011. Domestic consumption was 1,052 GWh, accounting for 43.9% of the total, the largest consumption category. When commercial consumption of 245 GWh (10.2% of the total) is added, the two categories combined account for 54.1%. Mozal aluminum smelter, the largest industrial facility in Mozambique, receives as much as 950 MW (installed capacity) of electricity from Maputo substation through a dedicated transmission line (132 kV, 3 circuits), independent from the grid of EDM. When a number of industrial facilities are constructed in Beluluane Industrial Park or in Nacala Industrial Park, it is likely that industrial electricity consumption will increase dramatically. Unless such a situation arises, electricity consumption for domestic use will continuously account for the major part of electricity usage for the years to come.

(4) Assistance from Donor Countries

Out of the priority projects requested by EDM, assistance for the following two high-priority projects has not been considered by other donor countries, according to EDM:

- 50 MW Power Plant at Beluluane
- Reconfiguration of Nampula-Monapo-Nacala and Nampula-Metoro-Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo

Other donors have assisted with some of the other priority projects. Some projects are in the stage of preparation for implementation and one is in the process of a feasibility study.

(5) Security Situation

The Ministry of Foreign Affairs of Japan has issued information on travel risks in Mozambique. As of June 2012, the alert states, "Please pay attention to the risks." The following is an overview of the situation and the potential risks in the Province of Maputo. The same risks apply in other provinces:

"In recent years, Mozambique has achieved a high rate of economic growth, and the political situation has been relatively stable. Against a backdrop of expanding income inequality, such crimes as robberies, sex crimes, burglaries, and car break-ins have frequently occurred, and deteriorating security has become a social problem."

In any part of the country or in any kind of project, careful attention shall be paid at all times to the security and safety information. In this regard, it would be useful to actively collect information on the risks from counterparts of the project or local staff.

3.3.2 New Maputo Thermal Power Plant

(1) Thermal Power Plant

- Mozambique has requested Japan to work out a Beluluane Power Plant construction plan as the top priority item. The background, necessity, adequacy and implementation program of the Beluluane Power Plant construction plan are described in the "Project Proposal—Beluluane Power Plant—50 MW CCGT Power Plant" (November 2011) created by EDM.

  According to EDM, electric power demand in the southern region of Mozambique including the metropolitan area of Maputo has steadily increased 50 MW per year. In order to meet this power demand, especially in Beluluane Industrial Park containing a great number of power consuming industries and its neighboring region, it is necessary to build a new 50 MW-class power plant within Beluluane Industrial Park.

In the Project Proposal, as a measure against overload at the Beluluane substation, EDM is planning to construct a 50 MW natural gas-fired thermal power plant within Beluluane Industrial Park to transmit power to the Beluluane substation. The Study Team shows that it is not common to construct a power plant as measures against overload of transmission line, but common to reinforce the line, and that is economical.

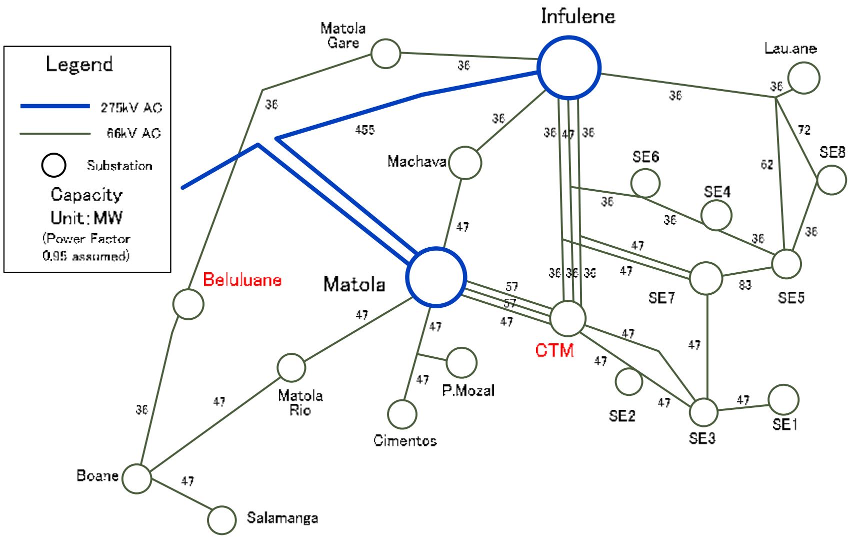
- In the first on-site survey, it was found that whereas the Beluluane area did not provide a satisfactory site for building a new power plant, the existing CTM–Maputo Power Plant met the location requirements to a comparatively satisfactory level. This led to focusing on the possibility of making the CTM-Maputo Power Plant site one of the site candidates, which therefore required collection and confirmation of the information on that site. Thus, both site proposals were studied in parallel, and a preliminary comparative study was conducted.
- In the second on-site survey, the Study Team explained to EDM the results of the approximate comparative studies made on the possible construction of a combined thermal power plant at either Beluluane Industrial Park or CTM Maputo Power Plant. Consequently, the Mozambique side including EDM recognized the advantages of building a new power plant at the CTM-Maputo Power Plant site due to the size of the site area and ease of securing coolant and make-up water (freshwater).
- If a preparatory survey is conducted after this survey, a combined cycle power plant will be built at either Beluluane Industrial Park or the CTM-Maputo Power Plant site. For this reason, the Study Team explained to EDM the draft TOR of a survey where it is assumed that a detailed comparative study of these two sites will be conducted and then specific basic design will be performed according to the site selected by the result of the study.

(2) Transmission Network System

Figure 3.3-1 illustrates the southern network system that Beluluane Power Plant and CTM (Maputo) Power Plant will be connected to.

Both sites belong to the low-order 66 kV network where the high-order system consists of the 275 kV Infulune and 275 kV Matola substations. Paying attention to the capacity and distance of the transmission line up to the high-order system, the Beluluane site has a one-circuit transmission line having a transmission capacity of 36 MW and a transmission distance of 28 km up to the Infulene site via the Matola Gare substation. It also has a one-circuit transmission line having a transmission capacity of 36 MW or 47 MW and a transmission distance of 32 km up to the Matola substation via the Boane and Matola Rio substations. On the other hand, the CTM (Maputo) site is located almost at the center of urban district extending in Maputo city and Matola city, and has transmission lines with a total of three circuits having a transmission capacity of 47 MW or 57 MW and a transmission distance of 5 km up to the Matola substation (Figure 3.3-2 left photo). It also has transmission lines with a total of three circuits having a transmission capacity of 36 MW and having a short transmission distance of 8 km up to the Infulene substation. Further, it is connected with a total of two circuits of the transmission line leading to the SE2 substation and SE3 substation, and, from the CTM, is connected with the transmission lines having a total of eight circuits including the above-mentioned ones. In terms of location, this place constitutes a so-called "center of gravity" for the 66 kV system.

Further, as illustrated in Figure 3.3-2 right photo, 66/33 kV transformers for power distribution are installed at the CTM (Maputo) site and are connected with a great number of 33 kV distribution lines. This site plays the role of the supply base for the Maputo city, not only as a power plant, but also as a substation.



(Source: Created with reference to PSS/E network analysis data provided by EDM)

Figure 3.3-1 Southern Network System

66 kV 3 Circuit Transmission Line Leading to Matola

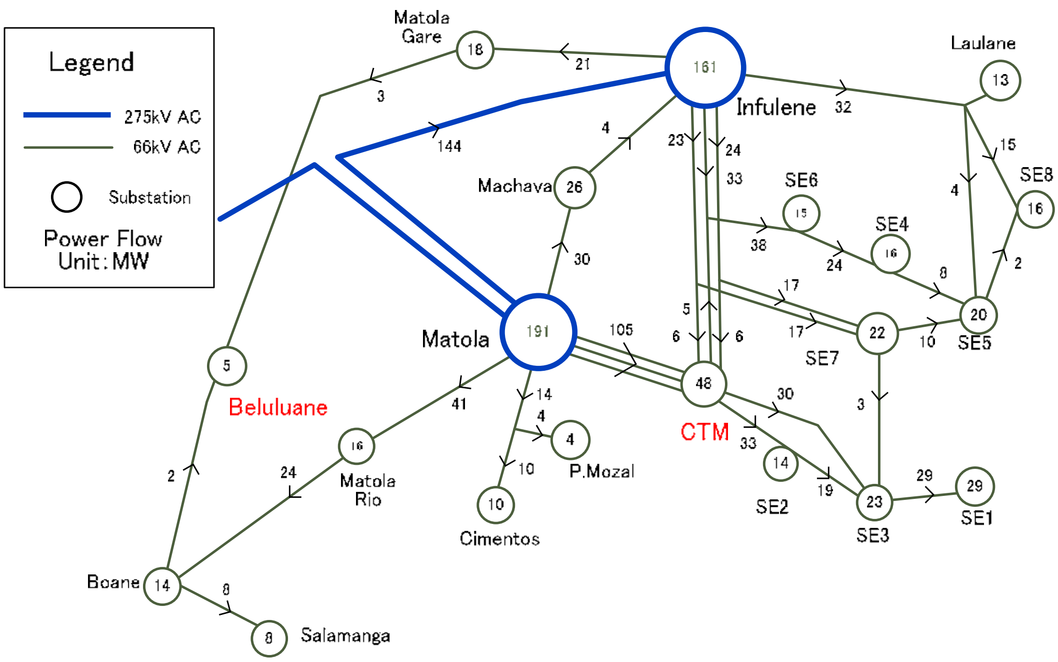
66/33 kV Transformer for Power Distribution and 33 kV Distribution Line

Figure 3.3-2 Transmission Line and Distribution Line at CTM (Maputo) Power Plant

(3) Power Flow

Figure 3.3-3 shows the power flow of the southern network system in 2011. In the Beluluane site, there is a power flow of about 2 to 3 MW through two transmission lines in order to supply power to a load of 5 MW at the Beluluane substation. When a generator is installed, the direction of power flow will be reversed, but both transmission lines have a small transmission capacity of 36 MW, so the generation capacity of the generator that can be installed is limited to about 50 MW.

In the meantime, in the CTM site, there is a greater power flow of a total of 105 MW for three circuits of the transmission lines from the Matola substation. When a generator is installed, this value will be reduced. In the transmission line from the Infulene substation, there is a power flow of 6 MW in the incoming direction for two circuits and a power flow of 5 MW in the outgoing direction for one circuit. When a power generator is installed, the direction of flow is expected to change to the outgoing direction for all three circuits. In any case, the connected transmission lines cover a total of eight circuits, and the load of the substation is as large as 48 MW. In terms of power flow, there is no restriction to the capacity of the generator that can be installed. As described above, this site is located at the center of the urban district, and there are many transmission lines connected. Further, a generator having a relatively large capacity can be installed. When all these advantages are considered, the CTM site can be positioned as an important site for supply of power to the metropolitan area in the future.



(Source: Created with reference to PSS/E network analysis data provided by EDM)

Figure 3.3-3 Southern Network System Power Flow (2011)

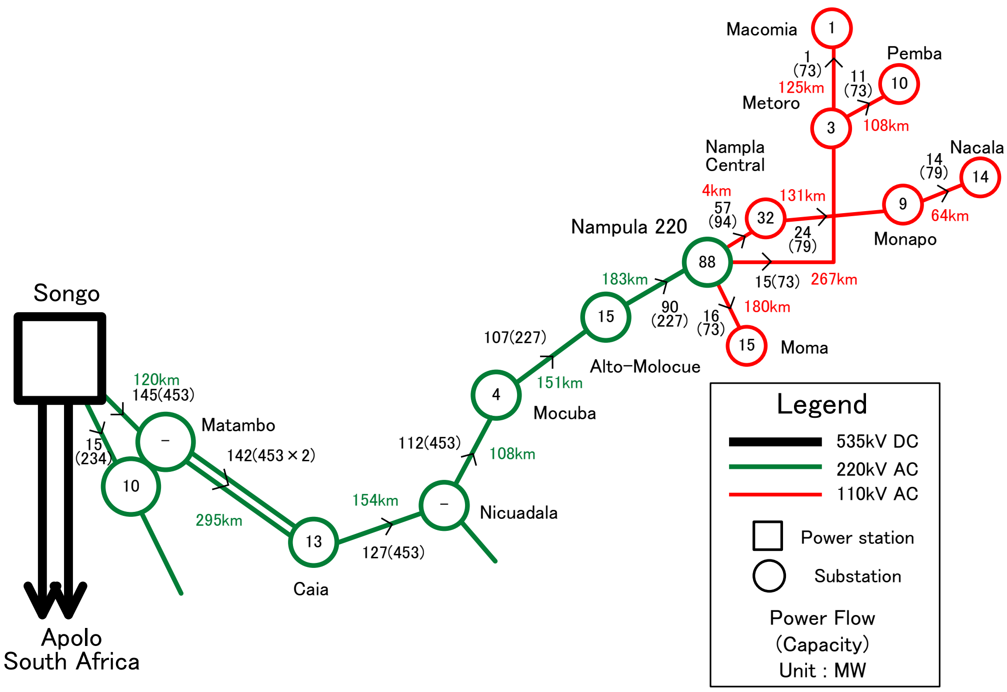
3.3.3 Power Transmission Project for Nacala Corridor Area

(1) Current Situation of the Network in Nacala Corridor Area

Figure 3.3-4 illustrates the network configuration for the Nacala corridor area and the power flow in 2011.

With the Nampula 220 substation as a power supply source, the 110 kV Nacala substation as a base substation of the Nacala corridor area has a 110 kV one-circuit transmission line with a transmission distance of about 200 km via the Nampula Central substation and Monapo substation.

The Nampula 220 substation as a power supply base for the Nacala corridor area has a 220 kV transmission line with a transmission distance of about 1,000 km from the Songo Power Plant as a power source end. Except for the two-circuit Songo–Matambo–Caia line, these lines are one-circuit lines having a transmission distance of approximately 600 km. Thus, power is transmitted by one circuit over a long distance of a total of approximately 800 km combined with the 110 kV Nampula 220–Nacala line having a distance of approximately 200 km. This has resulted in a network system of low supply reliability where power failure occurs frequently due to transmission line fault caused by lightning, contact with trees, etc.



(Source: Analysis result using PSSE network data provided by EDM)

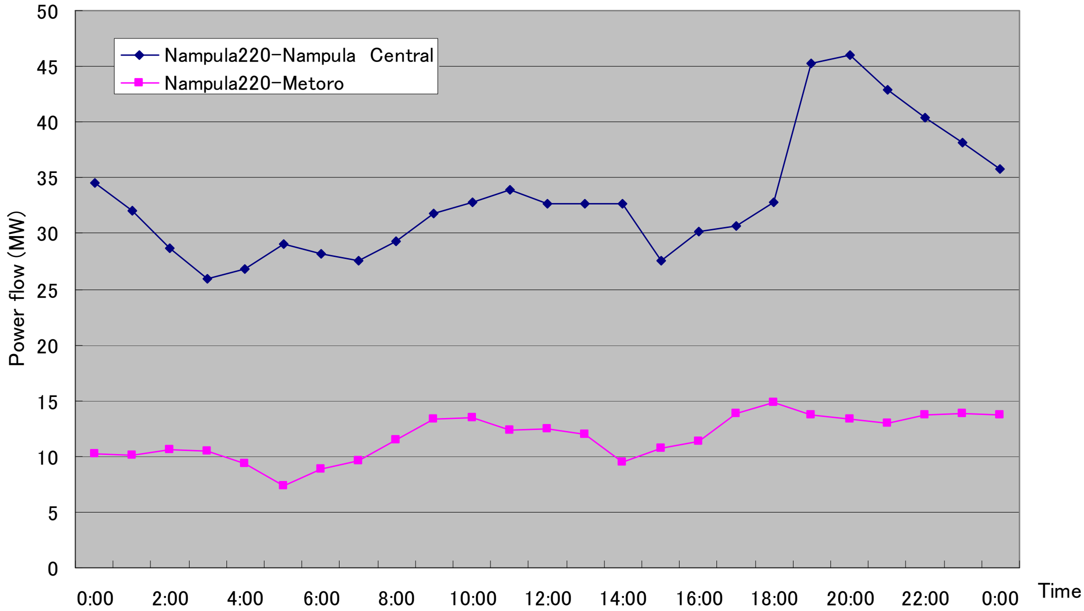
Figure 3.3-4 Network Configuration and Power Flow in Nacala Corridor Area (2011)

(2) Situation of Voltage and Power Flow in the Network System in Nacala Corridor Area

As shown in Figure 3.3-4, the maximum power flow of the 110 kV Nampula 220–Nacala line in 2011 is 57 MW between Nampula 220 and Nampula Central. This shows a small margin with respect to the transmission capacity of 94 MW (power factor 95% assumed).

Figure 3.3-5 is a graphic representation of the hourly change in the power flow in the Nampula 220 – Nampula Central line and the Nampula 220 – Metoro line recorded by the staff official of the substation on the day (May 23, 2012) an on-site survey of the Nampula 220 substation was conducted. It shows that the maximum power flow of this date was 46 MW at 20:00 in the Nampula 220 – Nampula Central line and 14.8 MW at 18:00 in the Nampula 220 – Metoro line, which proves that the peak power demand occurs during times of lightning.

Table 3.3-1 shows the forecasted demand in the Nacala corridor area that was shown in the Master Plan developed in November 2004. The annual growth of demand for intermediate cases is anticipated at 8.3%. In several years, the power flow of the Nampula 220 – Nampula Central line is estimated to exceed the transmission capacity (94 MW with power factor 95% assumed).



(Source: Load Record at Nampula 220 Substation)

Figure 3.3-5 Hourly Change in Power Flow of the Nampula 220 – Nampula Central Line (May 23, 2012)

Table 3.3-1 Forecasted Demand in Nacala Corridor Area

Scenario	Forecasted Demand (MW)				Equivalent Annual Growth Rate to 2020 (%)
	Year 2005	2010	2015	2020	
Low	17.20	23.22	29.53	35.90	5.4
Medium	20.95	33.08	45.88	60.26	8.3
High	22.56	42.81	70.10	103.53	11.5

(Source: Mozambique Electricity Master Plan Report Volume II Nov. 2004)

Figure 3.3-6 illustrates the reading of the 110 kV voltmeter photographed in the control room of the Nacala substation on May 23. The voltage at 17:13 about two hours before the demand peak was as low as 101.5 kV (92% of the operation target of 110 kV). This value is estimated to be further reduced at the peak period around 20:00. This is because the Nacala substation is located 200 km from the Nampula 220 kV substation as a voltage supporting station, and this area is not provided with a generator capable of maintaining the required voltage.

Figure 3.3-6 110 kV System Voltage at Nampula Substation

This study suggests the need to take measures against overloading of the transmission line and measures to improve the voltage.

(3) Proposed Measures

On April 2011, EDM asked for yen credits for the purpose of reinforcing the network system in the Nacala corridor area (title: The Project for Reinforcement of Transmission Network in Nacala Corridor). The following describes the details (see Figure 3.3-7).

In the measures against overload of the 110 kV Nampula 220 – Nampula Central line, a new Namialo substation (transformer capacity 40 MVA) will be built close to the intersection between the Nampula Central – Monapo line and Nampula 220 – Metoro line to connect to both transmission lines.

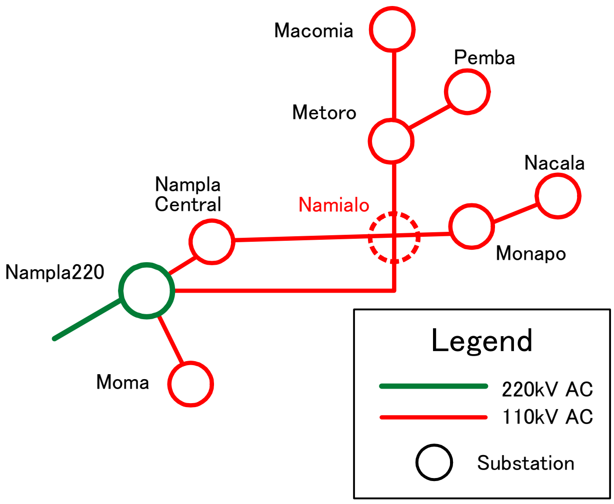


Figure 3.3-7 Reinforcing of the System in the Nacala Corridor Area (proposal)

This project will provide two circuits between the Nampula 220 and Namialo to improve the supply reliability. Further, the power flow will be leveled out by the parallel use of the Nampula 220 – Nampula Central – Namialo line of heavy power flow and Nampula 220 – Namialo line of light power flow, with the result that the overload problem will be solved.

Further, part of the load of the existing Monapo substation (transformer capacity 16 MVA) will be shifted to the new Namialo substation by modification of the distribution line linkage. This will avoid the anticipated future overload of the Monapo substation.

The total construction cost for these measures will amount to 1.3 billion yen, as shown in Table 3.3-2.

Table 3.3-2 Construction Cost for a New Namialo Substation

Description	Quantity	Unit Price (Million JPY)	Amount (Million JPY)
110 kV Line Bay	4 Bays	119.2	476.8
110 kV Transformer Bay	1 Bay	77.64	77.64
110/33 kV 40 MVA Transformer	1 Unit	132.0	132.0
33 kV Switchgear	1 Set	180.0	180.0
Control & Protection System	1 Set	84.0	84.0
Power, control cable & small items	1 Lot	30.0	30.0
Subtotal			980.44
Construction work	1 Lot	100.0	100.0
Transportation fee	1 Lot	100.0	100.0
Engineering service	1 Lot	118.044	118.044
Grand Total			**1,298.484**

(Source: Application Form for Grant Aid from Japan)

3.3.4 Caia－Nampula－Nacala 220 kV Transmission Line Project (additional request)

"Project for Reinforcement of Transmission Network in Nacala Corridor" illustrated in 3.3.3 has an advantage in that the cost is lower, but has the following disadvantages:

- The transmission capacities of the existing transmission lines between the Nampula 220 and Namialo are 73 and 79 MW. Even if the double-circuit system is adopted, there will not be much increase in the transmission capacity.
- Since the transmission line between Namialo and Nacala is not included in the reinforcement project, its one-circuit system with a transmission capacity of 79 MW will remain unchanged. This may cause overload in future.
- Further, the approximately 600 km line between the 220 kV Caia and Nampula 220 upstream of the Nampula 220 substation is based on a one-circuit system and power is transmitted by one circuit over a distance of approximately 700 km including the distance of approximately 100 km between the 110 kV Namialo and Nacala. This will not be very effective in improving the supply reliability for the Nacala corridor area system.

To solve these problems, EDM worked out a drastic measure entitled, "Caia – Nampula 220 kV Transmission Line Project Proposal" on March 2011. An additional request was made for yen credits. The following describes the details:

(1) Forecasted Demand

Table 3.3-3 shows the demand record in the central and northern areas. The average growth rate for the five-year period from 2005 to 2010 registered 18.5%.

Based on this figure, EDM assumes that the subsequent demand growth will be 12% as a lower case, 16% as an intermediate case and 20% as a higher case, reflecting the active industrial and commercial development program including expansion of the Nacala port and diversion of the Nacala army airport for use as a commercial airport. This leads to the estimation that the demand for 2018 will be 320 MW as the lower case, 430 MW as the intermediate case, and 560 MW as the higher case.

Table 3.3-3 Demand Record in the Central and Northern Areas

Year	2005	2006	2007	2008	2009	2010	2005-2010
Peak Demand (MW)	56.0	64.5	72.7	77.8	110.0	131.0	
Growth Rate (%)		15.2	12.7	7.0	41.3	19.1	18.5

(Source: Caia−Nampula 220 kV Transmission Line Project Proposal)

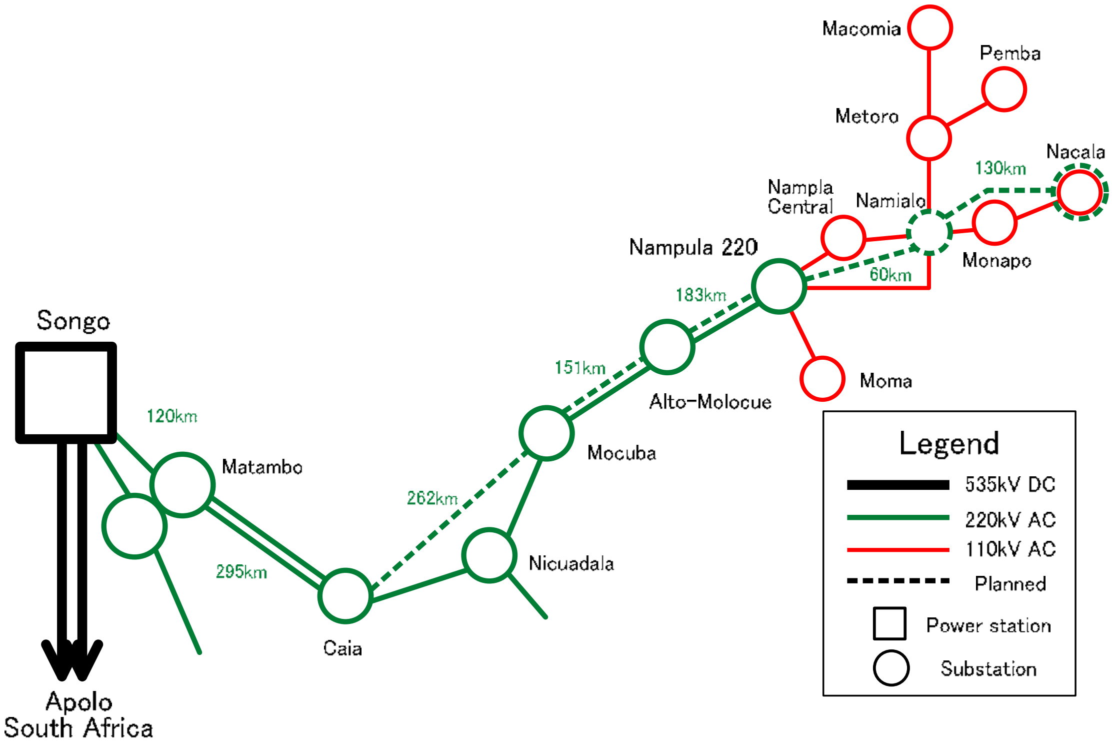
(2) Network Reinforcement Program

Figure 3.3-8 illustrates a central and northern network system reinforcement program. This program intends to build a 220 kV Caia – Nampula 220 line having a distance of approximately 600 km via two existing substations, side by side with the existing 220 kV Caia – Nicuadala – Mocuba – Alto Molocue – Nampula 220 line. Further, a new 220 kV transmission line with a distance of 190 km will be built from Nampula 220 to Nacala. A total distance of approximately 800 km over the entire section between Caia and Nacala will be converted into a 220 kV network.

This will result in installation of the two-circuit 220 kV transmission line from Caia to Nampula 220. At the same time, the section from Nampula 220 to Nacala will also be provided with the two-circuit system of the different-voltage transmission line, parallel to the existing 110 kV transmission line.

This program will also build a 220 kV Namialo substation close to the intersection between the 110 kV Nampula Central – Monapo line and Nampula 220 – Metoro line.

The above-mentioned two-circuit system of the transmission line and installation of a new substation provide a network configuration in such a way that, even if a fault occurs at one unit of the facilities, the remaining facilities will provide back up. This will ensure improved power supply quality due to a drastic reduction in power failures and improvement in voltage.



(Source: Created by JICA Study Team based on "Caia-Nampula 220 kV Transmission Line Project Proposal")

Figure 3.3-8 Central and Northern Network System Reinforcement Program

(3) Network Reinforcement Cost

The major items of the network reinforcement include installation of a new 800 km-long 220 kV transmission line, connection of transmission lines at four existing 220 kV substations, conversion of the 110 kV Nacala substation to a 220 kV substation, and installation of a new 220 kV Namialo substation. The construction cost is estimated at 223.7 million US$. Table 3.3-4 illustrates the details of the network reinforcement cost.

Table 3.3-4 Network Reinforcement Cost

Facility	Name	Description	Quantity	Amount (Million US$)
220 kV Transmission Line	Caia–Nampula 220		596 km	125.756
	Nampula 220–Nacala		190 km	40.09
	Sub total			165.846
220 kV Substation	Caia		1 set	2.856
	Mocuba	Bay extension	1 set	2.856
	Alto Molocue	Bay extension	1 set	2.856
	Nampula 220	Bay extension	1 set	2.856
	Namialo	220/110 kV 150 MVA Transformer	1 unit	2.720
		Bay extension	1 set	8.951
	Nacala	220/110 kV 150 MVA Transformer	2 units	5.440
		Bay extension	1 set	8.951
	Sub total			37.486
Total				203.331
Consultancy Service				10.167
Contingency				10.167
Grand Total				**223.664**

(Source: Caia – Nampula 220 kV Transmission Line Project Proposal)

Some representatives of EDM think that the entire 800 km-long Caia – Nacala line should be designed as a 400 kV transmission line (operated at 220 kV for the time being). The reinforcement cost of approximately 400 million US$ is estimated for this plan. In this case, the total transmission capacity of the existing upstream Songo – Matambo – Caia transmission line for two circuits is 688 to 906 MW (power factor 0.95 assumed). The transmission capacity will be reversed with that of the downstream 400 kV design area. To solve this problem, it will be necessary to install a new 400 kV transmission line in the upstream area when the operation voltage of the transmission line is upgraded to 400 kV.

3.3.5 Moatize Power Transmission Project

(1) Moatize Coal-fired Power Plant

Vale is planning construction of a 300 MW coal-fired power plant (IPP) for the first phase in order to supply power to the coal mine inside the Moatize coal mine and the Nacala port planned by Vale in the Nacala corridor area. Depending on the conditions (when there is an increase in the demand power supply), Vale is planning construction of another 300 MW plant for the second term.

The following gives an overview of the Moatize coal-fired power plant.

- Overall power generation: 300 MW
- Net power generation: 270 MW (30 MW for station power)
- Supply destination: Moatize-related facilities: 220 MW and EDM: 50 MW

- They plan to transmit the generated power to the Matambo substation through a 220 kV transmission line having a transmission distance of 50 km. The transmission line will be constructed through its own capital and will be owned by Vale.

The following describes the current situation of the Moatize coal-fired power plant.

- EPC bidding: Summer of 2012 (will be joined by Chinese and Korean companies)
- Financial and legal closing date: October 2012
- Construction to start in January 2013
- Construction to be completed in January 2016

(2) Transmission Method

As illustrated in Figure 3.3-9, installing a new 220 kV transmission line (also planned as a 400 kV line) with an approximately length of 50 km is planned for the Moatize Power Plant to connect it to the existing Matambo substation.

The following describes the basic concept in Japan regarding the connection cost to be borne for the construction of a transmission line to connect a power source developed by commercial business companies and an existing network. Although the cost to be borne may differ according to the classification of the power developer, it would be adequate to consider that this cost is not included in the scope covered by yen credits.

- Power Producer and Supplier (PPS: Power producer selling the power by using the transmission line of power companies): All borne by PPS.

- Independent power producer (IPP: Power producer selling the power to power companies) All borne by the power companies, provided, however, that, if there is more than one bidder, a bidder offering a lower total cost including the power generation cost and transmission cost will be selected.

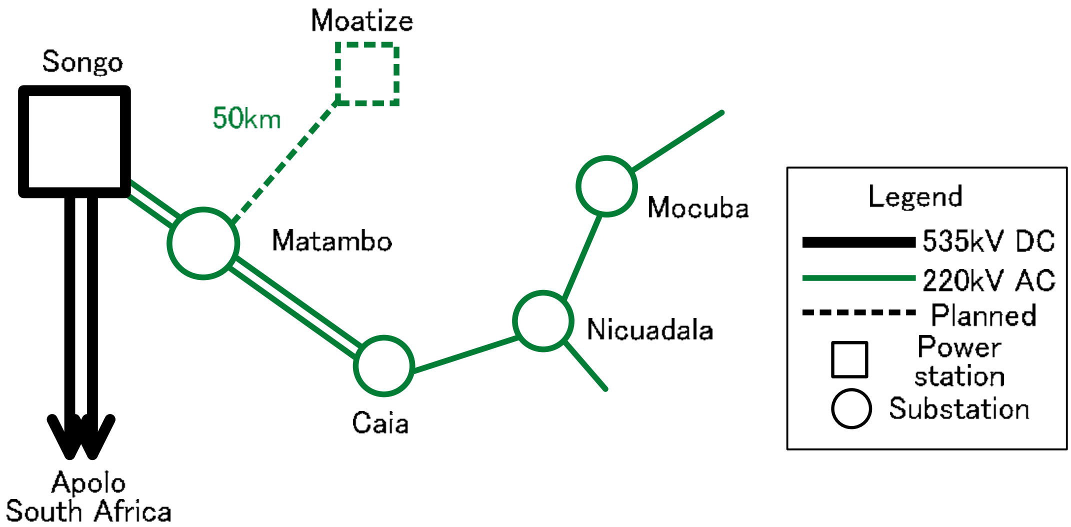


Figure 3.3-9 Moatize Power Plant Transmission Method

3.3.6 CESUL Transmission Project

The central area includes a wealth of untapped energy such as hydraulic energy of the Zambezi River and coal energy of open pit coal mines. In an effort to make effective use of these energies, large-sized power development programs have been worked out for the Cahora Bassa North and Mphanda Nkuwa hydro power plants, and Moatize and Benga coal fired power plants.

When supplying the power generated by these developed power plants to meet the demand in the southern area centering on Maputo, it is necessary to transmit power over a long distance of approximately 1,300 km. This project was named the "Mozambique Regional Transmission Backbone Project," and the Feasibility Study of this project was consigned by EDM to a joint business corporate body consisting of Swedish Vattenfall Power Consult AB Company and Norwegian Norconsult AS Company. The final report was submitted in March 2012. This project is also called the "CESUL Project." The following gives the overview:

(1) Existing Power Plants and Transmission Network Systems

1) Power plants

The Cahora Bassa Hydroelectric Power Plant (with rated power generation of 2,075 MW [415 MW by 5 units]) built by constructing a 164 m-long dam in the Zambezi River commenced its commercial operation in 1977. A largest-ever power generation of 13,064 GWh was recorded in 2005. This figure is equivalent to 72% of the capacity. The possible power generation capacity calculated from the flow rate is estimated at 18,177 GWh, where 28% or more is unused hydraulic energy.

Figure 3.3-10 Cahora Bassa Hydroelectric Power Plant

2) Transmission network system

Power generated by the Cahora Bassa Hydroelectric Power Plant is transmitted to both the home country and neighboring countries through the transmission lines based on the following three network systems. A 1400 km-long distance transmission line is used to transmit the greater part of the generated power to South Africa. For this purpose, a direct-current transmission method was adopted about 35 years ago, because DC transmission has an advantage in maintaining system stability. This is counted as one of the world's earliest examples of using DC transmission.

- For South Africa Apollo substation
  ±535 kV DC, approximately 1400 km, transmission capacity: 1,920 MW
- For Zimbabwe Bindura substation: 400 kV AC 252 km, transmission capacity: 989 MW (power factor 95% assumed)
- For Mozambique Matambo substation: 220 kV AC, 120 km, two-circuit, transmission capacity: 453 MW for one circuit and 234 MW for the other circuit (power factor 95% assumed)

Figure 3.3-11 ±535 kV DC Transmission Line for South Africa (front side), and 220 kV AC Transmission Line for Matambo Substation (furthest side)

(2) Power Development Project

The following describes the power sources to be developed in the CESUL Project. The final total capacity of all the development candidate power sources reaches 7,145 MW.

- Cahora Bassa North: Unused flow of the existing dam can be used by additional installation of power generators.
  Generation capacity: 1,245 MW (415 MW by each of three units), commercial operation will commence in 2017 (2020 or later in real terms).

- Mphanda Nkuwa: Generation capacity: 1,500 MW (375 MW by each of 4 units), commercial operation will commence in 2017 (2020 or later in real terms).
- Moatize coal fired: Developed at the open-pit coal mine by Vale Inc., 300 MW (Phase I); commercial operation will commence in 2014 (2016 or later in real terms); final generation capacity: 2,400 MW; connected to the existing Matambo substation with a 46.5-km-long 220-kV (also planned as 400 kV) transmission line with two circuits.
- Benga coal fired: Developed by Rio Tinto Inc., 250 or 300 MW (Phase I); commercial operation will commence in 2014; final generation capacity: 2,000 MW; connected to the existing Matambo substation with a 28.5-km-long 220-kV (also planned as a 400 kV), transmission line with two circuits.

(3) Power Transmission Project

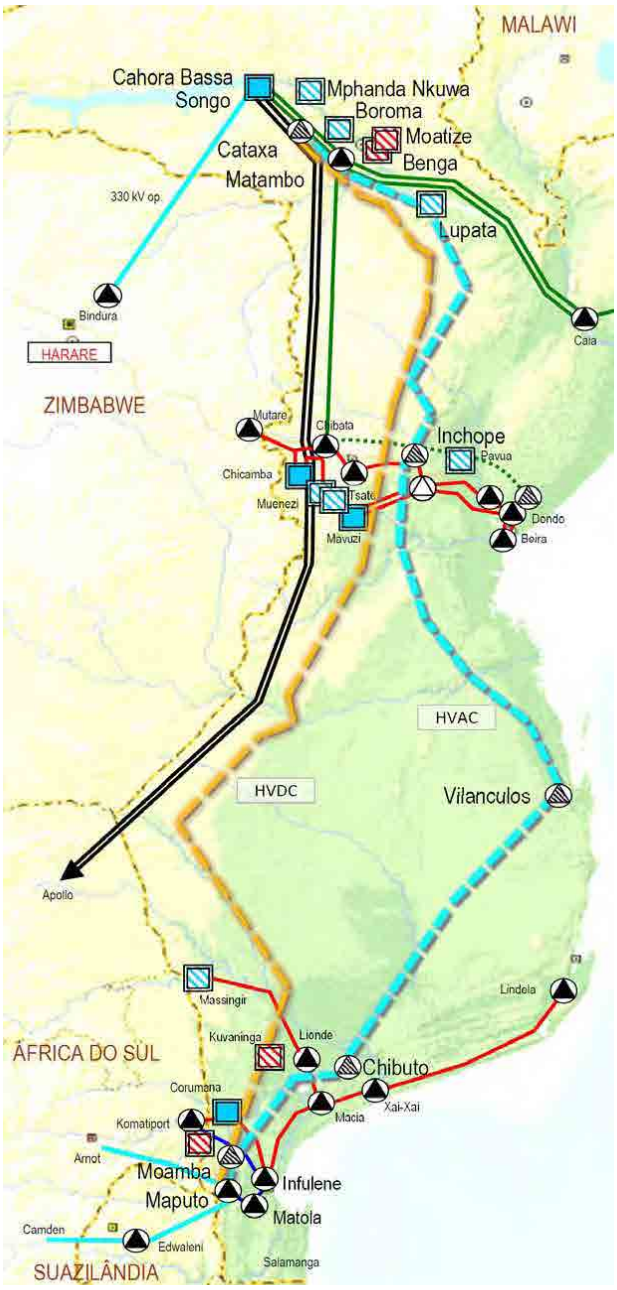
To ensure that the hydraulic and thermal power sources to be developed amounting to 3,295 MW including:

- 1,245 MW for Cahora Bassa North Plant (developed to cover the full quantity),
- 1,500 MW for Mphanda Nkuwa Plant (developed to cover the full quantity),
- 300 MW for Moatize coal-fired (Phase I), and
- 250 MW of Benga coal-fired (Phase I),

can be transmitted over a long distance of approximately 1,300 km to meet the demand in the south centering on Maputo, the greatest problem is how to maintain system stability. To solve this problem, use of the AC/DV hybrid transmission network system shown in Figure 3.3-12 has been recommended.

1) Transmission of 400 kV AC between Cataxa and Maputo by one circuit system over a distance of 1,340 km

- Four new 400 kV substations (Inchope, Vilanculos, Chibuto, Moamba) will be installed along the route to meet the local demand. At the same time, a new switching station will also be installed.
- Since power is transmitted over a long distance of 1,340 km, there will be an increase in transmission line impedance and restrictions will be imposed by system stability, with the result that transmission capacity cannot be ensured. Thus, impendence is compensated for by connecting a series capacitor capable of reducing the impedance. The transmission capacity shared by AC is 900 MW. To implement this value, a compensation factor of 50% (half the transmission line impedance) will be used.
- Even if four substations are installed along the way, the interval between substations will be as long as 352 km between Inchope and Vilanculos. Further, since the series capacitor compensation method is adopted, a rise in voltage in the middle portion of the transmission line cannot be avoided, even if the proper voltage is maintained at substations on both ends. Thus, the design voltage of the transmission line should be set at a higher value of 550 kV.



(Source: "Mozambique Regional Transmission Backbone Project" Final FS Report)

Figure 3.3-12 CESUL Power Transmission Project

- The network system for the central and northern areas and the network system for the southern area, which are currently unconnected, will be connected by this AC transmission line. This will allow the entire Mozambican network system to be configured into an integrated network system for operation.

2) Transmission of ±500 kV DC between Cataxa and Maputo over a distance of 1,275 km

From the very nature of the direct-current transmission, power is transmitted over a distance of 1,275 km directly to Maputo as a destination, without allowing access to the substation on the way.

The final transmission capacity shared by DC will be 5,300 MW. Accordingly, the ±500 kV bipolar direct-current transmission network system will be adopted.

The transmission line shall be a facility that satisfies the final transmission capacity in Phase I. In the meantime, it is easy to install additional AC-DC converters. So, to improve economic efficiency, additional AC-DC converters will be installed in conformance to the power development phase. A 1,325 MW facility will be installed in Stage 1 of Phase I, and a 1,325 MW facility will be added in Stage 2 of Phase I (a total capacity of 2,650 MW).

In Phase II, where all candidate power sources with a generation capacity of 7,145 MW (Cahora Bassa North 1,245 MW、Mphanda Nkuwa 1,500 MW、Moatize coal-fired 400 MW, Benga coal-fired 2,000 MW) to be developed commence commercial operation, additional AC-DC converters will be installed until a total generation capacity of 5,300 MW is reached.

(4) Project Cost

Table 3.3-5 illustrates the project cost. The project cost is 1,846.2 million US$ in Stage 1 of Phase I where the total AC and DC transmission capacity is 2,225 MW (AC 900 MW and DC 1,325 MW). The additional cost is 317.4 million US$ in Stage 2 of Phase I where the total AC and DC transmission capacity is 3,550 MW (AC 900 MW and DC 2,650 MW).

The project cost will reach a total of 2,163.6 million US$ in Stage 2 of Phase I where the capacity of the power sources to be developed reaches a total of 3,295 MW consisting of 1,245 MW of the Cahora Bassa North plant, 1,500 MW of the Mphanda Nkuwa plant, 300 MW of the Moatize plant and 250 MW of the Benga 2 plant.

Table 3.3-5 Project Cost

Components	Cost (Thousand US$)
HVAC Transmission Line	419,313
HVAC Substations	384,761
Total HVAC	804,074
Control Centre Cost	30,000
Total Compensation Cost HVAC	7,997
Engineering and Owner's Cost	58,384
Physical Contingencies (10%)	83,407
(1) Total HVAC Phase 1	**983,863**
HVDC Stage 1 of Phase I (1,325 MW)	
HVDC Line	379,232
Cataxa Converter Station	171,110
Maputo Converter Station	154,800
Total HVDC excl. Compensation Costs	705,142
Mitigation of Corrosion	30,000
Total Compensation Cost HVDC	7,294
Engineering and Owner's Cost	49,360
Physical Contingencies (10%)	70,514
(2) Total HVDC Stage 1 of Phase 1	**862,310**
(3) Total Stage 1 of Phase I = (1)+(2)	**1,846,173**
HVDC Stage 2 of Phase I (1,325 MW)	
Cataxa Converter Station	135,660
Maputo Converter Station	135,660
Total Stage 2 of Phase I	**271,320**
Engineering and Owner's Cost	18,992
Physical Contingencies (10%)	27,132
(4) Total HVDC Stage 2 of Phase I (1,325 MW)	**317,444**
Total Phase I (400 kV + HVDC 2,650 MW) = (1)+(2)+(4)	**2,163,617**

(Source: "Mozambique Regional Transmission Backbone Project" Final FS Report)

3.4 Environmental and Social Issues on the Priority Projects

3.4.1 Overview of the Surrounding Area of the Project Sites

Priority projects are located over a large area from the southern to northern part of the country. An overview of the surrounding area of each project site is shown in the table below.

Table 3.4-1 Overview of the Natural and Social Environment Around the Priority Projects Sites

Project	General Observations on the Natural Environemnt	General Observations on the Social Environment
New Maputo Gas-Fired Power Plant Project • Site : Beluluane Industrial Park/a Matola city or existing CTM-Maputo Power Station/Maputo city	• Possibilty of flora and fauna that require special protection is very low. • The site is cleared and leveled, therefore, loss of natural environment is expected to be very low.	• Well developed. Surrounding consisted of commercial and residential areas. • Adjacent and within commuting distance to the capital Maputo. • Main means of livelihoods the residents are employment at industries in and around the industral zone and the surrounding commercial area, and small scale agriculture in the adjacent area.
Reconfiguration of Nampula–Monapo–Nacala and Nampula–Metoro–Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo • Outskirts of Nampula/Namialo	• Possibilty of flora and fauna that require special protection is very low. • Substation and transmission lines are planned in the shrub zone.	• Although the planned site of the substation is far from the center of city, there is a possibility that settlement and agricultural land exist near by. • Main means of livelihoods the residents are employment in Nampula and agriculture in the surrounding area.
Tete Coal Generation Projects (Phase I: 500 MW) • Outskirts of Moatize	• Possibilty of flora and fauna that require special protection is very low. • The site is located in the coal mining area and along the Zambezi river. Possibility of impact on the natural environment by the project is expected to be very low in the coal mining area; however, special care shall be taken for the river crossing.	• Although the planned site of the substation is far from the center of city, there is a possibility that settlement and agricultural land exist near by. • Main means of livelihoods the residents are employment in Tete (commercial, industry), mining in coal industry, e.g., Vale, and agriculture in the surrounding area.
CESUL 400 kV HVAC, CESUL 500 kV HVDC • Cataxa to Maputo (via Inchope,Vilanculos, Chibuto, Moamba, etc.)	• Part of the transmission route passes through and/or near forests, rivers, reserve areas, and therefore requires adequate attention.	• Distances of the planned route for AC and DC transmission lines are more than 1,200 km each and consist of various areas. Generally, excluding the urban area, agriculture and fishing (river) are the main means of livelihood the residents.
Caia–Nampula–Nacala 220 kV Transmission Line • Caia to Nacala (via Mocuba, Alto Molocue, Nampula)	• Part of the transmission route passes through and/or near forests, rivers, and therefore requires adequate attention.	• Distance of the planned route of transmission lines is around 800 km and consists of various areas. Generally, excluding the urban area, agriculture and fishing (river) are the main means of livelihood the residents.

(Source: JICA Study Team)

(1) Overview of the Surrounding Area of the “New Maputo Thermal Power Plant” Site

Beluluane Industrial Park is located about 10 km inland from the coastline at an elevation of about 30 meters above sea level. CTM Maputo is located on reclaimed land facing the Bay of Maputo. The two sites are only about 13 km apart. The rainy season is from about November to March and the average rainfall during the season is about 100 mm to 400 mm. However, there are great irregularities from year to year with respect to the beginning and duration of the season, and the precipitation. Rainfall of about few millimeters to about 80 mm of rainfall is recorded during the dry season. The average temperature of the rainy season is in the range of 20 ~ 25 degrees C. Generally, the soil in this area is sandy/sandy loam and/or brown forest soil/Cambisol.

Small-scale agriculture has been widely performed and the main crops are cassava, maize, groundnut, and cowpea. Potatoes are produced in lowlands and along the river where there is moister retention. In addition, pasturing of cattle and goats is carried out.

Mozal, an aluminum smelter company, and other companies that provide services to Mozal are located at the candidate site, Beluluane Industrial Park. The Industrial Park is providing employment opportunities; however, there are opinions that the amount of local employment is still small. CTM Maputo is located in the urban district extending in Maputo city and Matola city. Many residents are engaged in commercial industries around the area or commute to the center of the city Maputo.

(2) Overview of the Surrounding Area of "Reconfiguration of Nampula-Monapo-Nacala and Nampula-Metoro-Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo" Site

The site is located at Nampula, the capital city of Nampula province (population 4.5 million, 2011), and Namialo. The elevation of existing Nampula 220 substation is approximately 390 m above sea level and the planned substation at Namialo is approximately 190 m (the distance between the two substations will be approximately 86 km). The elevation rises towards the west and it reaches around 700 m at the highest point in Nampula province.

The annual rainfall of the region ranges between 1000 and 1400 mm. The average temperature during the rainy season is between 20-25 degrees C (moderately warm). The texture of the soils varies from sandy to clay, consistent with the topography and some topsoil of brown forest soil/Cambisol.

Main crops in the area are maize/sorghum, cassava, cowpea and groundnut. The eastern part of the province, especially from Namialo, is famous for the production of cashew nuts. In addition, there is a high potential for the production of cotton. Nampula province is an agricultural area with huge potential to be developed in the near future.

Nampula city is the third largest city in Mozambique in respect to population (largest is Maputo, followed by Beira) and an important city linking the others in the northern area (provinces of Nampula, Cabo Delgado, Niassa, Tete and Zanbezia). Large industries, e.g., the Coca-Cola factory, are located in the city. Nampula is the largest relay point of the railway between Nacala and the border of Malawi. A two-lane road is paved between Nacala port and the center of Nampula city. Nampula also plays a role as a hub of domestic air flights. A number of daily flights are operating between the other major cities e.g., Maputo, Lichinga, Tete and Beira.

At Monapo, about 35 km east of Namialo, there is a cashew nut and a cotton factory.

(3) Overview of the Surrounding Area of "Tete Coal Generation Projects (Phase I: 500 MW)" Site

This area is one of the driest areas in the country. The site is located in Moatize, which is about 220 m above sea level. In the northern area of Tete province, the elevation rises up to more than 1,000 m. Annual rainfall is about 500 to 800 mm and most of the precipitation is concentrated in the rainy season from November to March. Zambezi River, the largest river in the country, flows through the area. Upstream, the Cahora Bassa Hydroelectric Power Plant generates a huge amount of power utilizing the abundant water of Zambezi River.

The main agricultural product of this region is sorghum. Cassava, which is widely grown in other regions, cannot be cultivated due to the dry climate. On the other hand, tobacco, which is suited to the dry climate, is cultivated.

(4) Overview of the Surrounding Area of "CESUL 400 kV HVAC, CESUL 500 kV HVDC" Site

An EIA report has been conducted for the project and the following is an abstract from the report, "Mozambique Regional Transmission Backbone Project Environmental and Social Impact Assessment – Volume II" (EDM May 2011).

The project zone of influence includes a varied cross section of the country, including the Manica plateau, Rift Valley, the valleys of the Zambezi, Pungue, Buzi, Save, Limpopo and Incomati and other rivers of lesser concern, sparsely populated areas and suburban areas, natural vegetation and cultivated areas, protected areas and exploited areas.

Annual precipitation varies from 500 to 1500 mm depending on the region. Cyclones are also common during the wet season.

(Source: Mozambique Regional Transmission Backbone Project)

Figure 3.4-1 Transmission Lines and National Parks, Reserves, and Coutada

Average temperatures in the lowland parts in the southern part of the country are around 25 to 27 degrees C in the summer and 20 to 25 degrees C in winter. The inland

and higher altitude northern regions of Mozambique experience cooler average temperatures of 20 to 25 degrees C in the summer, and 15 to 20 degrees C in winter.

The proposed corridors of transmission lines run close to four national park areas, one national conservation area, and eleven Coutadas (hunting blocks / game reserves). In addition, some IBA (Important Bird Areas) and places of cultural and/or archaeological interest are recognized outside the transmission line route.

1) Gorongosa National Park
2) Zinave National Park
3) Banhine National Park
4) Limpopo National Park
5) Chimanimani National Reserve
6) Coutada 4～7, 9～15 (hunting blocks / game reserves)

(5) Overview of the Surrounding Area of "Caia – Nampula – Nacala 220 kV Transmission Line" Site

This project is located in the area that overlaps with the two projects, "Reconfiguration of Nampula – Monapo – Nacala and Nampula – Metoro – Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo" and "Tete Coal Generation Projects (Phase I: 500 MW)," and the overview of the project area for this project can be referred to these two projects.

3.4.2 Consideration of the Environmental and Social Impacts from the Priority Projects

(1) New Maputo Thermal Power Plant

There are two candidate sites to consider, namely the CTM Maputo site and the Beluluane Industrial Park site.

The Beluluane Industrial Park site is cleared and leveled; therefore, negative impact on the natural and social environment due to the new power plant is expected to be very low. On the other hand, depending on the results of the technical study to be conducted in the future, there is a possibility that a pipeline to supply cooling water and fuel gas might need to be laid in the populated area. If this were the case, it would be necessary to examine the environmental and social impacts caused by the cooling water pipeline of about 18 km and a gas supply pipeline of about 3.5 km.

The CTM Maputo site is within the plot managed by EDM and is also cleared and leveled. Similar to the site in Beluluane Industrial Park, negative impact on the natural and social environment due to the new power plant is expected to be very low. The gas supply point will be near the CTM Maputo site boundary since a different project, which is going to be implemented by ENH and KOGAS, is planning to lay pipelines to supply natural gas to Matola and Maputo, and the supply point to CTM Maputo is considered in that project.

Nevertheless, the discharge of heated effluent and intake of cooling water will be carried out in Maputo Bay, where the coast is covered by mangroves. Therefore, it is necessary to consider the impact on changes in the water temperature and currents due to the project.

Nature Reserves nearest CTM Maputo are the Inhaca and Protuguese Island Reserve (16 square kilometers, set in 1965) and the Maputo Special Reserve (700 square kilometers, set in 1969). Both are located about 40 km from the site.

(2) Reconfiguration of Nampula – Monapo – Nacala and Nampula – Metoro – Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo

The planned site of a new substation is near the intersection of Nampula 220 – Metoro Nampula transmission line and Central – Monapo transmission lines. This area is located far from the population and the possibility of resettlement, relocation of cultivated land due to acquisition of land, and any impact on the residents are expected to be low. However, farmlands and settlements in this area are scattered over a wide range away from the city; therefore, a detailed assessment is necessary to confirm the above.

The possibility of rare flora and fauna, historic sites and cultural heritage in the area is expected to be low; however, a detailed assessment is necessary to confirm the above.

It shall be noted that the scale of new facilities in this project is very limited; therefore, environmental and social impacts, if any, are very small when compared to other priority projects. The Government of Japan is providing diverse assistance intensively in the Nacala Corridor, e.g., roads/bridges, agriculture (ProSavanna), port (Nacala Port Development), and planning (Nacala Corridor Economic Development Strategies). A stable power supply by the project is expected to contribute to the economic development of the surrounding area between Nampula and Nacala.

(3) Tete Coal Generation Projects (Phase I: 500 MW)

The possibility of flora and fauna that require protection is expected to be low at the substation site. However, the construction and operation of transmission lines that will cross the Zambezi River may result in negative impact on the water quality due to pollution, change of current, or erosion. Therefore, adequate assessment and consideration of mitigation measures shall be carried out.

Settlements in the rural area of Mozambique are characterized by their scattered layout over a wide area. (This is also the factor that makes it difficult for the electrification of rural areas.) For this reason, there is a possibility that settlements and agricultural land are in the area around the planned 50 km transmission line so a more detailed assessment shall be carried out.

(4) CESUL 400 kV HVAC, CESUL 500 kV HVDC

The following possibilities of environmental and social impacts and mitigation measures are stated in the ESIA report (Mozambique Regional Transmission Backbone Project Environmental and Social Impact Assessment Vol. II, May 2011) for the project.

Natural Environment

a) Noise produced by the operation of machines and the presence of humans (workers)
   - Good maintenance and careful operation of equipment, localization of temporary residence close to existing agglomerations.

b) Drainage during Construction (woodland terrain, substation area, river/stream, dry terrain, flood areas, wetlands, etc.)
   - Adequate provision of cross drainage structures
   - Best practice control measures during earthworks
   - Slope breakers on slopes greater than 5 percent where the bases of the slope isles than 15 m from water bodies, wetlands and road crossings.
   - Minimize work by water courses during the wet season months
   - Site construction compounds away from sensitive water features to avoid pollution (waste or sediment) or erosion, etc.

c) Site Clearance / Right of Way Clearance
   - Appropriate procedures (licensing) for felling of trees, appropriate removal of material to avoid risks of fire; avoid clearance during the nesting season of key (bird) species
   - Minimise vegetation removal (nonessential trees)

d) Oily waste/fuels/lubricants (hazardous waste)
   - General best practice through SWMP

Social Environment

a) In-migration of work force and opening of new areas
   - Worker code of conduct, transparent recruitment procedures, community liaison officer and activities, local recruitment preference, labour accommodation plan, etc.

b) Land Acquisition
   - Establishment and implementation of Resettlement Action Plan. Implementation of Community Investment Program.

(5) Caia-Nampula-Nacala 220 kV Transmission Line

This project is the construction of transmission lines and substations of 800 km in total length. Essentially, the same consideration should be given in the "CESUL 400 kV HVAC, CESUL 500 kV HVDC" and "(2) Reconfiguration of Nampula-Monapo-Nacala and Nampula-Metoro-Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo." Protected areas do not exist around the region. However, there are a number of rivers, ranging from the large Zambezi River to smaller rivers, which are important for agriculture and livelihoods of the local residents. Nonetheless, the route of the transmission line shall be determined after thoroughly investigating the current situation of the area.

3.5 Effectiveness of the Priority Projects

In this section, the impact and effectiveness of New Maputo Thermal Power Plant, which is deemed an urgent project and given the highest priority by EDM and regarded to be compatible with Japan’s aid policy for Mozambique, is described.

(1) Provision of Peak Load Capacity (Short-Term Effect)

According to EDM, the peak value of the electricity demand has been increasing at a steady growth rate of 50-60 MW/year and is deemed likely to surpass EDM’s supply capacity. More specifically, while Mozambique’s current share of the 2,075 MW power generation in Cahora Bassa South Bank (CBSB) is 300 MW firm and additional 200 MW non-firm power, the maximum power demand has already reached 380 MW. In order to bridge occasional gaps in power balance, EDM purchases electricity from ESKOM on a spot basis. According to EDM, the electricity purchased from ESKOM during the on-peak hours costs 25 ~ 30 USc/kWh, which is three to four times higher than EDM’s average sales price (7.5 USc/kWh). It is likely that this expenditure may put pressure on EDM’s corporate profit sooner or later. Since power shortages are becoming more and more serious in RSA as well, it is highly likely that purchasing electricity from ESKOM will be difficult in the near future. When the CESUL Project is completed, power shortage in the southern region will be eliminated, but completion of the CESUL Project is scheduled to be 2020 at the earliest.

Accordingly, the project is deemed indispensable in the near term to provide peak load capacity prior to completion of the CESUL Project.

(2) Contribution to Energy Security of Mozambique (Mid- to Long-Term Effects)

Although EDM has a number of small-scale hydro and thermal power plants, output of these power plants is generally low due to age-related failure. Thus, EDM procures most electricity from HCB.

The Government of Mozambique owns 85% of HCB. In principle, as the largest owner, Mozambique could cover its increasing power demand by increasing the share from the existing Cahora Bassa at the expense of Eskom’s share, which would be reduced accordingly. However, this is probably not realistic in the near to medium term. The power sold from HCB to Eskom generates the required revenues for serving HCB’s debt, and before this debt is paid off, it would probably be difficult to increase Mozambique’s share of the output.

Furthermore, there is a possibility that the river flow fluctuation will become larger in the future than it is now. This may be a significant risk for Mozambique, which relies heavily on hydroelectric power for its electricity supply. Thus, in the long run, it is preferable to diversify power sources to enhance the energy security of Mozambique. In this regard, the project can be regarded as a significant first step toward energy security of Mozambique.

(3) Effective Utilization of Existing Staff of EDM

Prior to preparation of the project proposal of “50 MW Gas-fired Power Plant at Beluluane,” EDM had a plan to rehabilitate the existing GTGs in CTM-Maputo (e.g., conversion of open cycle to combined cycle GTG system). In order to prepare for this project, EDM has provided its employees with basic capability of the O&M works on the power plant by using the existing GTGs. Thus, if the proper training is provided to the existing O&M staff thorough the implementation of New Maputo Thermal Power Plant Project, the capability of these staff can be significantly improved. It is also possible that the new generation facilities can be operated by existing staff. Moreover, effective utilization of the existing employees results in a productive improvement, thus enhancing the operational efficiency of EDM.

(4) Job Creation

Through the implementation of the project, direct and indirect job creation is expected, including construction workers in the construction phase, employment of additional staff members at the new power plant, job creation regarding the regular maintenance of the new power plant, operation of the new pipeline, environmental monitoring of the power plant and pipeline, etc. This job creation can contribute to the expansion of the economic scale of Mozambique and poverty reduction that the Government of Mozambique considers a top priority issue to be solved.

(5) CO_2 Emission Reduction

In order to bridge the gap in power balance up to completion of CESUL Project slated for 2020, EDM, in the near term, 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 70 MW is replaced by a CCGT plant with the same output, the potential CO_2 emission reductions can be preliminarily calculated as follows:

Potential CO_2 emission reduction

① Gas consumption of CCGT power plant (assuming thermal efficiency of 50%): 3,418,485 GJ/year (refer to Section 4.8)

② Gas consumption of gas-engine power plant (assuming thermal efficiency of 44%[4]): 3,884,642 GJ/year

③ CO_2 emission factor for natural gas: 0.051 tCO_2/GJ

④ CO_2 emission reduction: 23,774 tCO_2 (=(②-①)*③)

Since Mozambique with a significant proportion of hydro-generation capacity (95%) has an extremely low Grid Emission Factor (GEF)[5], grid-connected CDM projects are not feasible. Currently, the cross-border CDM methodology is not accepted all over the world, but SAPP Member Countries are now committed to developing bilateral and multilateral cross-border CDM projects (i.e. involving one or more neighboring countries)[6]. If this methodology is accepted, CCGT operations in Mozambique can offset coal-based electricity from South Africa that, in the absence of the CCGT operations, would supply the Mozambican grid with power. In the latter case, the CO_2 emission difference between the ESKOM grid and the CCGT operations would be eligible for the generation of CERs.

It is anticipated that by the time the new plant starts operation, a (revised) methodology will be available to enable EDM to make use of it. Thus, it is necessary to keep watching this situation continuously.

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

5 Ref: "The CDM Project Potential in Sub-Saharan Africa with Focus on Selected Least Developed Countries, Wuppertal and Hamburg, January 2011." The GEF of Mozambique is estimated at 5.3 tCO_2/GWh (Operational Margin). It is extremely lower than that of neighboring countries: South Africa (1,020 tCO_2/GWh) and Zimbabwe (619 tCO_2/GWh).

6 Ref: Enabling the Inclusion of Cross-Border Emissions for CDM Projects on the Southern African Power Pool, Camco & Standard Bank, December 2011.

3.6 Study of Maintenance Management Sustainability

3.6.1 Current Situation of EDM Employees

Table 3.6-1 lists the number of EDM employees by skill level:

Table 3.6-1 Breakdown of EDM Employees by Skill Level

Força de Trabalho/Active Workforce	2005	2006	2007	2008	2009	2010	2011
Tarefeiros /Seasonal	225	229	203	205	259	151	184
Indiferenciados/Unskilled	178	144	125	116	105	89	85
Semi-Qualificados/Semi-Skilled	867	873	813	819	942	915	869
Qualificados/Skilled	992	971	915	901	987	983	934
Altamente Qualificados/Highly Skilled	611	703	820	888	1005	1041	989
Técnicos Superiores/High Level Technicians	188	207	237	241	274	260	276
Estagiários/Trainees	133	106	210	362	163	72	66
Total	**3,194**	**3,233**	**3,323**	**3,532**	**3,735**	**3,511**	**3,402**

(Source: EDM)

In the above table, the number of employees whose rank is equal to or higher than "skilled" was 2,265 in 2011. This figure accounts for approximately 67% of the total number of EDM employees. There is no detailed information on the breakdown of the "skilled or higher-rank" employees for the respective categories of thermal power generation, hydro power generation, power transmission/distribution, or substation.

3.6.2 Future Measures

At present, there are very few thermal power plants owned by EDM. It is therefore likely that the number of employees engaged in related work is small. There are no thermal power plants (gas turbine power plants) operating in regular service. Most of the thermal power plants are diesel power plants.

Thus, it will be important to increase the amount of manpower for thermal power generation. For the construction and operation of a combined cycle power plant in the future, it is necessary to establish the following technological divisions and secure the related personnel:

- Design management division
- Procurement division
- Construction management division
- Operation division
- Maintenance division (including repair)
- Environmental management division

Further, the maintenance management of a thermal power plant can be classified into two categories in terms of technology -- operation and maintenance. Since the combined cycle power generation facilities are almost fully automatic in the range from plant startup to rated load and from rated load to stoppage of the facilities, the workers are required to not only learn the basic operation procedures, but to be trained to deal with an accident or emergency. For the training on operations, it should be based mainly on on-the-job training for test operation. Using an operator training simulator as a supplementary means should also be studied. This simulator is assumed to be included in the scope of major equipment procurement.

For maintenance, daily visual inspection of facilities and equipment is very important. Further, training on periodic inspections and daily simple repairs should be performed at a training center or the like.

EDM attaches a great importance to the education and training of the operation and maintenance personnel. The Project Proposal provides an item on education and training to include it in the scope of the items requested to Japan for support. Therefore, in the preparatory investigation for cooperation in this matter, a detailed study of education and training must be examined. In this case, studies could include providing a training course at some of the Japanese thermal power plants or training centers as part of a training program to be implemented in Japan.

3.7 Key Considerations for Implementation of the Project

(1) General

On the assumption that the priority projects are financed by yen loans, they should be implemented in accordance with general guidelines and considerations stipulated in the "The Operational Guidance for the Preparation of the Projects Financed by Japan's ODA Loans (the ODA Loan Operational Guidance)." More specifically, key considerations for the implementation of the project should be identified and thereby any approach for solutions and/or mitigation of them should be presented by conducting a feasibility study under the framework of the preparatory survey for the project.

(2) Consistency with the Electricity Master Plan

The update of 2004 Master Plan: the project entitled “Technical Assistance to Strengthen EDM’s Capacity for Investment and Network Development Planning – Master Plan Update Project” is now underway with Norwegian assistance, and is scheduled to be completed by the end of 2012. This project provided a presentation and workshop regarding “System Analysis & Load Forecast” in May 2012. The Master Plan update is to identify the development goals for the power sector. The result of the Master Plan update should be an important reference in formulating Japan’s assistance policies for the power sector of Mozambique and in formulating and implementing power projects in Mozambique. Accordingly, formulating and implementing individual projects consistent with the above-mentioned Master Plan should be ensured.

(3) Coordination with Other Aid Agencies

In the power sector of Mozambique, a number of projects in the form of technical cooperation, grant aid and loan assistance have been implemented by both international aid agencies and foreign donors. There are also a number of projects now underway or under contemplation, which are supported by World Bank (WB) and foreign donors such as the Government of Norway, Sweden, Germany, France, etc. Although some projects are solely implemented by a certain county based on its assistance policy, more projects are implemented through the cooperation of several aid agencies from multiple countries. They work closely, share information through e-mail and hold meetings to discuss cooperative framework for effective assistance and solutions to the problems, if any. In formulating and implementing an individual project, it is necessary to coordinate with these donor agencies and try to get relevant information, in order to create a cooperation mechanism that ensures aid effectiveness of the individual projects.

(4) New Maputo Thermal Power Plant Project

New Maputo Thermal Power Plant Project is deemed as the project with the highest priority among the selected priority projects. Prior to formulation and implementation of this project, a detailed study is required, and it is proposed that this study should be implemented as a Preparatory Survey for Japan’s Official Development Loan Assistance. Details of the Preparatory Survey are described in Section 4.9 (Recommendation for Implementation of Detailed Survey).

(5) Cooperation with EDM

Since EDM’s power generation capacity is very small, it purchases most of its electricity from HCB and sells it to customers through its own transmission and distribution networks. As a result of this business configuration, EDM has a number of employees proficient in construction and operation of transmission and distribution facilities. On the contrary, since large-scale generation projects have not been implemented for many decades, it has few personnel proficient in the operation of generation facilities. It is indispensable to identify appropriate counterparts who will be responsible for operation and maintenance of the proposed new generation facilities and to create a strong cooperative relationship with them.

Chapter 4 Data Collection and Review on the Proposed New Maputo Thermal Power Plant Project

4.1 Backgrounds and Objectives of Requested Project

ME and EDM have requested assistance from Japan in the power sector of Mozambique, and identified a priority project in EDM's presentation document entitled "Mozambique Electricity Sector & Power Infrastructure." The power plant construction project at Beluluane is cited as the top priority project among the others. EDM's document, "Project Proposal - Beluluane Power Plant – 50 MW CCGT Power Plant" (November 2011) describes the backgrounds, needs, suitability, implementation plan, etc. of the project. The contents of the project proposal are shown in Table 4.1-1.

Table 4.1-1 Contents of the Project Proposal

No.	Contents of Project Proposal
Chapter 1 Project Description	
1.1	Background
1.2	Maputo vs. Industrial
1.3	The Existing Network
1.4	Growth Prospects and Resources Needs
1.5	Energy and the Socio-Economy
1.6	Projective Objectives and Justification
1.7	Relevance of the Project
Chapter 2 System Analysis	
2.1	System Analysis
Chapter 3 Project Implementation and Organization	
3.1	Scope of the Project
3.2	Project Location
3.3	Brief Details of the Power Plant
3.4	Target Beneficiaries
3.5	Project Implementation
3.6	Institutional Arrangement
3.7	Environmental and Social Impact Considerations
3.8	Results
3.9	Activities
3.10	Strategy
3.11	Inputs
3.12	Assumptions
3.13	Organization and Administration
3.14	Organizational and Financial Sustainability
3.15	Indicators and Means of Verification
3.16	Project Review, Reporting and Evaluation
3.17	Accounting and Auditing
Chapter 4 Cost Estimate	
4.1	Budget

(Source: EDM)

EDM feels a strong need to implement the power plant project at Beluluane in order to meet the electricity demand in the Maputo metropolitan area in general where the power demand is steadily increasing, and in the Industrial Park at Beluluane and its neighboring areas in particular, where a wide range of industries with a large power consumption are located.

Mozal aluminum smelter, one of the major power consumers in Mozambique, is located in Beluluane Industrial Park. Its power demand (950 MW) is met by receiving power through dedicated transmission lines from Maputo substation. Other consumers receive power from Beluluane substation (66/11 kV, 20 MVA), which was originally constructed to feed power for construction of the Mozal aluminum smelter. In the meantime, Beluluane substation is fed by 66 kV transmission lines from both Boane substation and Matola Gare substation. In the normal operation of the transmission lines, no overload is anticipated. It is expected, however, that the transmission lines will be overloaded in a few years because of increasing power demand.

In addition, even for the current power demand, some transmission lines are overloaded at the time of system faults. The project proposal of EDM suggests construction of a 50 MW gas-fired power plant in Beluluane Industrial Park to transmit power from the power plant to Beluluane substation in order to address the issue of overloading. The JICA Survey Team collected data and information on the project and carried out a site survey. The survey included examination of the need for conducting a detailed survey for project formulation. It was decided that an appropriate scheme and work items be proposed if such detailed survey is justified. The results of the examination are discussed in Section 5.2 and thereafter.

The rehabilitation plan of CTM-Maputo power station has been presented to the JICA Survey Team through the discussion with EDM, and its F/S report titled “Exploration of Natural Gas for Power Generation in Maputo, Mozambique - Feasibility Report” (Vattenfall, July 2010) was presented by EDM. The rehabilitation project is supposed to be implemented in three stages: firstly, repair of the three peaking gas turbine generators, which are aging and operated only for a short time of the year; secondly, switching of fuel from diesel/jet fuel to natural gas; and thirdly, conversion from open cycle to combined cycle by installing a steam generator (HRSG) and steam turbine. Power supply capacity after completion of the rehabilitation project is already included in the long-term power supply outlook of EDM. For this reason, EDM wants to implement the project.

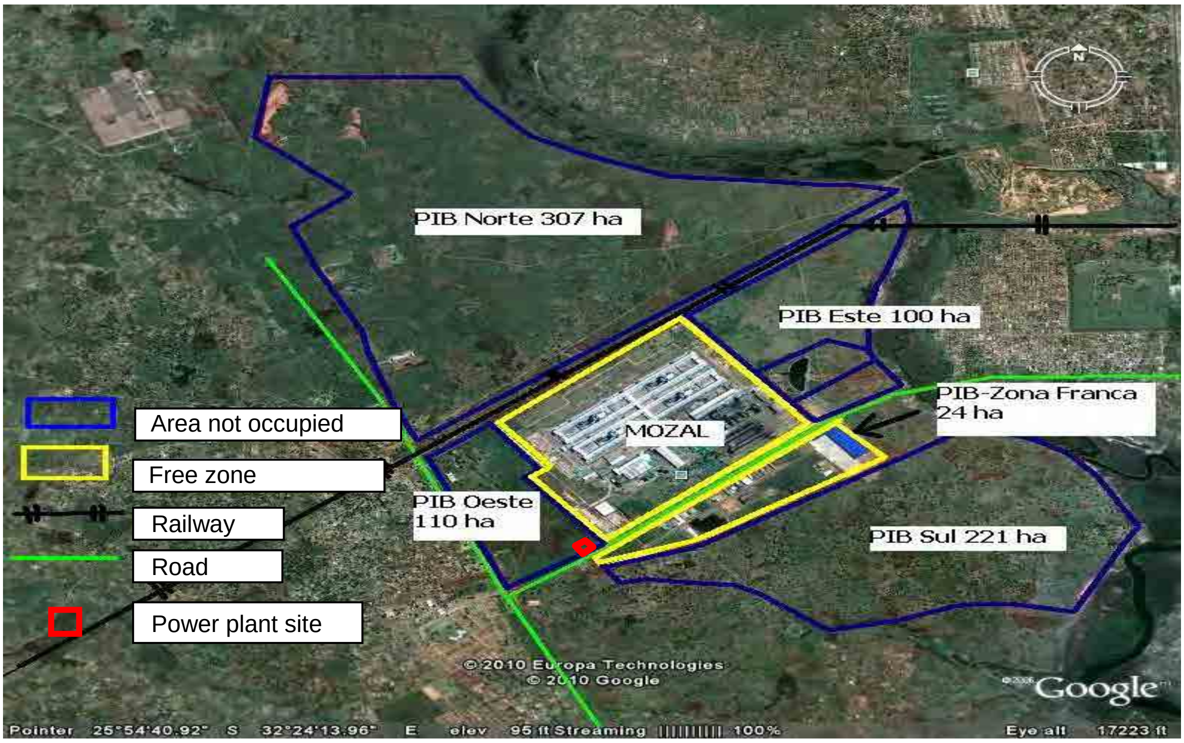
The Survey Team has learned, as a result of the first site work, that data collection and analysis is required not only for the proposed power plant project at Beluluane, as requested of Japan by EDM, but also for the rehabilitation project at CTM-Maputo power plant. The two projects have been studied in parallel and examined preliminarily. The results are discussed in Section 4.2 and thereafter.

4.2 Current Situation of Construction Site

4.2.1 Beluluane Site

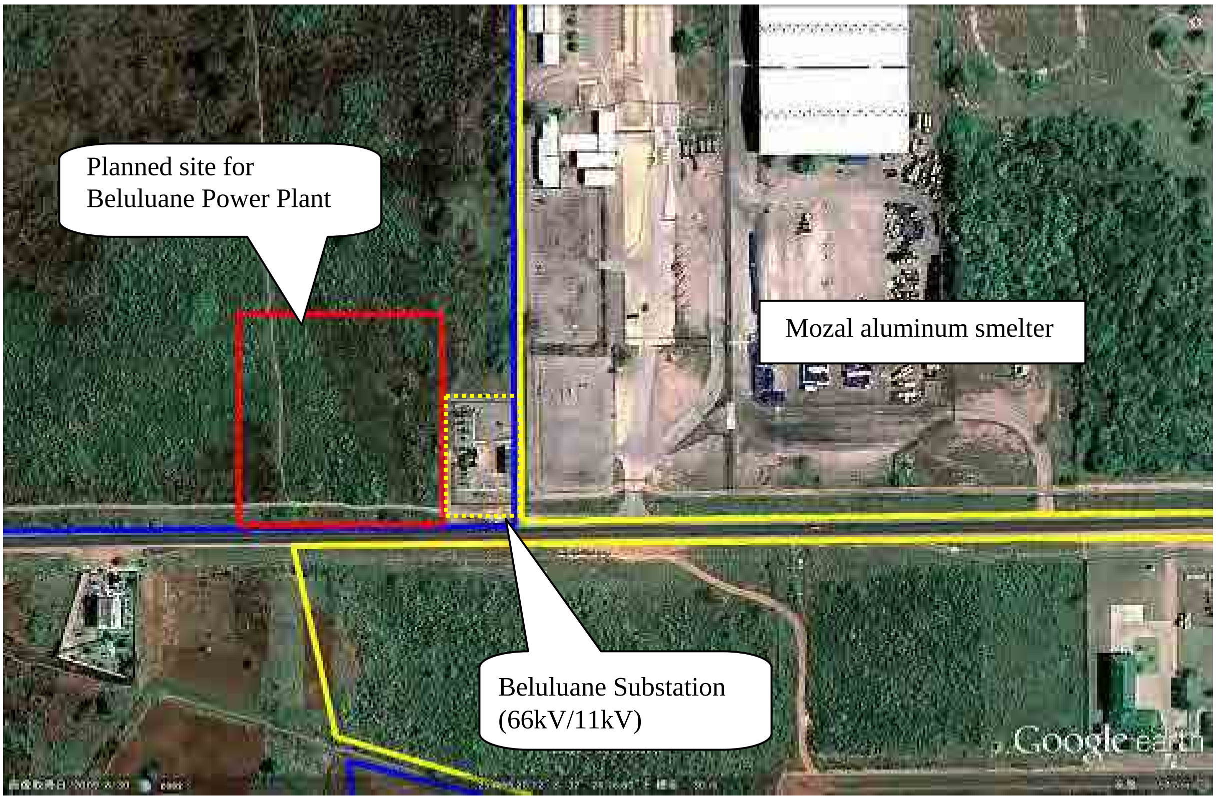
(1) Power Plant Construction Site

The planned construction site of the Beluluane Power Plant proposed by Mozambique is located within Beluluane Industrial Park to the west of the Mozal aluminum smelter, and is adjacent to the existing Beluluane substation (refer to Figure 4.2-1). Beluluane Industrial Park is private land whose sole right of use is granted by the Government of Mozambique according to the Government Ordinance; so, it does not include any residences or farmland in principle. The planned power plant construction site is generally flat and is overgrown with shrubs and grass at present. This site contains no conspicuous obstacles and does not seem to require deforestation or large-scale grading work during the construction work. A power plant site of 1 hectare (100 m × 100 m) has already been secured (as shown in Figure 4.2-2). However, this space is insufficient considering the installation site for auxiliary facilities and possible extension work in future. When the power plant site needs to be enlarged, it is essential to coordinate with the party in charge of the Industrial Park.



(Source: GAZEDA)

Figure 4.2-1 Beluluane Industrial Park Layout

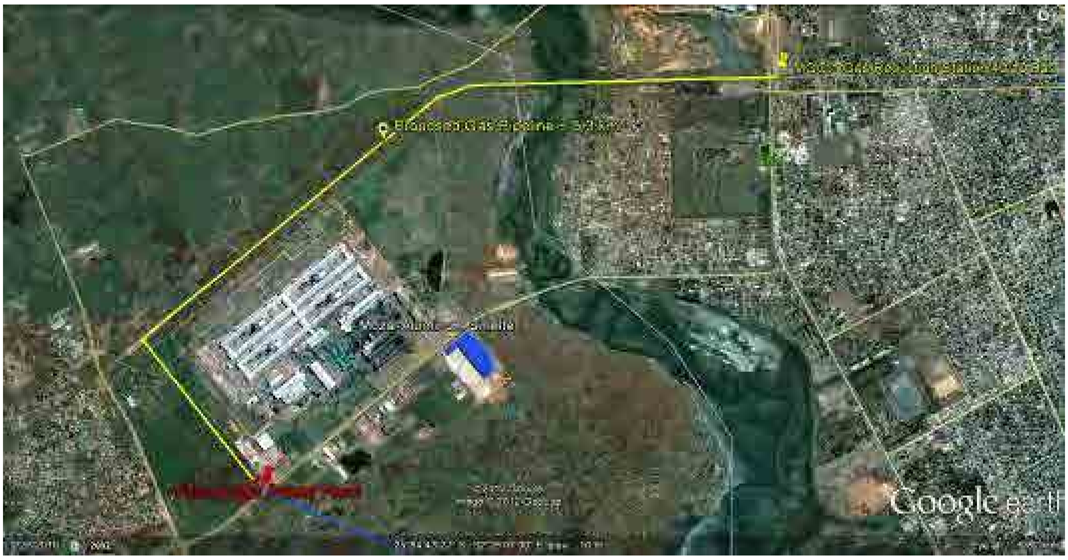


(Source: Created by the JICA Study Team)

Figure 4.2-2 Planned Beluluane Power Plant Construction Site

(2) Fuel Supply

Gas pressure is reduced to 10 bar by the pressure reducing station (PRS 2). This gas is also sent to Beluluane Industrial Park through a pipeline with a diameter of 200 mm (8 inches) (see Figure 6.2-8). A metering station is located at the side of the front gate of the Mozal aluminum smelter. The distance from the metering station to the candidate site of the Beluluane Power Plant is only approximately 1 km. However, the inlet pressure of the gas turbine is too low at 10 bar. Further, it will be difficult to increase the pressure of the gas supplied to the existing users located in the Industrial Park, and therefore, it will be difficult to supply gas to the Beluluane Power Plant using the existing pipeline. This assumption is backed by the diagram created by EDM (Figure 4.2-3) illustrating the gas pipeline route. In this diagram, installation of a new pipeline (with an extension of approximately 5.3 km) is assumed as a prerequisite. In this case, the new pipeline will be branched off immediately upstream of the existing PRS-2 (probably by hot-tapping) so that gas having a pressure of 40 bar will be led to the power plant.



(Source: EDM)

Figure 4.2-3 Route for Gas Supply Pipeline to Beluluane Thermal Power Plant

(3) Cooling Water Supply (Figure 4.2-4)

The condenser cooling system for the steam turbine can be selected from among three types: a once-through cooling system, forced draft cooling tower system, and an air-cooled condenser system. The once-through cooling system requires a large amount of cooling water, so it will be difficult to adopt this system when consideration is given to the conditions of the Matola River running in the vicinity of the Industrial Park.

The Matola River, which runs immediately east of Beluluane Industrial Park, reportedly dries up in the dry season (Photo 1) so that water intake is impossible. It has been confirmed that there is a certain amount of water several kilometers upstream of the estuary (Photo 5). To check if water intake is possible from this site, it is essential to collect and examine data on the annual flow rate and quality of water running in the Maputo River.

If adopting the forced draft cooling tower system, freshwater must be replenished because cooling water is dispersed and evaporated from the cooling tower facility, and a certain amount of cooling water has to be discharged in order to maintain satisfactory cooling water quality.

According to AdeM (Aguas de Mozambique), the water abstraction point for the water supply system for Metropolitan Maputo is located 18 km from Beluluane Industrial Park. The water supply capacity is 10,000 m^3/hr, of which 9,000 m^3 per hour is currently supplied to the metropolitan area.

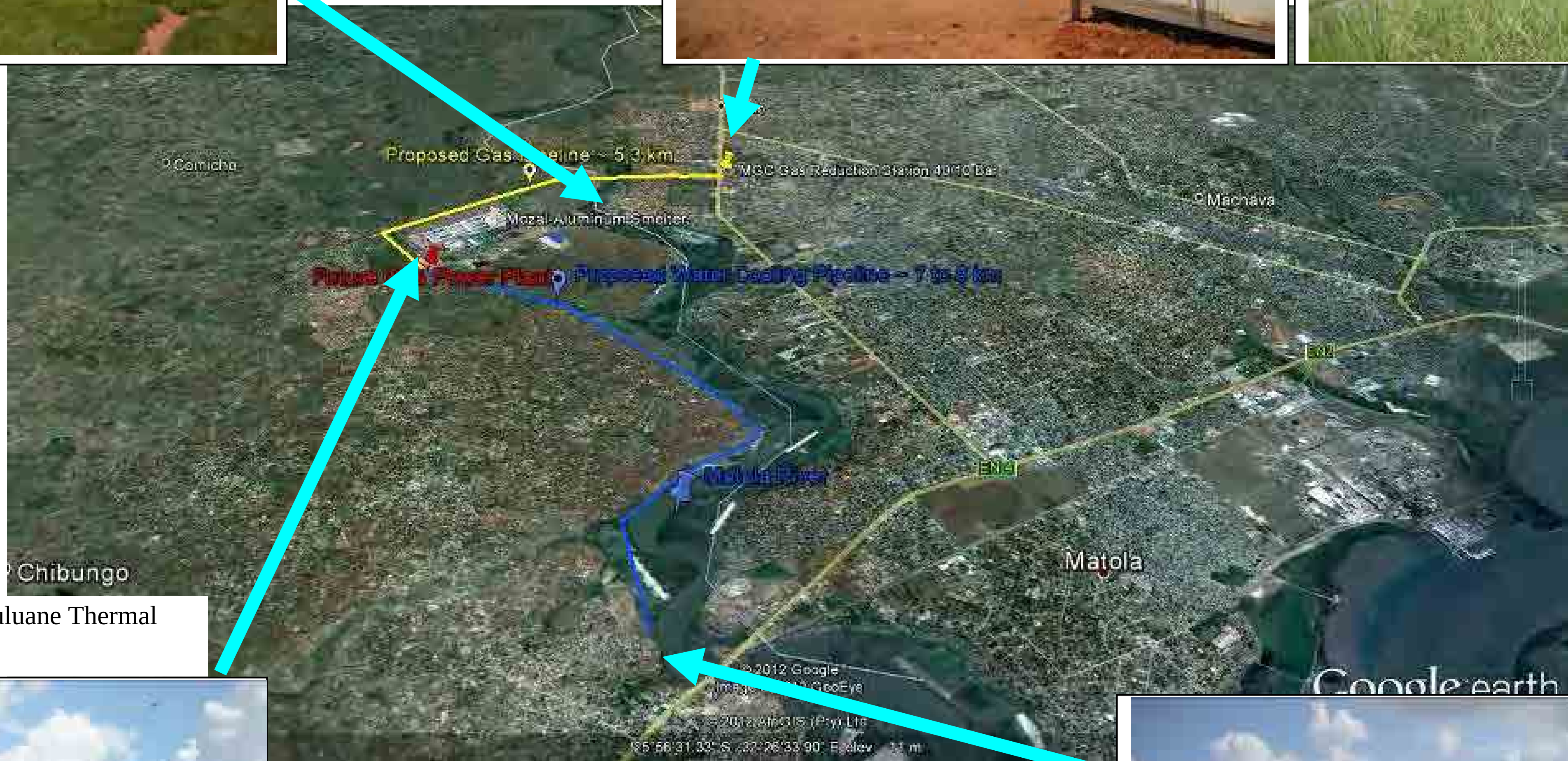
Further, the Mozal aluminum smelter has its own pipeline installed to receive water.

Photo 1：Matola River close to Beluluane Industrial Park

The river dried up.
No water comes from upstream except during/after heavy rain.
When the tide rises, seawater flows into the river.

Photo 2：Pressure Reducing Station 2 (PRS 2)

Photo 3：Railway neat the PRS 2 (candidate pipeline route)



Gas pipeline route

Intake water pipeline route

Photo 4：Construction Site of Beluluane Thermal Power Plant

Photo 5：Situation of Intake Water Point

Since it seems that some water can be taken at the portion of the river near the bridge located near the river mouth, the possibility of intake water should be studied.

Figure 4.2-4 Current Situation of Beluluane Industrial Estate and Surroundings

(4) Power Transmission Plan

Since the Beluluane substation is located adjacent to this planned construction site, as shown in Figure 4.2-2, connection with this substation will not be difficult. However, it is necessary to study the modification of Beluluane substation.

(5) Environmental and Social Considerations

Since this construction site is located within Beluluane Industrial Park, it is thought that there will be no serious consideration for environmental and social impacts. Meanwhile, this project will most probably be designated as category A in the categorization by the Government of Mozambique and therefore requires implementation of an EIA.

Taking the environmental impacts into consideration, "the gas-fired combined cycle power generation facility" will be adopted, because the environmental impact of this facility is the smallest among the feasible types of thermal power generation facilities.

4.2.2 CTM-Maputo Site

The existing Maputo Thermal Power Plant is surrounded by the ocean and highway, and can be reached in about 20 minutes by car from the center of Maputo.

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); however, they are rarely operating.

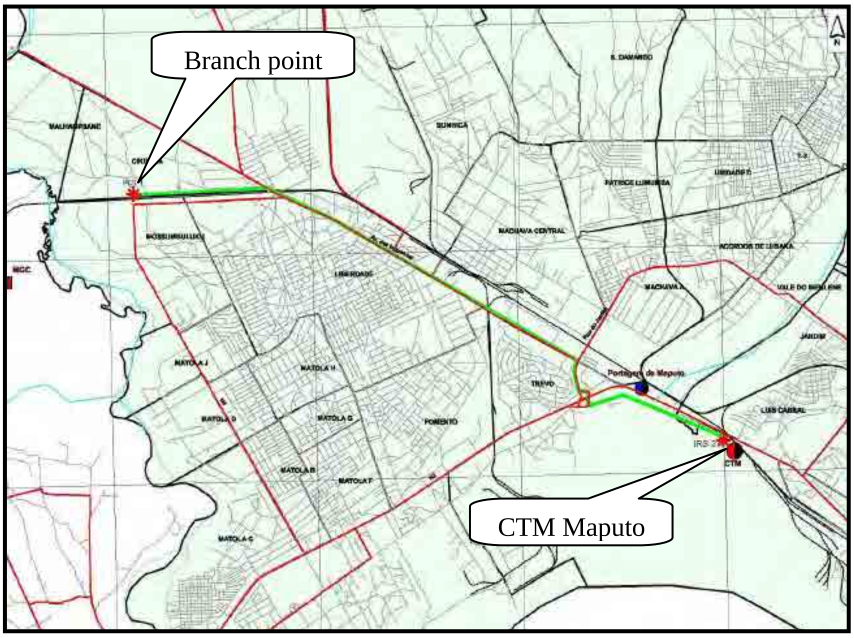
(1) Power Plant Construction Site

The existing Maputo Thermal Power Plant site includes the site where the coal-fired thermal power plant was demolished. The current unoccupied space measures approximately 3 hectares (100 m x 300 m). This will be adequate for a 70 MW-class combined cycle power generation facility to be installed.

Figure 4.2-6 shows the conditions of the Maputo Thermal Power Plant site.

(2) Fuel Supply

The gas pipeline branching off from the existing MGC pipeline and leading to CTM-Maputo (total length is approximately 11 km, refer to Figure 4.2-5) will be constructed and operated by a joint venture of ENH and KOGAS of Korea (shareholding ratio: ENH 30% and KOGAS 70%). According to ENH, construction will start in October 2012 and will be completed in November 2013.



(Source: ENH)

Figure 4.2-5 New Gas Pipeline Route (green line)

Also, according to ENH, the concessionaire of the new pipeline (ENH/KOGAS) has agreed with the concessionaire of Pande-Temane Gas fields (Sasol/ENH/IFC) on the term sheet (basic conditions for the agreement) of “Gas Sales Agreement (GSA)” and with operators of the upstream pipelines (i.e. ROMPCO and MGC) on the term sheet of the “Gas Transportation Agreement.”

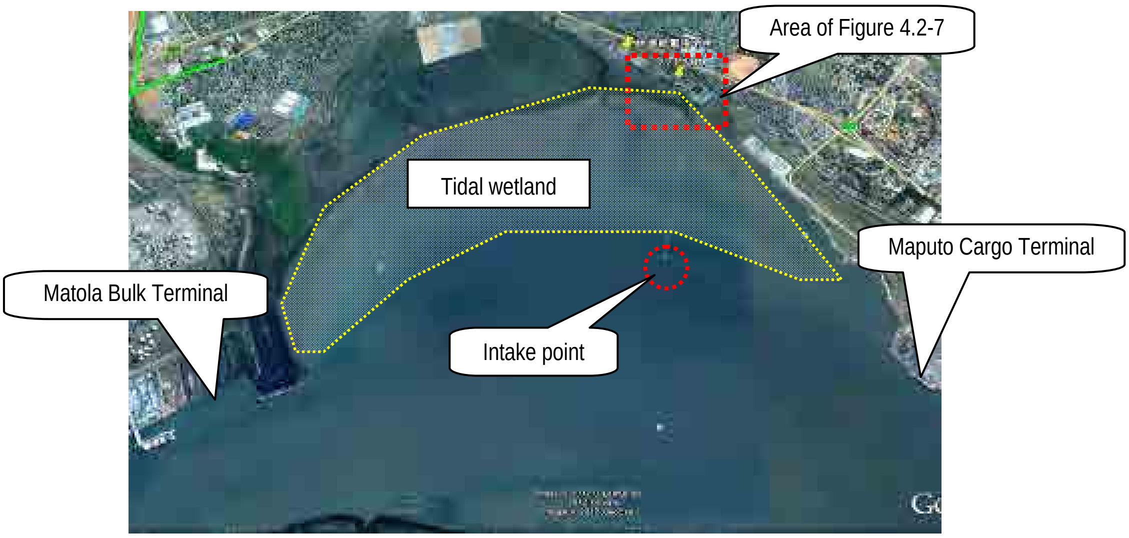
If the CTM Maputo site is selected as the site of New Maputo Thermal Power Plant, EDM needs to act in concert with the new company (ENH/KOGAS) on the gas supply to CTM-Maputo.

(3) Cooling Water Supply

Since CTM-Maputo had coal fired thermal power facilities, seawater was used as condenser cooling water (i.e. circulating water). The sea area in front of CTM-Maputo is characterized by a gently shelving bottom at the time of low water. Accordingly, a pump was used for water intake at the site approximately 1.5 km from the coastline. At present, the intake pump and intake pipes have been removed. The reinforced concrete piping bridge and pump room still remain, but are seriously damaged and deteriorated according to visual observation (Figure 4.2-8).

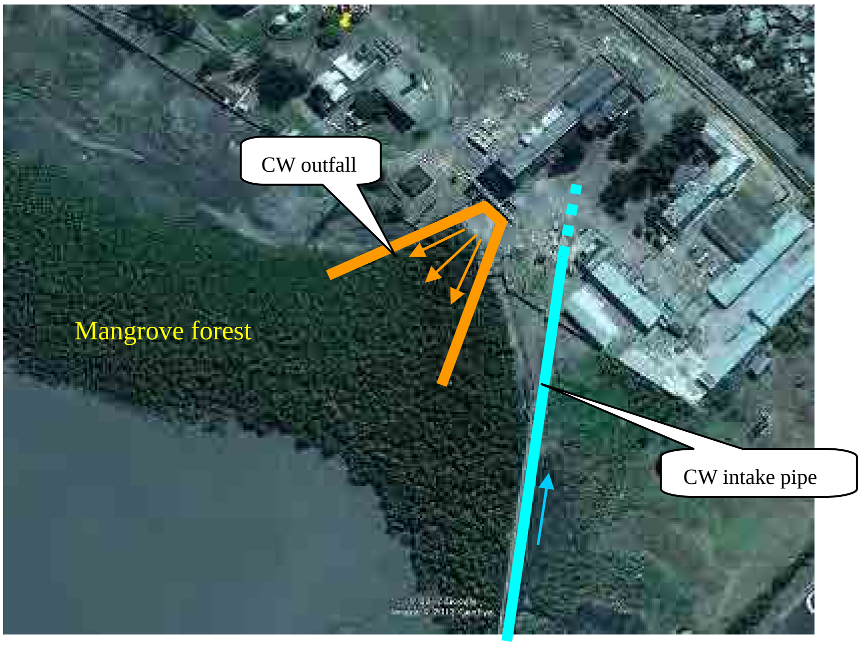
Accordingly, in the next step, it is necessary to study whether the existing intake piping bridge can be repaired and used for cooling water intake pipe installation of the new CCPP, or should be removed and replaced by a new piping bridge or main water channel.

Figure 4.2-6 shows the location of the circulating water (CW) intake water pipe and pump and Figure 4.2-7 shows the location of the CW outfall of the former coal fired thermal power plant.



.(Source : the Study Team)

Figure 4.2-6 Location of CW Intake Point of the Former Coal Fired Thermal Power Plant



(Source: the Study Team)

Figure 4.2-7 Location of CW Outfall of the Former Coal Fired Thermal Power Plant

The intake and discharge water system and layout of the new gas-fired thermal power plant will be studied based on the layout of intake and discharge water facilities of the former coal fired thermal power plant.

In the next step (F/S), it is necessary to conduct the following detailed study.

➢ Is the temperature of the seawater adequate or not to be used as cooling water for the condenser? And, does sand or mud enter the intake water mouth?

- Does the existence of the intake water facilities disturb the operation of ships? Since it is expected that the ship lane is periodically dredged, does the existence of the intake water mouth influence dredging work?
- After the intake water mouth is constructed, is there a possibility that the facility will be buried by mud or sand from upstream?
- Are there any impacts on the ecology or fisheries (berthic organisms or sea grass and algae such as fish or shells)?
- Depending on the location and quantity of water intake and discharge, is there danger of (erosion-deposition) riverside topographic change?
- Is felling of the mangrove area of the front of the discharge water mouth permitted?
- If changes occur to the riverside terrain, will it affect the surrounding area of mangrove (species with root respiration are likely to die)?

(4) Freshwater Supply

Freshwater, such as industrial water, will be necessary to be used as make-up water for waste heat recovery boilers. Freshwater was supplied to the former coal-fired thermal power plant. At present, a booster pump for supply of freshwater still remains on the left side of the entrance of the power plant. The freshwater supply capacity and water charges will be checked in the next field survey.

(5) Power Transmission Facilities

The Maputo Thermal Power Plant site includes a 66 kV/33 kV substation. If new combined cycle power generation facilities are to be installed, they will be connected to 66kV bus in this substation.

(6) Others

In the Maputo Power Plant, the power generation facilities have been flooded in the floods caused by cyclones in the past. If this place is to be used as the planned power plant construction site, it will be necessary to study the possibility of increasing the height of the ground to provide against floods.

Piping bridge of demolished coal fired plant

The same as the left

Deteriorated portion of piping bridge of demolished coal fired plant

The same as the left (some parts have fallen)

Piping bridge of demolished coal fired plant

Intake pit for cooling water pump of demolished coal fired plant

Figure 4.2-8 Current Situation of Intake Piping Bridge and Intake Pump Room

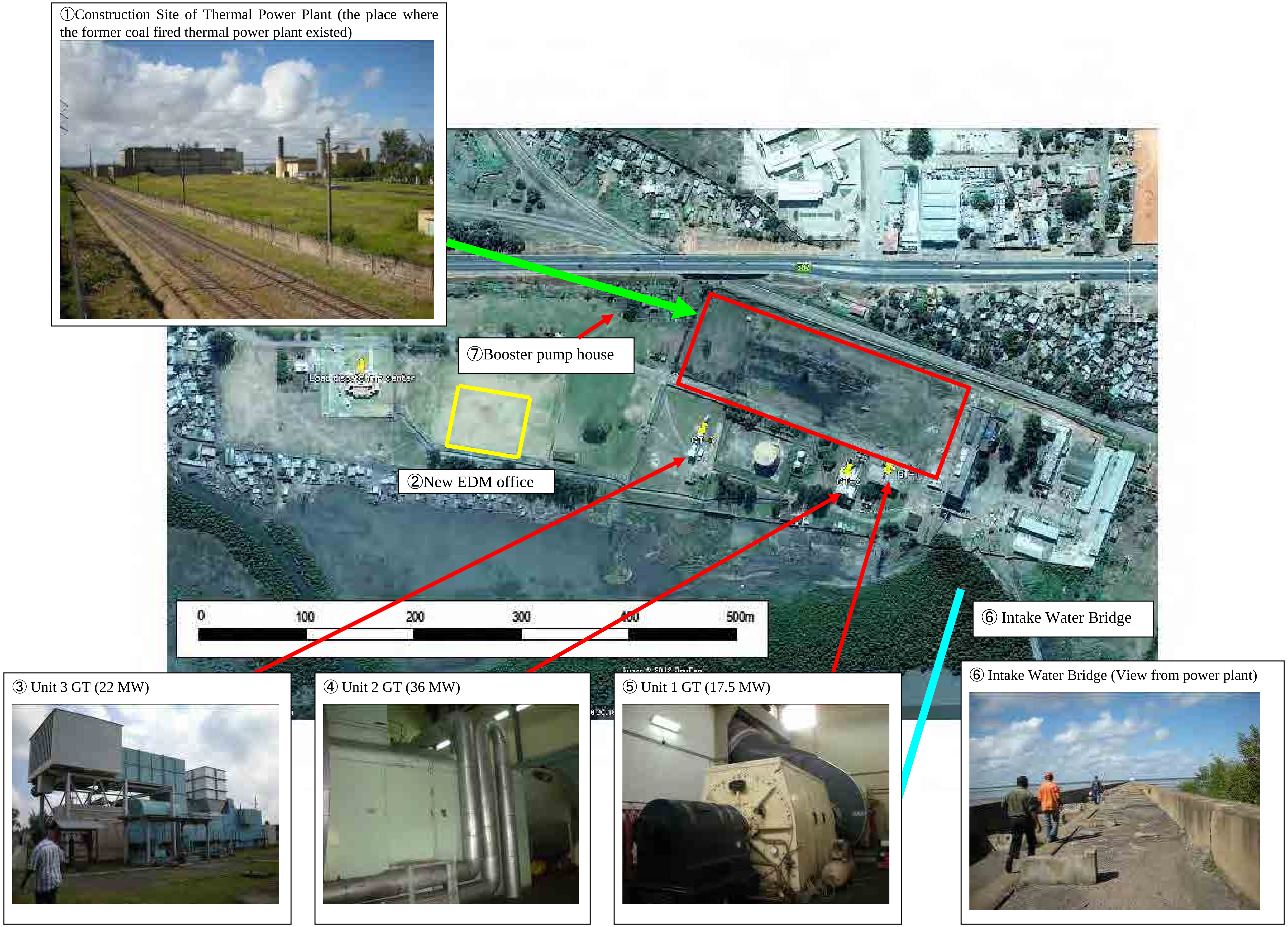


Figure 4.2-9 Current Situation of Maputo Thermal Power Plant

4.3 Overview of Construction Plan

4.3.1 Location of the Planned Power Plant Construction Site

In this project, a combined cycle thermal power plant having an overall installed capacity of around 70 MW (depending on site conditions) will be installed in Beluluane Industrial Park located approximately 18 km west of Maputo city, the capital of Mozambique, or at the Maputo Thermal Power Plant located approximately 3 km west of the urban district of Maputo city.

70 MW has been calculated based on 3.2 MGJ/year which is the possible annual gas supply volume as mentioned in 4.3.3, (2).

The locations of these sites are illustrated below.

(Source: Nokia map)

Figure 4.3-1 Beluluane and Maputo Thermal Power Plant Location Map

4.3.2 Current Conditions regarding the Collection of Data and Information on Candidate Sites

With reference to the data and information regarding the site area, fuel supply and cooling water supply given in Section 4.2 describing the current conditions of the site, Table 4.3-1 summarizes the characterization and preliminary evaluation of the Beluluane and Maputo sites.

The site area that can be procured at the Beluluane site measures one hectare (100 m × 100 m). This is insufficient for construction of a 70 MW class combined cycle thermal power generation plant. Further, difficulties are found in supplying cooling water for the power plant to the Beluluane site. Although further study is needed, the Maputo site can be said to be a more suitable power plant construction site.

In the next step (FS), simple technological and economic studies will be made based on the information and data obtained with respect to both sites, so that the candidate construction sites can be narrowed down to one particular site.

Table 4.3-1 Characteristics of the Beluluane and Maputo Sites

			Beluluane Site	Maputo Site
1	Site area	Available site area	1 ha (100 m × 100 m)	3 ha (100 m × 300 m)
		Required site area	2.7 ha (150 m × 180 m)	Same as the left
	Evaluation result		not favorable	favorable
2	Access	Distance from main highway	10 m	500 m
		Means of access	Road	Road
		Conditions	Good	Good
	Evaluation result		favorable	favorable
3	Topographic features		Flat	Flat
4	Geographical features		See Table 4.3-9	Not clear
5	Plant system		Weeds	Weeds
6	Meteorological conditions	Atmospheric temperature	29.8 °C maximum/ 17.8 °C minimum (five-year average value)	Not clear, almost the same as left
		Humidity	69% (five-year average value)	Same as above
		Precipitation	49.7 mm	Same as above
		Wind direction	Mainly southerly winds	Same as above
		Wind speed	9.4 m/s	Same as above
		Others	-	Flood-prone
	Evaluation result		favorable	moderate
7	Cooling water source	Name of river source	Matola River	Maputo Bay
		Distance from river source	7 to 8 km	1.5 km
		Available intake volume	Not clear	A large amount of intake available
	Evaluation result		moderate	favorable
8	Freshwater source	Name of river source	Intake weir of the Umbeluzi River	Not clear
		Distance from river source	15～18 km	Not clear
		Available intake volume	Difficult to supply from the existing water supply line (A new pipeline must be installed independently.)	Not clear
	Evaluation result		moderate	moderate
9	Fuel	Fuel type	Natural gas	Natural gas
		Possibility of supply	Installation of a gas pipeline (3.5 km) from PRS-2 is included in the plan.	Installation of a gas pipeline (11.2 km) from PRS-2 is included in the plan.
		Supply volume	3.2 MGJ/year	6.0 MGJ/year
	Evaluation result		favorable	favorable
10	Access to substation and transmission line		50 m	50 m

			Beluluane Site	Maputo Site
11	Environmental and social impacts (planned power plant construction site)	Presence or absence of protected area	Absent	Absent
		Presence or absence of precious animals or plants	Absent	Absent
		Presence or absence of historic sites	Absent	Absent
		Need for relocation of inhabitants	Absent	Absent
	Evaluation result		favorable	favorable
12	Environmental and social impacts (cooling water intake/discharge)	Presence or absence of protected area	Not clear (survey required)	Absent
		Presence or absence of precious animals and plants	Absent	Mangrove found
		Presence or absence of historic sites	Absent	Absent
		Need for relocation of inhabitants	Not clear (survey required)	Absent
		Circulation of warm waste water	No problem	To be studied
	Evaluation result		favorable	favorable
13	Transportation of heavy objects		Transportation from the Maputo port by the EN4 highway (road width sufficient)	Transportation from the Maputo port by the EN2 highway (road width sufficient)
	Evaluation result		favorable	favorable

(Source: Created by the JICA Study Team)

4.3.3 Planning Conditions of the Project

Toward the next step (FS), planning conditions of this power plant project are summarized and studied, as follows.

(1) Planned Power Plant Construction Site

The planned power plant construction site is assumed to be located within Beluluane Industrial Park and CTM Maputo. At present, the site area is insufficient. It can be expanded after subsequent discussions and negotiations with related authorities/parties.

On the other hand, there is enough space to construct 70MW class combined cycle power plant in the CTM Maputo because old coal fired power plant had been demolished and there is a space.

(2) Basis for the Generation Capacity

Normally, the generation capacity is determined according to the long-term power development plan or master plan prepared by giving consideration to the future power supply-demand balance. According to the data provided by EDM, supply is much greater than the demand in the future supply-demand balance in Mozambique, leaving doubt about the credibility of the data.

According to the discussion with EDM, an annual increase of 50 MW in demand is predicted. This is considered to be the reason for estimating the generation capacity of this project at 50 MW.

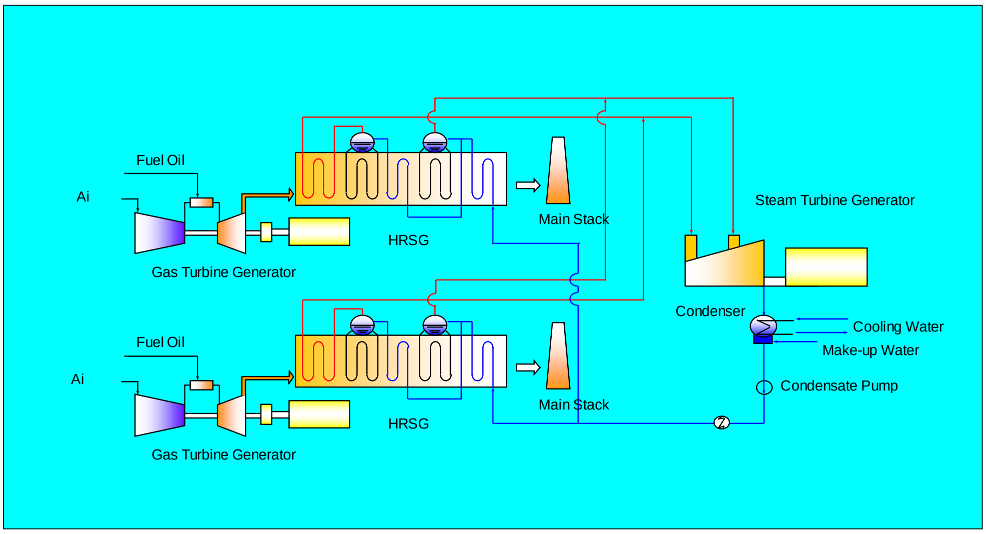
The power generation capacity is restricted by the volume of natural gas that is available at present. As discussed above, the annual volume of gas supplied to a newly installed gas-fired thermal power plant is 3.2 MGJ. Calculating backwards from this volume of gas supplied, the generation capacity is approximately 72.5 MW.

Available generation capacity = $3.2 \times 10^6 \times 10^6 \times 50 / 100 / 8760 / 70 \times 100 / 3600$

where the plant efficiency and capacity factor are assumed to be 50% and 70% respectively.

(3) Plant Type

The plan includes the construction of a multi-shaft type combined cycle thermal power plant (hereinafter referred to as "multi-shaft type CCPP") consisting of one block of combined cycle power generation facilities having an overall installed capacity of 70 MW class (at site conditions) (Figure 4.3-2). The equipment for one block is based on the 2-on-1 configuration comprising two gas turbines, two waste heat recovery boilers and one steam turbine. The unit capacity of the power generation facilities is approximately 25 MW.



(Source: Created by the JICA Study Team)

Figure 4.3-2 Configuration of Multi-Shaft Type Combined Cycle Plant

According to another configuration, it is possible to install two blocks of single-shaft combined cycle power generation facilities (one gas turbine, one waste heat recovery boiler and one steam turbine connected in series; hereinafter referred to as "single-shaft CCPP"). When the multi-shaft type CCPP is adopted, commercial operation of the gas turbine facility as a single unit can be commenced at an earlier stage. After installation of the whole combined cycle power generation facilities, the gas turbine can also be operated independently as a single unit. Because of these advantages, the multi-shaft type CCPP will be adopted.

In the meantime, in the case of a smaller power plant, a simple cycle gas turbine plant does not require a large amount of cooling water and freshwater, and the facility configuration is simpler than that of the combined cycle power generation facilities. Further, the construction cost is lower. However, taking "reduction in carbon dioxide gas" into account at the request of EDM, the combined cycle power generation plant will be adopted, because the combined cycle power generation is characterized by higher plant efficiency and lower volume of carbon dioxide gas emission, even if the generation capacity is the same.

(4) Condenser Cooling System

As major types of condenser cooling systems, there are once-through cooling systems, forced draft cooling tower systems and air-cooled condenser systems. Of these cooling systems, the forced draft cooling tower system and air-cooled condenser system are mainly employed in Europe and the United States. These two systems can be expected to reduce environmental impacts due to the warm wastewater discharged from the power plant. However, when applying these cooling water systems, plant efficiency is lower than that of the once-through cooling system. At this stage, the forced draft cooling tower system is considered to be the basis of the plan.

(5) Gas Turbine Fuel

A dual-firing gas turbine power generation facility will be planned based on the assumption that diesel oil and natural gas are used as the gas turbine fuel.

(6) Make-up Water

Make-up water for the feed water system and steam system will be supplied from the industrial water system.

(7) Diesel Oil

A diesel oil tank will be installed within the power plant area, and the diesel oil will be supplied by a tank lorry.

(8) Transmission Line

A 66 kV transmission line (with one circuit) will be installed from the Beluluane Thermal Power Plant to the 66 kV Beluluane substation, and modification work of the bank of the 33 kV substation will be included in the plan.

(9) Meteorological Conditions

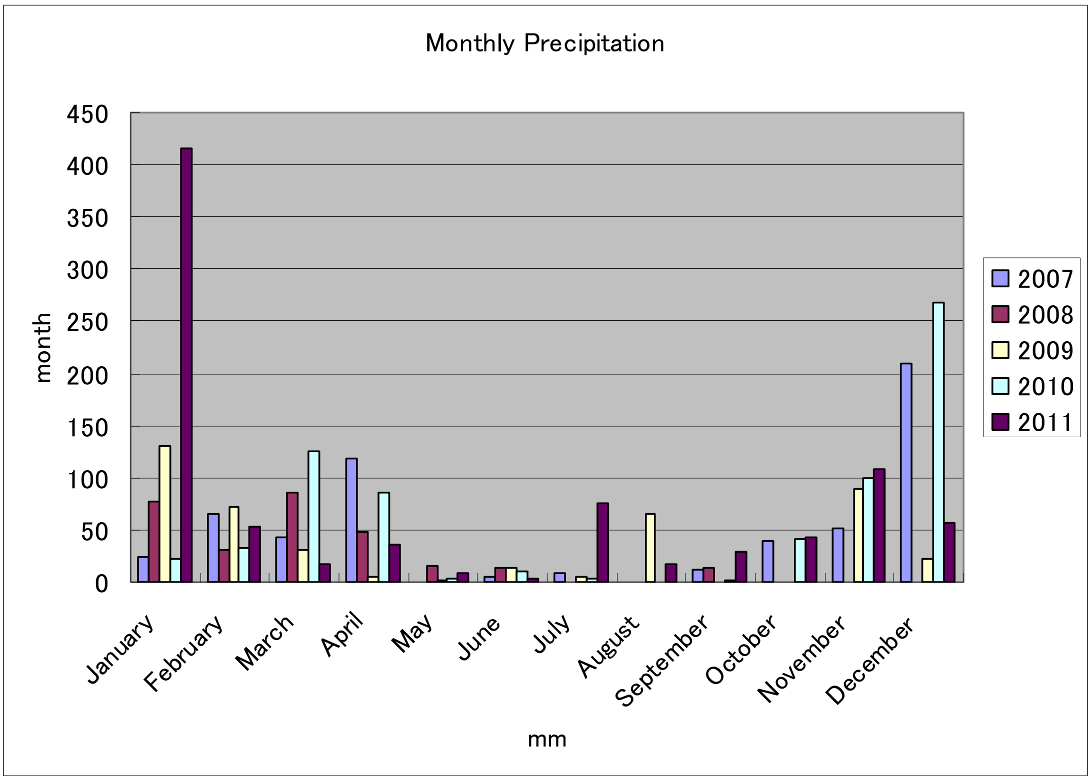
Tables 4.3-2 through 4.3-5 show the meteorological conditions of the Beluluane Industrial

Park. The data are the basis of the planning conditions of the Beluluane Thermal Power Plant.

Table 4.3-2 Monthly Precipitation (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	24.2	64.8	43.0	118.0	0.0	5.1	7.9	0.0	11.6	39.7	51.8	210.3
2008	77.0	31.0	85.2	48.7	15.2	14.2	0.0	0.0	13.3	0.5	0.0	0.0
2009	129.9	72.4	31.2	5.4	1.7	13.0	5.5	64.9	0.0	0.0	89.8	22.7
2010	21.9	33.0	125.0	86.7	3.6	9.5	3.3	0.0	1.2	40.6	99.7	267.9
2011	415.6	53.1	17.9	36.0	8.9	2.9	76.0	18.0	28.8	42.2	108.7	56.6

(Source: EDM)



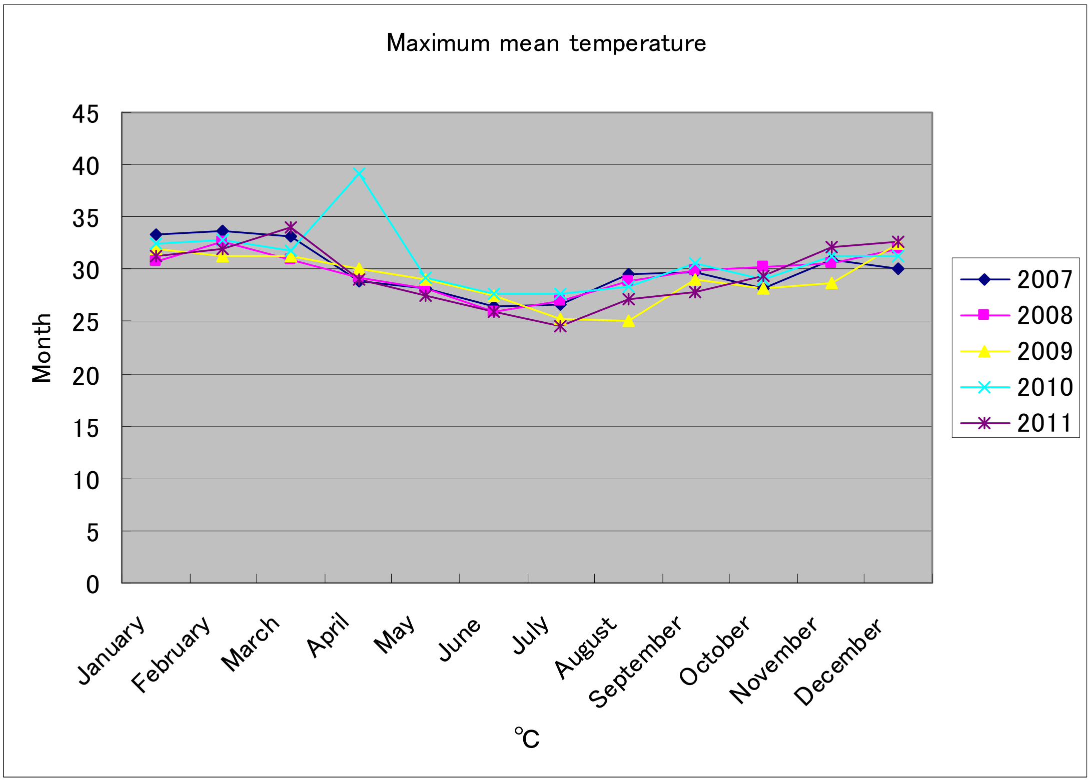
(Source: EDM)

Figure 4.3-3 Monthly Precipitation (mm)

Table 4.3-3 Maximum Average Temperature (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	33.3	33.6	33.2	28.9	28.1	26.4	26.7	29.6	29.7	28.2	30.9	30.0
2008	30.7	32.6	30.9	29.2	28.2	26.0	26.9	28.9	29.9	30.2	30.6	31.9
2009	31.9	31.3	31.2	30.0	29.0	27.5	25.3	25.1	29.0	28.2	28.6	32.5
2010	32.4	32.8	31.8	39.1	29.2	27.6	27.6	28.4	30.5	29.1	31.2	31.3
2011	31.3	32.0	34.0	29.0	27.4	26.0	24.6	27.2	27.8	29.4	32.2	32.7

(Source: EDM)



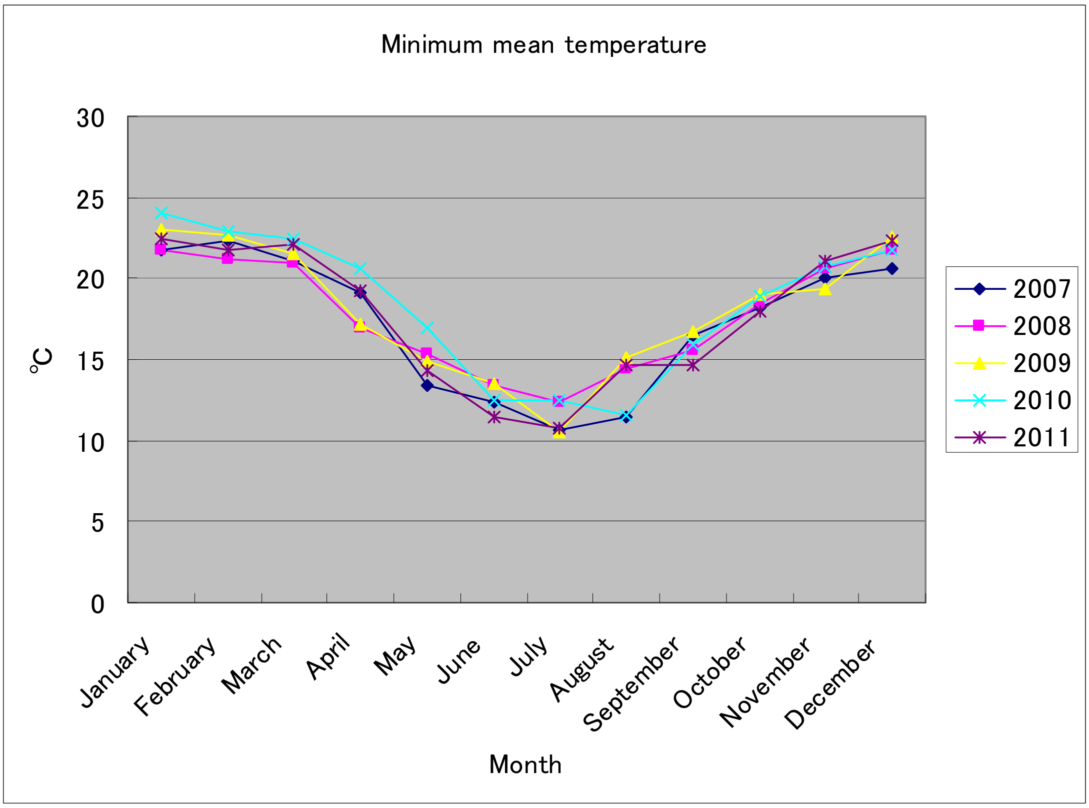
(Source: EDM)

Figure 4.3-4 Maximum Average Temperature (°C)

Table 4.3-4 Minimum Average Temperature (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	21.7	22.3	21.1	19.1	13.4	12.4	10.6	11.5	16.5	18.2	20.0	20.6
2008	21.7	21.2	20.9	17.0	15.3	13.4	12.4	14.4	15.6	18.4	20.6	21.8
2009	23.0	22.7	21.5	17.2	14.9	13.5	10.5	15.1	16.7	19.0	19.4	22.6
2010	24.0	22.9	22.5	20.6	16.9	12.5	12.5	11.6	15.9	18.9	20.7	21.8
2011	22.5	21.7	22.1	19.2	14.3	11.5	10.8	14.6	14.6	18.0	21.1	22.3

(Source: EDM)



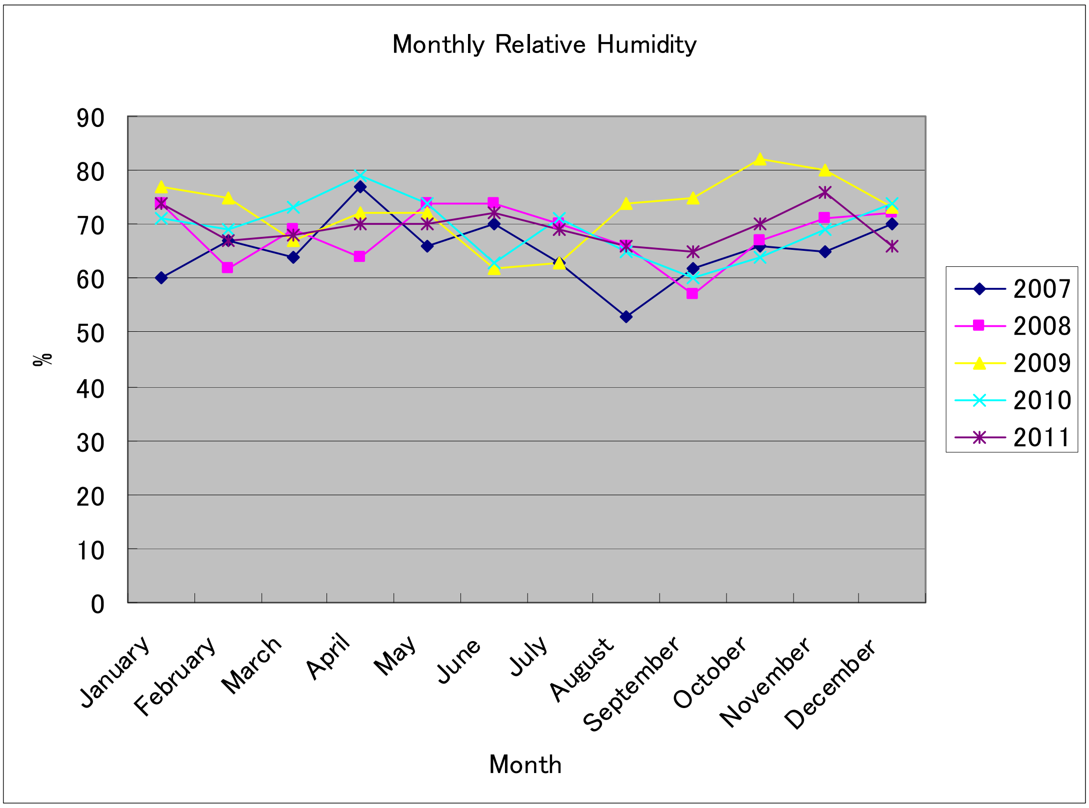
(Source: EDM)

Figure 4.3-5 Minimum Average Temperature (°C)

Table 4.3-5 Relative Humidity (%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	60	67	64	77	66	70	63	53	62	66	65	70
2008	74	62	69	64	74	74	70	66	57	67	71	72
2009	77	75	67	72	72	62	63	74	75	82	80	73
2010	71	69	73	79	74	63	71	65	60	64	69	74
2011	74	67	68	70	70	72	69	66	65	70	76	66

(Source: EDM)



(Source: EDM)

Figure 4.3-6 Relative Humidity (%)

The average temperature and humidity during the five-year period are calculated according to the above data on atmospheric temperature and humidity. The result of the calculations reveals that the maximum atmospheric temperature is 29.8°C, the minimum atmospheric temperature is 17.8°C, and the average humidity is 69%. This indicates a hot, humid climate. Such meteorological conditions are disadvantageous in terms of performances of the combined cycle plant. To be more specific, when the atmospheric temperature is higher, the power generation capacity and plant efficiency are lower.

In this survey, plant performances will be calculated under the design conditions shown in the table below on the temporary basis.

Table 4.3-6 Design Conditions

Atmospheric temperature	30°C
Relative humidity	60%
Altitude	50 m
Fuel	Natural gas

(Source: Created by the JICA Study Team)

For backup fuel, light oil is assumed.

Table 4.3-7 Natural Gas Properties

(Unit: Vol. %)

Methane	C1	90.823
Ethane	C2	3.452
Propane	C3	1.732
iso-Butane	iC4	0.449
n-Butane	C4	0.535
neo-Pentane	neoC5	0.000
iso-Pentane	iC5	0.152
n-Pentane	nC5	0.121
n-Hexane	nC6	0.172
n-Heptane	nC7	0.066
n-Octane	nC8	0.018
Nonane	C9	0.002
Decanes	C10	0.000
Nitrogen	N_2	2.454
Carbon dioxide	CO_2	0.001
Oxygen	O_2	0.027
Total inerts	(N_2, CO_2) Max 5 Vol%	2.455
H2S	Max 4 ppm	0.000
Energy Content (EC) (Gross)		
(101.325 kPa and 0 °C)	MJ/nm^3	42.6
(101.325 kPa and 15 °C)	MJ/nm^3	40.2
Relative density		0.622

(Source: EDM)

4.3.4 Plant Performance

Computer software was used for tentative calculation of the performances (e.g., generation capacity (output) and plant efficiency) of the single-shaft CCPP (35 MW and 45 MW class) and multi-shaft type CCPP (70 MW class) under the design conditions (atmospheric temperature 30 degrees C, relative humidity 60%). The results of this calculation are given in Table 4.3-8. For reference purposes, the following includes the performances of the combined cycle plant based on the gas turbine (LM6000) derived from aero (aircraft) gas turbine.

Table 4.3-8 Plant Performances

Generation System	Single-shaft Type CCPP		Multi-shaft Type CCPP
Cooling system	Forced draft cooling tower system		
Number of blocks	2	2	1
Number of gas turbines per block	1	1	2
Gas turbine type	Heavy Duty type	Aero derivative	Heavy Duty
Overall generation capacity (MW)	72	90	73
Plant capacity (MW)	36	45	73
Gas turbine capacity (MW)	23	34	47
Steam turbine capacity (MW)	13	11	26
Overall plant efficiency (%)	47.5	52.3	47.8
Cooling tower make-up water volume (m^3/h)	102	102	202
Pure water make-up water volume (m^3/h)	1.7	1.7	3.2

(Source: Created by the JICA Study Team)

4.3.5 Facility Specifications and Layout Plan

(1) Facility Specifications and Scope of the Project

As discussed in 4.3.3, this power plant is composed of one block of multi-shaft type CCPP. The equipment for one block is based on the 2-on-1 configuration comprising two gas turbines, two waste heat recovery boilers and one steam turbine.

The major facility specifications are planned as follows:

<u>Brief specifications of the major equipment/system</u>

- The gas turbine (single unit) shall meet the requirements of 30 MW class in conformity to the ISO rating.
- The gas turbine can be operated independently as an open cycle unit. A bypass stack and others are installed for this operation.
- The gas turbine combustor and accompanying equipment shall be designed in a dual-firing configuration so that they can be operated by diesel oil or natural gas.
- A fuel gas receiving facility or fuel gas compressor shall be installed.
- Make-up water for the feed water system, steam system and cooling water system shall be supplied from the industrial water system.
- The condenser cooling system shall be designed in a forced draft cooling tower system.
- The environmental laws and regulations of Mozambique shall be observed.

The following describes the scope of supply in this project.

<u>Scope of the project</u>

- Gas turbines and accompanying equipment
- HRSGs and accompanying equipment

- Steam turbine and accompanying equipment
- Diesel oil tank and light oil supply equipment
- Water pretreatment system (if required)
- Demineralized water supply system and wastewater treatment system
- Forced draft cooling tower facility
- Power house and office building
- 66 kV switchyard
- Gas pipeline from the PRS-2 to the Beluluane thermal power plant
- 66 kV transmission line (one circuit) from the Beluluane thermal power plant to the Beluluane substation and modification of the bank of 66 kV substation

(2) Layout Plan

The efficient layout plan of the Beluluane Thermal Power Plant shall be worked out by giving consideration to the outgoing connection of the 66 kV transmission line with the adjacent Beluluane substation, planned facilities for receiving natural gas from the PRS-2 (pressure reducing valve station or gas compressor facilities), and industrial water receiving facilities. The gas pipeline shall be connected to the northern side of the power plant, and the 33 kV transmission line shall be connected to the eastern side of the power plant. The main entrance to the power plant shall be located on the south side of the site, allowing for smooth ingress and egress to/from the access road (similarly to the main entrance of the Mozal aluminum smelter plant). In planning the facilities layout within the power plant, the gas turbines and the steam turbine are to be installed within the power house, and a sufficient maintenance space should be ensured for periodic inspection and overhaul. An office building, warehouse for spare parts and maintenance area shall be planned considering operation and maintenance of the plant. Further, during the construction of the thermal power plant, and subsequent to the commencement of commercial operation, the most careful consideration must be given to the safety management.

Figure 4.3-7 illustrates the standard site layout plan for the multi-shaft type CCPP for reference purposes.

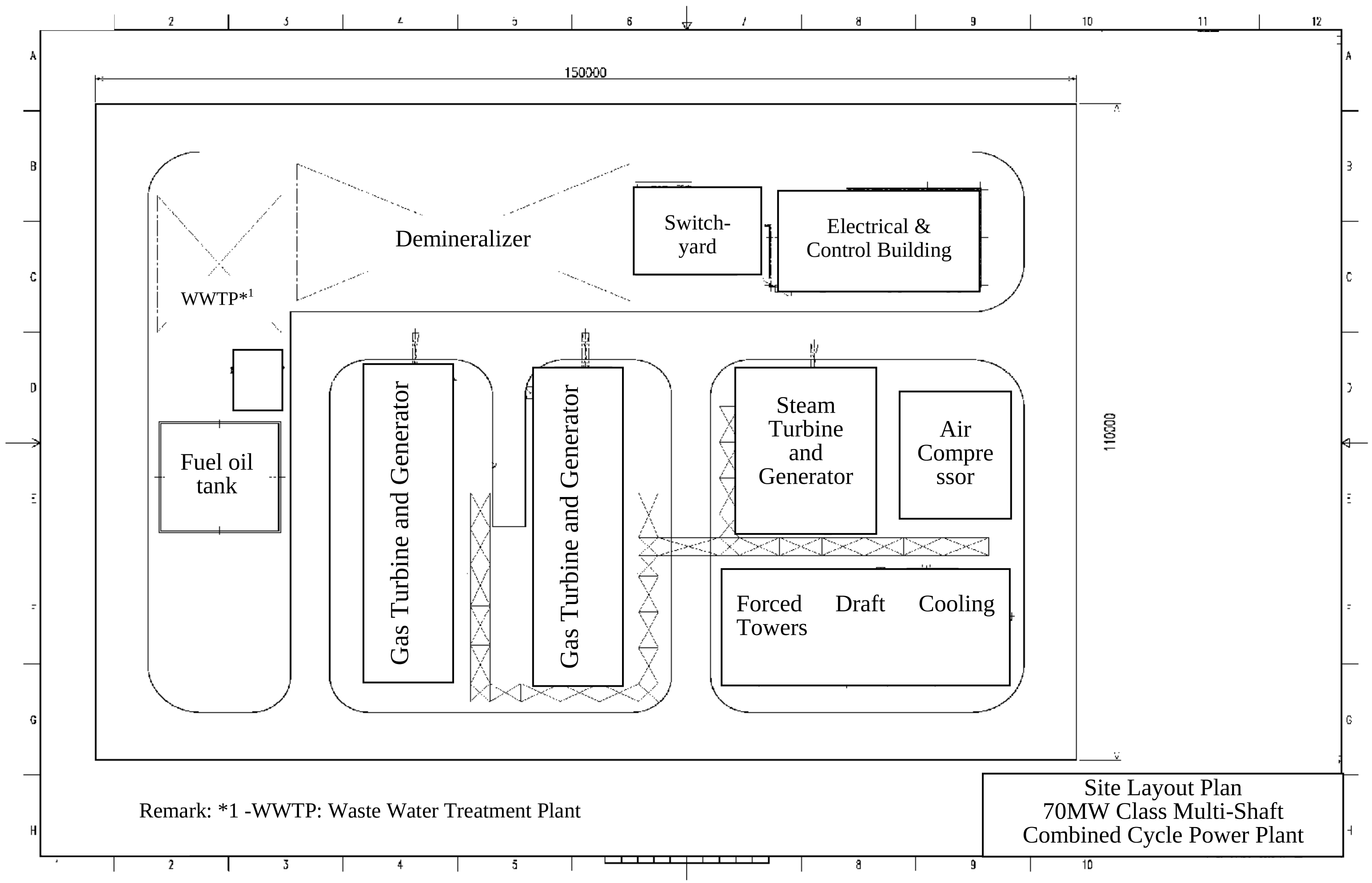


Figure 4.3-7 Site Layout Plan

(3) Civil Engineering Plan

In the civil engineering work for the Beluluane Thermal Power Plant, when a once-through cooling system is used as the condenser cooling system, it is important to study the water intake and discharge facilities. Since there is no data available on the flow rate, water temperature and water quality in the lower reaches of the Matola River as a candidate intake point, the available water will be studied in the next step. However, the distance from the planned intake point to the planned power plant construction site measures approximately 7 to 8 km. This matter should be studied from an economic point of view. It is also necessary to carefully check whether or not the length and layout of the above-mentioned cooling water intake pipe (pipeline) and discharge pipe (pipeline) are capable of preventing the recirculation of the warm wastewater and meeting the environmental regulations. Table 4.3-9 shows the subsoil conditions at Beluluane Site. This data is concerned with a rather shallow soil strata with a depth of 70 to 120 cm, and will not be sufficient to study the foundation structure. Accordingly, boring operations should be performed to reach the supporting ground level so that samples are collected to test the nature of the soil.

Table 4.3-9 Subsoil Conditions at Beluluane Site

GLOSSARY FOR "P3" TYPE SYMBOL

Soil Group	Post-Mananga soil with thick texture
Prevailing characteristic of the underground	Franc-arenaceous (brown reddish – very deep soils)
Geology	Deposits (0.5–10m depth) of rubefaction of the upper pleistocene
Ground Form	Reddish coluvions over rock deposits or Mananga
Topography and Slope (%)	Smoothly undulated (0-5)
Texture on Superficial Soil Underground	Arenaceous and Arenaceous-Franc Arenaceous-Franc and Franc-Arenaceous
Depth (cm)	70 – 120
Drainage	Good
Acidity and alkalinity of Superficial Soil ($pH-H_2O$) Underground ($pH-H_2O$)	(5,9 – 7,4) (5,8 – 7,5)
Organic material on Superficial Soil	(0,5 – 2,5)
Saltiness on Superficial Soil (CEe) (mmhos/cm) Underground (CEe) (mmhos/cm)	Non salty (0,3 – 1) Non salty (0,2 – 0,7)
Sodicity on Superficial Soil (PST%): Underground (PST%):	Non sodic (0 – 6) Non sodic (1 – 7)
Classification of the prevailing soils	FAO – Chromic Cambisols USDA – Ustollic Camborthids
Vegetation Type	Open forest

(Source: EDM)

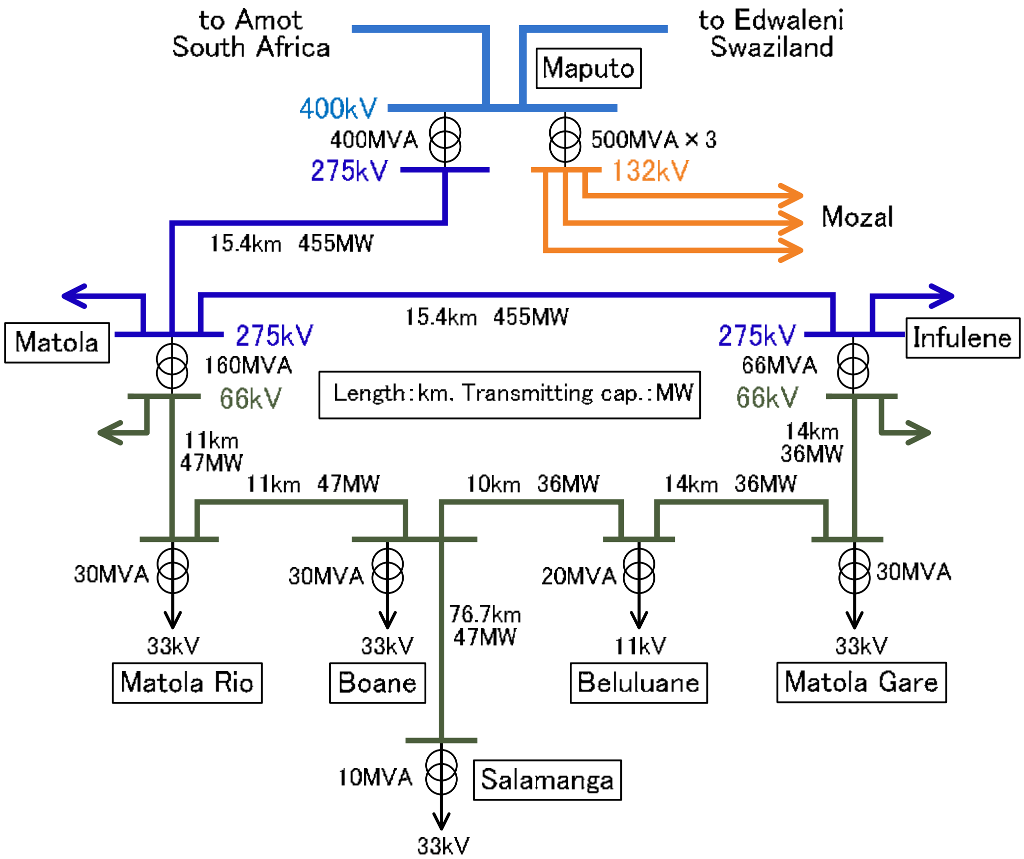
4.4 Current Situation of Power Transmission, Distribution and Substation Facilities

4.4.1 Network System in the Vicinity of the Beluluane Industrial Park

Figure 4.4-1 illustrates the network system in the vicinity of Beluluane Industrial Park. The Mozal aluminum smelter located in this Industrial Park is supplied with power directly from the Maputo substation by three circuits of the 132 kV transmission line. Other small-to-medium-sized plants are supplied with the power stepped from 66 kV down to 11 kV at the Beluluane substation within the Industrial Park, by means of 11 kV distribution lines.

The Beluluane substation is supplied with power through the 66 kV single-circuit transmission line from both terminals of the Matola substation and the Infulene substation where 275 kV is stepped down to 66 kV. The distance of transmission line to the Matola substation is 58 km through two substations located along the way, and the distance of transmission line to the Infulene substation is 50 km through one substation located along the way.

The Beluluane substation is the substation built to supply power for the construction of the Mozal aluminum smelter. This substation has been used as the Beluluane substation for the purpose of general power supply after completion of the plant construction. For this reason, the secondary voltage of the transformer is 11 kV, which is different from the standard distribution voltage of 33 kV. As a result, power cannot be supplied to meet the load of the Industrial Park from the power distribution substations located on the periphery.



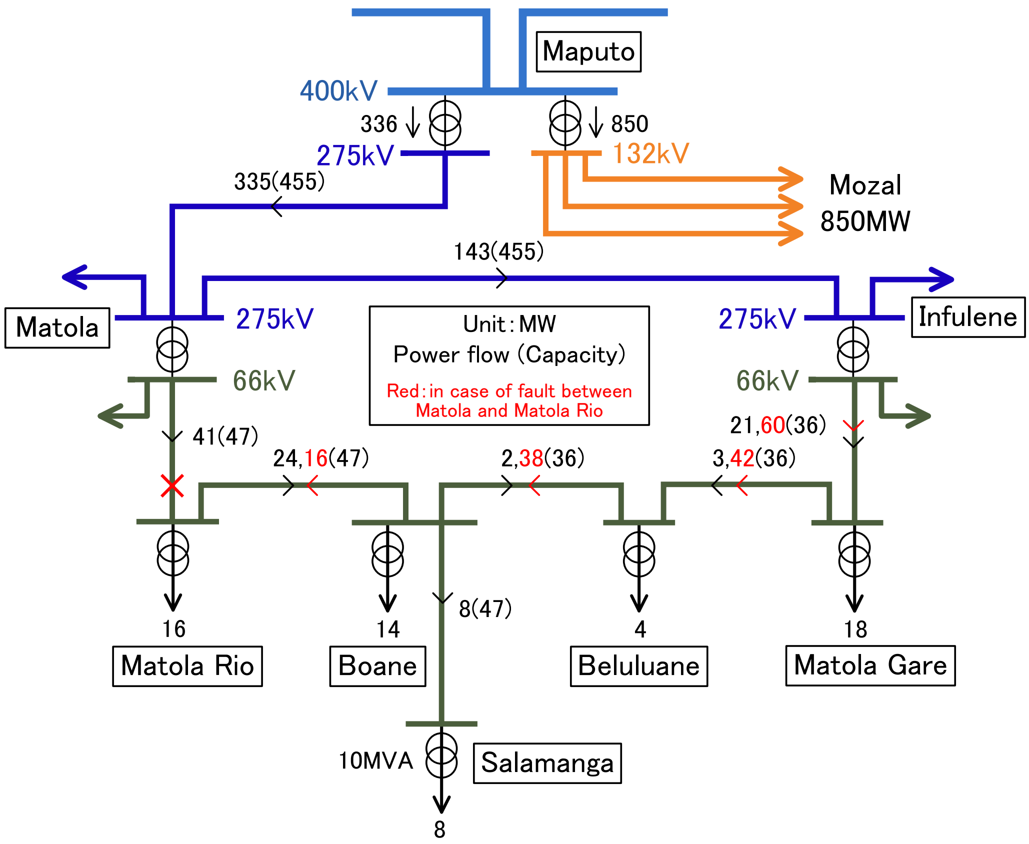
(Source: Created with reference to PSS/E network analysis data provided by EDM)

Figure 4.4-1 Network System in the Vicinity of Beluluane Industrial Park

4.4.2 Power Flow of Beluluane Network

Figure 4.4-2 shows the result of analyzing the power flow using the 2011 network analysis data provided by EDM. This diagram uses black letters to indicate the power flow in cases where the transmission line is free from any trouble, and red letters to indicate the power flow in cases where a fault occurs in the 66 kV Matola-Matola Rio line that is opened as a result.

When the transmission line has no problem, an overload does not occur. When a fault occurs in the Matola-Matola Rio line however, an overload occurs in each section of the Infulene-Matola Gare-Beluluane-Boane line where the power transmission capacity is as small as 36 MW. When consideration is given to the approximate 10-percent annual growth in the demand recorded for each of the past several years, an overload is expected to occur even when the transmission line is free from any trouble in the near future.



(Source: Created with reference to PSS/E network analysis data provided by EDM)

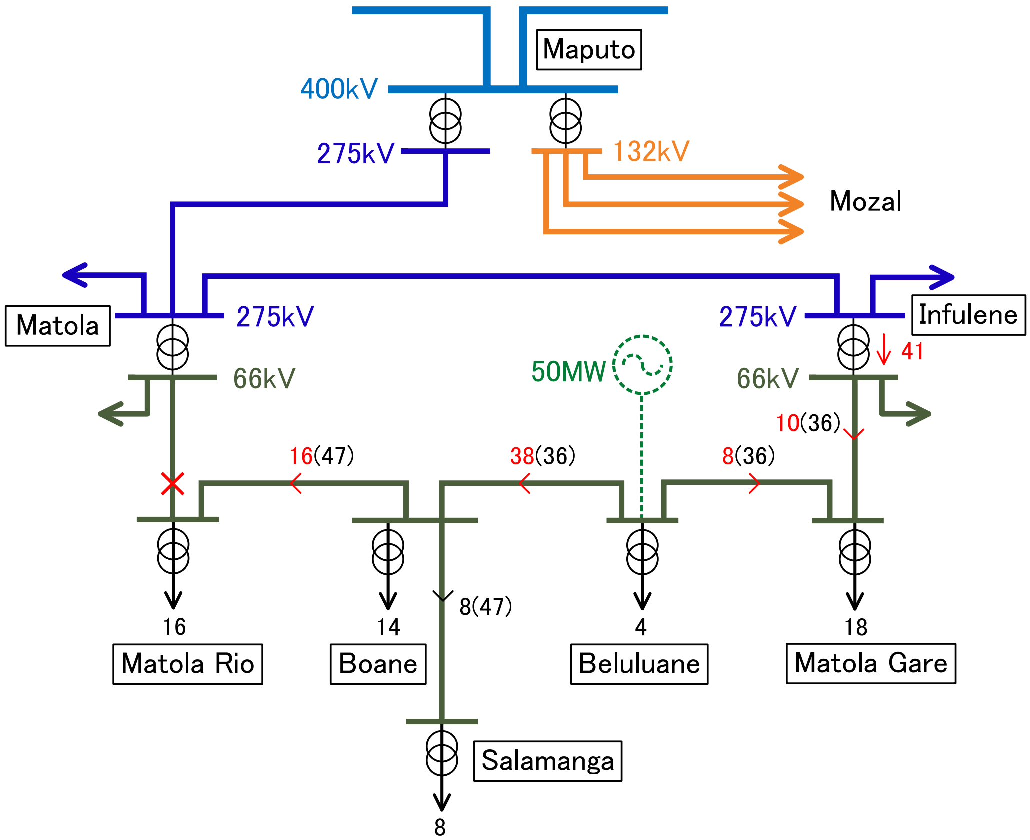
Figure 4.4-2 Power Flow in 2011 in Beluluane System

4.4.3 Measures against Overload worked out by EDM

Figure 4.4-3 shows the power flow in case of fault occurrence in the Matola – Matola Rio line when a new 50 MW generator is installed at the Beluluane substation, which is planned by EDM as a measure against possible overload.

Power flow is reduced by installation of a generator, and the overload problem is therefore solved in the Infulene – Matola Gare – Beluluane sections. However, the power flow in the Beluluane –

Boane section is 38 MW, which is slightly greater than the power transmitting capacity of 36 MW, thus causing overload to occur. One of the ways to solve this problem is to shift the load of the Matola Rio substation and Boane substation where the distribution voltage is standard at 33 kV to another substation by changing the connection of the distribution line to reduce the load of both substations. However, when the growth of the demand is taken into account, it seems that this solution will not be effective for a long time.



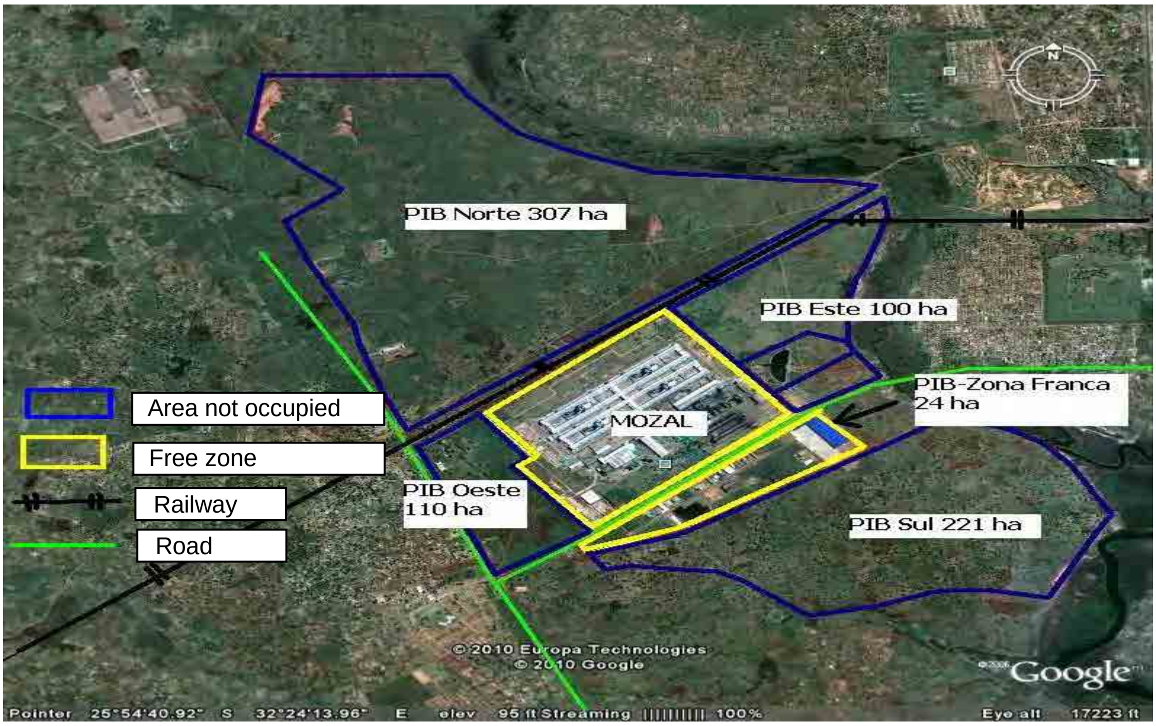
(Source: Created with reference to PSS/E network analysis data provided by EDM)

Figure 4.4-3 Power Flow in Case of Fault Occurrence after Installation of 50 MW Generator at Beluluane (2011)

4.5 Situation of the Surrounding Area and Infrastructure

(1) Beluluane Industrial Park

The total development area of Beluluane Industrial Park (excluding Mozal aluminum smelter) is 700 hectares, which is composed of the Free Zone (i.e. Export Processing Zone (EPZ) or Free Trade Zone (FTZ)) and Non Free Zone. Figure 4.5-1 shows the layout plan of Beluluane Industrial Park. Currently, only the Free Zone (24 hectares), which is immediately located south of MOZAL and across the access road, is serviced with infrastructure (e.g., electricity, water, gas, telecommunications, roads, storm water drainage, sewer, sewage treatment, etc.) to accommodate small and medium industries.



(Source: GAZEDA)

Figure 4.5-1 Layout Plan of Beluluane Industrial Park

Table 4.5-1 is the list of companies located (or to be located) in Beluluane Industrial Park as of February 2012, provided by GAZEDA.

As shown in the table, quite a few companies located in the Free Zone are businesses affiliated with MOZAL. Since most of the Non Free Zone is not serviced with infrastructure, there are no companies currently operating in this section. According to the operator of the Park (Parque Industrial de Beluluane SARL), construction of the cement factory (GS Cimentos SA) is scheduled to commence this year.

Table 4.5-1 List of Companies located in Beluluane Industrial Park

ZONA FRANCA (Free Zone)
1. Agro Alfa, SARL - Prestação de serviços de Engenharia a Mozal
2. Brian Pienaar Mozambique, Lda - Fabricacao e Prestação de serviços de equipamentos de segurança a outras empresas de zona franca.
3. Capital Star Steel, SA - Fabricação de tubos de aço
4. Chiefton Moçambique SA - Gestão e manutenção de
5. Cosmos Controls Moçambique Lda – Prestação de serviços hidráulicos a Mozal
6. Dendustri Moz Lda - Prestação de serviços de engenharia e mecânica a Mozal – reparacao de ânodos a fabrica de alumínio.
7. DRS Moçambique Lda – construção de potes com material refractário para a Mozal e instalação
8. ECL Serviços Moçambique Lda: Metalomecânica a Mozal
9. Hencon Maquinaria Lda - engenharia maçanica e manufactura de diferentes estruturas metálicas.
10. Hytec Serviços Moçambique Lda - Prestação de serviços hidráulicos a Mozal
11. Kempe Engineering Lda : engenharia mecânica
12. Laresh International Lda : Servicos e Engenharia a Mozal
13. MRO Produtos Industriais Lda- Fabricação e fornecimento de materiais de segurança de trabalho para as empresas de zona franca
14. Nat Africa Constructions & Manufacturing Lda : prestação de serviços de fundição de alumínio e derivados
15. Omega Serviços - Zona Franca Lda : serviços de transporte e lavandaria as empresas de zona franca
16. Operações Duys Moçambique Lda : Reparação dos potes de alumínio a industrial Mozal
17. Parque Industrial de Beluluane SARL : Operador
18. Ram Trading : Fundição de aço
19. Sunshine Limitada: Processamento e Empacotamento de castanha de caju
20. Somacal Metalomecânica: Metalomecânica a Mozal
21. Técnica e Engenharia Moçambique Lda (TEMOC): serviços eléctricos a Mozal
22. Trentyre Moçambique Lda : serviços pneumáticos a Mozal
23. Turnkey Solutions Moçambique: Prestação de serviços de construção as empresas de Zona Franca
ZONA NÃO FRANCA (Non-Free Zone)
1. Abbey Moz Lda : fabricação e montagem de perfis de alumínio
2. Agridelta Moçambique Lda: Insumos agricolas
3. Cheater Industrial Roofing Moçambique Lda : fabricação de e montagem de tectos –
4. Cimento Nacional, Limitada: Fábrica de Processamento de Cimento
5. Gastov : processamento distribuição de gás doméstico.
6. GS Cimentos SA: Fábrica de Cimento
7. Harrop Allin Moçambique Lda - Montagem de vedação e outros serviços
8. Oasis Grease Refinary – Fabrica de lubrificantes
9. Opway – Engenharia, SA – Construcao civil
10. Pierlite Moçambique Lda – Fabrica de montagem de perfis eléctricos
11. Rompco Moçambique Lda

(Source: GAZEDA)

(2) Water Supply

In 1998, the government adopted a comprehensive institutional reform for the development, delivery and regulation of urban water supply services in large cities. The new framework, known as the Delegated Management Framework, was inaugurated with the creation of two autonomous public bodies: an asset management agency (FIPAG) and an independent regulator (CRA).

In 1999, FIPAG signed a 15-year lease contract with a private operator (Aguas de Moçambique: AdeM) for water supply in the capital city, Maputo, and management contracts for water supply in four provincial capitals (i.e. Beira, Quelimane, Nampula and Pemba). AdeM was created by a consortium of foreign water supply operators (i.e. the French private operator, SAUR[7] and Aguas de Portugal) and local investors. The current Maputo water supply system covers the Maputo metropolitan area (Maputo city, Matola city and Boane district).

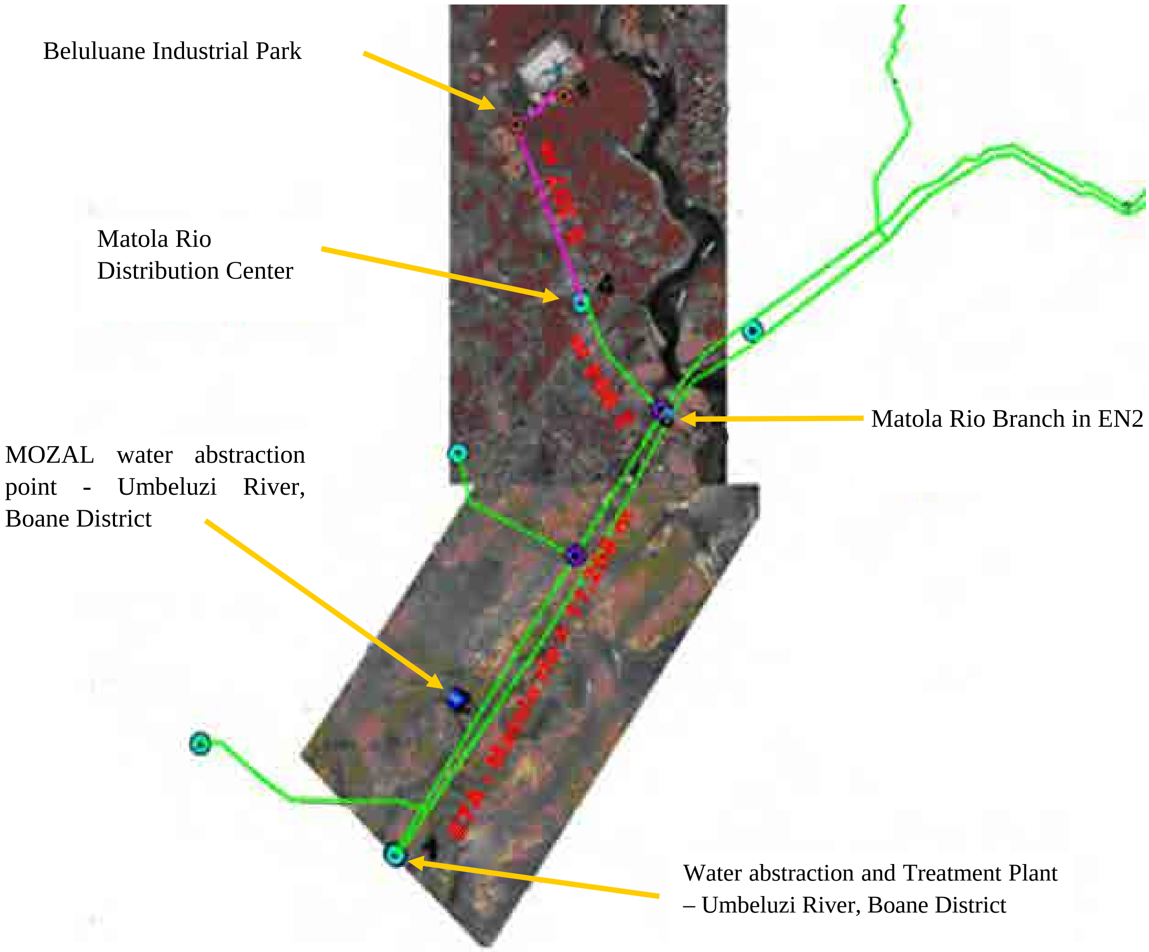
As shown in Figure 4.5-2, the water intake and treatment plant is located 18 km from Beluluane Industrial Park (along the pipeline route). While the capacity of the water treatment plant is 10,000 m^3/h, the current water demand in the Maputo metropolitan area is slightly below 9,000 m^3/h. Figure 4.5-2 shows the route of the pipeline from the intake point to Beluluane Industrial Park. Up to Matola Rio Branch in EN2 (National Highway No.2), three water mains (with diameters of 800 mm, 1,000 mm and 1,100 mm) are closely laid parallel to one another. From Matola Rio Branch to Matola Rio Distribution Center (DC) there is a 300 mm diameter pipeline with a maximum water conveyance capacity of 500 m^3/h, and from Matola Rio DC to the Park there is a 200 mm pipeline with a capacity up to 250 m^3/h. It should be noted that this is not a dedicated pipeline to the Park but it supplies the population along the way to the Park. The current water demand in the Park is around 600 m^3/day.

According to AdeM[8], it is necessary to install a new pipeline with a diameter of 400 mm from Matola Rio Branch in EN2 to the Park (8 km) to supply the additional water demand of 200 m^3/h, which corresponds to the make-up water demand for a 70 MW class gas-fired CCPP equipped with forced draft cooling towers. However, a steady increase in water demand for human consumption in the Maputo metropolitan area is expected and it is possible that there will be a shortage of water for essential uses in the near future.

In fact, MOZAL has installed its own raw water supply system that includes the water intake in the same river but in a different location, and the pipeline follows the same route as the potable water pipelines (see Figure 4.5-2). This water is used for industrial processes similar to the cooling water system.

[7] In 2001, AdeM encountered serious financial difficulties due to flood damage in 2000. In addition, SAUR terminated its involvement and sold its shares to Águas de Portugal. Subsequently, FIPAG and AdeM's remaining partners led by Águas de Portugal renegotiated the contracts introducing higher fees and improvements in the specification of service obligations. The Revised Lease Contract became effective in April 2004, and will terminate on November 30, 2014.

[8] The information presented here was obtained through email-based correspondence with a representative from AdeM.



(Source: AdeM)

Figure 4.5-2 Route of Existing Water Pipelines

(3) Ports

Six of Mozambique's seven seaports are operating through involvement of the private sector, which positions Mozambique as a country with a relatively high level of private sector involvement in the port system. In 2003, the ports of Maputo and Matola were conceded to a consortium that included the Maputo Port Development Company (MPDC). MPDC is a Mozambican registered company formed to operate the concession to redevelop the ports Maputo and Matola in Maputo city. In 2003, MPDC was given the concession for Maputo Port for a period of 15 years, with an option to renew for a further 15 years. In 2010, the concession period was extended for another 15 years, with an option to extend it for a further 10 years for any operations after 2033. The current shareholding rate of MPDC is shown in Table 4.5-2[9]:

[9] The original consortium included the Merseyside Docks and Harbour Company, Skanska AB of Sweden and Liscont SA of Portugal, with equal shares of a 51% shareholding. The other 49% is held by CFM with 33% and the Government of Mozambique with 16%, held in trust by CFM. Over the years, shares have changed hands and from early 2008, Dubai Port World and the South African freight company Grindrod became the majority shareholders in MPDC.

Table 4.5-2 Shareholding Ratio of CFM

<table>
<tr><td>Grindrod SA</td><td rowspan="3">57%</td><td>48.5%</td></tr>
<tr><td>DP World (UAE)</td><td>48.5%</td></tr>
<tr><td>Mozambique Gestores</td><td>3%</td></tr>
<tr><td>CFM</td><td>33%</td><td></td></tr>
<tr><td>Mozambique Government</td><td>16%</td><td></td></tr>
</table>

(Source：MPDC website)

The Maputo port complex consists of the main port of Maputo and its subsidiary port of Matola, located 6 km upstream.

Since the Port of Maputo is situated at the mouth of the river, continuous maintenance dredging of the channel and berth basins, etc. is required to keep them open for large vessels. The North Channel, which serves as the access channel, was initially designed for a depth of 9.5 meters. Due to the dredging works done in 2010/2011, the channel has a minimum depth of 12 meters and it now caters to Panamax ships (70,000 DWT class).

The characteristics of each of the terminals are presented in Table 4.5-3 along with their handling equipment.

Table 4.5-3 Specifications of Maputo Cargo Terminal and Matola Bulk Terminal

Name of Port Facility	Length	Equipment	Shed	Use
		Maputo Cargo Terminals		
Coastal Terminal	288m		●	Coastal (cabotage) Traffic
Berth 1	163m			Small Vessels, Bunker Barge and Tugs
Berth 2	150m			Trawlers, Warships, Cruise Liners
Berth 3	225m		●	Break-Bulk, RoRo, Cruise Liners
Berth 4	225m		●	Break-Bulk, RoRo
Berth 5	227m			Break-Bulk, RoRo
Berth 6	98m			Small Vessels
Berth 7	200m		●	Citrus Terminal, Reefers, Break-Bulk, Molasses Terminal
Berth 9	200m		●	Citrus Terminal, Reefers, Break-Bulk
Berth 10	400m	2 X Bulk Sugar Loaders	●	Bulk Sugar Terminal, Bagged Sugar Terminal, Break-Bulk
Berth 11	200m		●	Ferrochrome Terminal, Scrap Metal Terminal, Break-Bulk, Bulk
Berth 12 and 14	450m	2 X 35 ton Gantry Crane	●	Container Terminal
Berth 15	185m	2 X Heavy Mobile Cranes		Break-Bulk, Bulk
Berth 16	172m			Break-Bulk, Bulk, Bulk Liquids Terminal
		Matola Bulk Terminal		
Coal Terminal	205m	1 X Shiploader		Bulk Coal and Minerals Terminal
Petroleum Jetty	230m	4 X Chiksans		Petroleum Terminal
Aluminum Terminal	210m	2 X Vacuum Bulk Discharger	Silos	Mozal Aluminium Terminal
Grain Terminal	210m	2 X Vacuum, 1 X Shiploader, Bulk Discharger		Bulk Grain Terminal and Silos

(Source: Port Maputo Handbook & Directory 2010/2011)

The Port of Maputo is the export gateway of the Maputo Corridor, a major import and export route that consists of 3 railway lines. The Ressano Garcia rail line (88 km in length) links Maputo to the RSA and carries commodities such as coal, sugar, citrus and steel from both the RSA and Zimbabwe. The Goba line (74 km in length) links Maputo to Swaziland and caters to sugar, coal, molasses and pulp traffic. The 3rd railway line is the 534 km Limpopo line which links Maputo to Zimbabwe. The Port is also connected to Johannesburg in South Africa through EN4 and to Swaziland through EN2.

(4) Transportation Route

The heavy weight equipment to be transported during construction of the CCPP includes a gas turbine as the main engine, steam turbine, HRSG, generator and transformer.

Heavy weight cargoes will be discharged at the Maputo Cargo Terminal, which has a cargo terminal that allows carrying of large cargo that will be transported by trailers through to the power plant site. Figure 4.5-5 shows a possible transportation route for the heavy weight equipment and materials during construction of CCPP. This figure exhibits two alternative power plant sites: the site within the existing Maputo Thermal Power Plant (Alternative-1) and the site within Beluluane Industrial Park (Alternative-2). Both sites are served by arterial high-standard highway(s) with at least two lanes each way (EN2 and/or EN4). For Alternative-2, there is a bridge across Matola River on the access road linking EN4 and Beluluane Industrial Park. However, repair and renovation of the bridge will not be required for construction of CCPP, since the bridge should allow the heavy load trailers during construction of MOZAL Phase 2.

EN2 (two or three lanes each way)

EN4 (two lanes each way)

(Source: JICA Study Team)

Figure 4.5-3 Photographs of Transportation Route

Figure 4.5-4 Transportation Route of Materials

4.6 Status of Environmental and Social Considerations

4.6.1 Beluluane Site

(1) Power Plant Site

The power plant is planned to be located at the Beluluane Industrial Park (Boane district, Maputo province, Mozambique). This site is approximately 15 km from Matola Port, adjacent to the existing Beluluane Substation. A 1 ha plot has been secured for the power plant.

(2) Natural Conditions

The planned construction site is located within the existing Beluluane Industrial Park and the plot was leveled at the time of developing the park. There seems to be no rivers, deep ditches or depressions inside the plot. The climate is tropical, average annual rainfall is 400 ~ 860 mm, the dry season is around May to September and the rainy season is around November to March. The following photographs show the current state of the site.

View from center of site towards north

View from center of site towards east

(Source: JICA Study Team)

Figure 4.6-1 Photographs of Beluluane Site

(3) Flora

The site consists predominantly of degraded Miombo Savannah. Most of the woody vegetation has therefore been cleared, and the area is dominated by relatively open grassland with scattered shrubs and small trees. Therefore, impact on flora due to the construction of the power plant is expected to be minimal or negligible. However, it shall be noted that a detailed assessment shall be made in the EIA before implementation of the project.

(4) Social Situation

All local people living within the boundaries of the Beluluane Industrial Park have been resettled to adjacent lands and currently there are no households or any kind of settlement or agricultural activity inside the boundary of the project site. However, small-scale agricultural activity, e.g., corn and beans, were observed in other open plots within Beluluane Industrial Park. This is because communities are allowed to grow crops within the park until a developer requires the land, at which time they are required to vacate this land and are not entitled to compensation.

4.6.2 CTM Maputo Site

(1) Surrounding Area of the CTM Maputo Site

The plot for the planned power plant is reclaimed land managed by EDM. The plot is surrounded by the national highway (EN2, 4 lanes), railway line (double track), and Maputo Bay. The other side of the national highway in the north spreads across a low-rise residential area and a commercial area. On the east side over the railway line, which connects the main line to Maputo commercial port, spreads a low-rise residential area. The site faces Maputo Bay in the south. The water is shallow and during low tide, the tideland appears over a wide area. The west side of the site is the mouth of Infulene River that flows into Maputo Bay.

(Source: JICA Study Team)

Figure 4.6-2 Surrounding Area of CTM Maputo Site

(2) Power Plant Site

There are three gas turbine generators, which do not generate power at the moment, oil tanks, a substation (CTM S/S), and EDM training facilities in CTM Maputo. In addition, there used to be a coal-fired power plant in CTM Maputo but as of today the remaining are: an open area which used to be the coal stock yard, a partially demolished power house, a water discharge facility, and an intake water bridge which is seriously damaged and deteriorated.

A fence/wall along the boundary of CTM Maputo isolates the site from the outside public area and there is no illegal occupancy of land so resettlement is not necessary.

(3) Water Intake and Outfall

The new gas-fired power plant will require taking in seawater to cool the condenser and discharge the heated water into the Maputo Bay. Although there is an effluent standard (temperature) established in Mozambique, it regulates effluent from small-scale commercial business or households, but not for thermal power plants (according to a local environment consultant). Therefore, it is thought that globally accepted effluent standards such as the World Bank Standard or any other equivalent standards should be applied to the project. Details on the application shall be investigated in the future study.

(4) Flora and Fauna

Residential areas and commercial land spreads to the east and north of the site and species that require protection were not identified. A wide area of mangroves along the tideland lies to the west and south of the site along the coastline. According to the authorities, there are no fauna that require special protection in this area, including shrimp that are susceptible to the mangrove environment. Furthermore, it was pointed out by the authority that a full EIA will be required if the project requires cutting down the mangroves, and in addition, if there are any landowners in the said area, compensation shall be made in accordance with the regulations.

(5) EIA of the Gas Pipeline

Fuel to the site will be procured from a new connection point planned to be established near the CTM Maputo boundary. The supply pipeline up to the connection point will be constructed by the so-called “ring-project” which will be invested by ENH and KOGAS (South Korea). The ring-project is aimed at supplying natural gas to the center of Matola and Maputo. Construction is scheduled to start in October 2012 and finish in November 2013. The EIA for the project has been completed (the environmental consultant for the project is SEED Ltd.) and negative impacts on the environmental or social aspects that require particular attention have not been confirmed in the report.

(6) EIA Category of the Project

In accordance with the regulations on the EIA process in Mozambique, construction of a gas-fired power plant is categorized as “Category A” and requires an EIA (and other documents, see Chapter 5 for details). However, for this site in CTM Maputo, the new 70 MW class gas-fired power plant is not expected to bring major negative impact on the environment because resettlement is not required, there are already three gas turbine generators installed on site, and the site has been cleared and leveled. On the other hand, there are commercial and residential areas to the north and east of the site. The negative impacts to these surrounding areas are expected to be minimized if the power plant facilities are located in the south part of the plot.

The south of the plot is covered by mangrove in Maputo Bay. At the moment, the impact on mangroves due to the water intake and discharge facilities cannot be estimated. Therefore, it is necessary to examine the impact in detail in the EIA to be implemented in the next stage.

4.7 Consideration of Positioning and Adequacy of the Construction Plan

4.7.1 General

In the southern area, particularly in the metropolitan area where electricity demand is anticipated to register a steady long-term growth, EDM has the intention to promote the construction of a gas-fired thermal power plant as a new power source. For the purpose of putting the idea into effect, EDM has worked out a project proposal for promotion of a gas-fired thermal power generation project in the Beluluane area and has requested assistance from the Government of Japan. Supply of thermal power (50 MW) is already reflected by EDM in the demand-supply plan for the period up to the end of 2015.

If the power supply volume is increased by providing a power source that can reduce environmental impact, there will be a significant contribution to economic development and reduction in poverty, which is the national target of the Government of Mozambique. Moreover, as that particular power source is based on the power development plan and supply/demand plan at the national level, development of this power source is sufficiently justifiable.

In order for Japan to support the Mozambican power sector from a strategic viewpoint, it is necessary to conduct sector surveys on a regular basis in the future and to have a closer tie-up with other developed countries. This assistance does not overlap or conflict with that offered by any other countries that precede Japan in providing assistance. Moreover, it is noteworthy that other countries are also expecting support to be extended by JICA, which represents Japan in assistance of this kind.

Combined cycle power generation technology is planned to be adopted in the power plant for the present project. It is believed that Japanese manufacturers have international competitiveness in such technology. It can be said, therefore, that if Japanese suppliers participate in the competition for the power plant project, a promising market will be formed. The Mozambican power sector shows signs of recording drastic growth in the coming years. Considering the strong need for the power plant project as requested by the Government of Mozambique and the potential market in which Japanese technologies can be deployed, it will be very meaningful to implement a detailed survey for the gas-fired thermal power generation project plan in this metropolitan area.

The following describes the other rationale or grounds to justify conducting the survey under assistance of JICA:

(1) Optimum Mixture of Power Source

Most of the power is supplied to Mozambique by the Cahora Bassa Hydroelectric Power Plant whereas thermal power plants supply only a few percent. Since the generation capacity of the hydroelectric power plant depends heavily on the fluctuation in the amount and level of water, excessive dependency on hydroelectric power generation is not recommendable. From the viewpoint of the optimum mixture of power sources, it is necessary to maintain a certain percentage through the use of a thermal power generation system with environment-friendly technology.

(2) Improvement in Energy Security

An increase in the percentage of thermal power generation contributes to improvement of energy security. Further, in the event that an accident occurs on the power transmission line from the Cahora Bassa Hydroelectric Power Plant to the power pool of South Africa, or on the power transmission line from the power pool to Mozambique, there will be a serious negative impact on the power supply to the capital, Maputo. To avoid this, it is important to build power generation facilities in the vicinity of Maputo as one of the measures to increase energy security.

(3) Contribution to Improvement of the Environment

A greater amount of air pollutants, such as NO_x, SO_x and dust contained in the emission gas, can be reduced by natural gas-fired power generation than by diesel oil-fired power generation. In this sense, natural gas-fired power generation is expected to make a significant contribution to improvement of the environment. Further, the combined cycle power generation proposed herein provides an increase of approximately ten percent (10%) in plant (thermal) efficiency over power generation by gas-fired turbine or diesel oil-fired power generation alone. This will lead to a reduction in the volume of carbon dioxide gas produced, and pave the way to make the proposed project a CDM project.

(4) Improvement in Economic Efficiency

The currently installed thermal power generation facilities, which consist of diesel power plants and gas turbine power plants, use liquid fuel such as diesel oil. The operating cost has increased due to the global rise in the price of crude oil. Thus, the operating cost can be reduced by using less costly natural gas that is produced domestically. Further, if the availability factor in terms of operation can be improved, overall economic efficiency will increase.

The subsequent section describes the considerations regarding the power system associated with the construction of the Beluluane Thermal Power Plant.

4.7.2 Alternative Measures against Transmission Line Overloading

It shall be noted that a generator is rarely installed to take measures against possible overload in a transmission line. Normally, an additional transmission line is installed parallel to the overloaded transmission line. This will form a double-circuit line in that section, resulting in a situation where not only measures against overload are ensured but also, in case of fault occurrence in one of the circuits, linkage with the main network will be maintained by the circuit where the fault did not occur. This will greatly improve power supply reliability.

Assuming that the unit construction cost required by reinforcement of this transmission line is 0.1 million US$/km as a ballpark figure, the total construction cost is estimated at 3.8 million US$ for the overall length of 38 km for the Infulene-Matola Gare-Beluluane-Boane section. This means a substantial cost saving compared to the cost of installing a generator.

Since the power transmission capacity of the existing 66 kV transmission line is only 36 MW, the generator capacity to be adopted is limited to only 50 MW. This will fail to provide the benefit of economics of scale, the per-kilowatt unit construction cost will be increased, and the generating efficiency will be reduced. These factors may lead to worsening of the economic feasibility of the proposed project.

Further, according to EDM's power sector Master Plan, commercial operation of the proposed Cahora Bassa North Power Plant (1,245 MW) and the Mphanda Nkuwa Power Plant (1,500 MW) will start in 2017. If the annual growth in demand is assumed to be 10 percent in order to ensure the power supply before the commencement of commercial operation of the power plants mentioned above, a demand increase of approximately 200 MW will be anticipated during the course of the three years from 2014 to 2017 in which the earliest production of a 50 MW facility will be completed. This may result in insufficiency in power supply capacity.

The above preliminary investigation suggests that measures should be taken against overload in the transmission line to reinforce the transmission line, and supply-demand balance improvement measures should be taken in such a way to select a larger-sized power plant site where easier acquisition of fuel and cooling water is ensured.

4.8 Economic Viability

In this section, the unit cost of generation of electricity (hereinafter called “generation cost”) for the proposed Maputo Thermal Power Plant Project is preliminarily calculated and thence, by comparing it with relevant figures of alternative projects, the economic viability of the New Maputo Thermal Power Plant Project is preliminarily examined.

(1) Calculation Method of Production Cost

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

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

Where, Σ NPV (Cost) : Sum of discounted[10] future cost (construction cost, O&M cost and fuel cost)

Σ NPV (Electricity) : Sum of discounted future electricity to be produced at sending-out

(2) Basic Parameters

The basic parameters used for the LCOE calculation are summarized in Table 4.8-1.

Table 4.8-1 Basic Parameters Used for Calculation of LCOE

Item	Value	Remarks
Installed capacity	70 MW	See Section 4.3
Capacity factor	70%	Ditto
Thermal efficiency	50%	Ditto
Annual electricity production	429,240 MWh (=70 MW×70％×24 hours×365 days)	－
Construction period	2 years	－
Operation period	30 years	－
Construction cost (excluding IDC)	74,624,000 US$	Based on Project Proposal prepared by EDM
O&M cost	3,731,200 US$/year	Assuming 5% of the construction cost
Gas purchase price	4.7 US$/GJ	Based on information given by ENH
High heat value (HHV)	52,637 kJ/kg	－
Low heat value (LHV)	47,587 kJ/kg	－
Annual gas consumption (at HHV)	3,418,485 GJ/year	－
Fuel cost	16,066,880 US$/year	Assuming the gas to be traded on an HHV basis

(3) Preliminary Evaluation of Calculation Result

Based on the parameters set forth in (2), the generation cost of New Maputo Thermal Plant is estimated at <u>6.55 USc/kWh.</u> This value 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

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

if the New Maputo Thermal Power Plant is operated as a peaking power plant (although the proposed plant is assumed to operate in baseload mode), it can generate electricity at a competitive price in the market.

Furthermore, if the production cost of the New Maputo Thermal Power Plant is level with the supply cost of electricity generated at the new hydro plants in Tete province to the south (6.4～7.3 USc/kWh)[11], it is highly likely that the proposed plant will be able to operate even after commissioning of the said hydro plants.

Since the evaluation of economic viability of the proposed New Maputo Thermal Power Plant Project presented here is based on a number of assumptions and may contain a certain amount of uncertainty, economic viability of the project shall be carefully examined in the detailed study (F/S).

4.9 Recommendation for Implementation of Detailed Survey

It is recommended to initiate a gas-fired combined cycle power generation project in the southern area as a cooperation project between Japan and Mozambique in the power sector of Mozambique. To bring the project into realization, a preparatory survey is required to investigate the feasibility of the project. This section discusses the basic policy, precautions and working items required for this survey, based on the assumption that a detailed investigation will be made for two options for the site: the Beluluane site and CTM Maputo site.

4.9.1 Request by Mozambique and Policy for Meeting This Request

In the Project Proposal "Beluluane Power Plant -- 50 MW CCGT Power Plant" discussed in 5.1, EDM requests the cooperation of Japan in the project to implement Beluluane gas combined cycle power generation. In its implementation, EDM divides the entire project into two components, a consultancy contract and an EPC contract, with requests for the following tasks in the consultancy contract:

Output I:

a) A detailed project proposal
b) A preliminary survey on the project site
c) Socio-economic survey
d) Environmental and social impact assessment (ESIA)

Output II:

a) Tender preparation and contract negotiations with the contractor for the turn-key supply and erection contract
b) Elaboration of detailed survey and design performed by the assigned contract

[11] This value is sum of the unit generation cost of two hydro plants (i.e. Cahora Bassa North 1 and Mphanda Nkuwa 1) and unit transmission cost via transmission lines created by CESUL Projects (Ref: Volume II Economic Impact Study; Final Report of Mozambique Regional Transmission Backbone Project, 2012)

c) Control and inspection of the supplied equipment for the construction

In the general framework of the JICA preparatory survey, all the tasks of Output I are included, but the tasks of Output II are to be implemented in the phase of a yen credit project subsequent to the completion of the preparatory survey. The following sections propose the detailed survey based on the framework of the preparatory survey.

4.9.2 Survey Policy and Precautions in Detailed Survey

The preparatory survey (hereinafter referred to as "the Survey") will be implemented based on the following survey policy and precautions:

1) Since the Survey is to be conducted with EDM, close coordination with EDM is required. EDM is responsible for providing the JICA Study Team with all necessary data and information and will take part in the study and compilation of the report of the Survey.

2) EDM will assign the staff officials as counterparts and will share use of the details of the Survey whenever required.

3) In the final report for “Data Collection Survey on the Power Sector of Mozambique,” the results of the preliminary investigation for the proposed thermal power plant in the southern region are included. Based on the results, the Survey will be conducted.

4) The two candidate project sites will be the one inside Beluluane Industrial Park and the vacant lot within the existing Maputo Thermal Power Plant (CTM-Maputo). From technical and economic viewpoints, the optimum gas-fired thermal power plant construction site shall be selected. The Survey will be carried out in two steps. In the first step, an approximate comparison and study of the two candidate sites will be made to submit the optimum proposal. After this proposal has been verified and approved by EDM and JICA, the second step will be carried out to implement a feasibility study of the selected site.

5) Wherever possible, the Survey period shall be shortened in order to allow for the earliest commencement and completion of the yen loan-financed project, which will be implemented after completion of the Survey.

6) The power generation capacity of the generation facilities to be examined in the Survey is estimated to be up to approximately 100 MW, if such capacity is deemed possible after careful investigation. In the Survey, each unit capacity and number of units shall also be studied and an optimum plan shall be proposed, taking into account the volume of gas to be supplied and the volume of cooling water for the present and in the future, procurement of the site including that for future extension, impact of natural and climatic conditions such as cyclones, and restrictions resulting from the capacity of the connected power system.

7) It should be noted that the type of power generation system to be introduced into this

power plant will be determined through close discussions and consultations between JICA and EDM.

8) All the required environmental and social consideration surveys shall be conducted in conformity with the environmental impact assessment system of Mozambique by paying full attention to the JICA environmental and social consideration guidelines.

9) Proposal on local subcontracts required for the Survey and implementation thereof (for the subcontract, see 5.8.3).

4.9.3 Work Items for Detailed Survey

The work items shall be as follows:

(1) Confirmation of Background and Necessity (power supply-demand status and power development program)

1) Current situation and issues/challenges of the power sector of Mozambique
   a) Confirmation of supply-demand balance in the power sector
   b) Confirmation of the outline of the current situation of power sector and confirmation of issues/challenges

2) Confirmation of the policy and plan of the power sector in Mozambique (development program/sector goal)
   a) Confirmation of the related laws and policies related to the power sector
   b) Confirmation of the priority in implementation of this project and appropriateness of the implementation

3) Current status of the assistance for the power sector by other donors (U.N. and other international organizations) and assistance policy

4) Current situation of the target field/area

5) Study of alternative proposals (study of power generation methods other than the method using gas)

6) Positioning of this project in the Mozambican power sector, including the facility availability factor in the connected power system of this project

(2) Selection of the Planned Construction Site

The candidate project sites will be the site within Beluluane Industrial Park and the vacant lot in the existing Maputo Thermal Power Plant. From technical and economical viewpoints, the optimum gas-fired thermal power plant construction site shall be selected.

(3) Collection and Confirmation of Basic Data and Information (information on topographic features and geological features, meteorological and oceanographic information, transmission system, social and economic information, etc.)

With regard to this item, the following survey shall be conducted on the planned construction site selected in (2) above. If data on the geological features is already available, that data shall be collected and analyzed. Based on the result of this analysis, the necessity for boring or other processes shall be determined.

1) Overview of topographic and geological features at the planned power plant construction site
   a) Topographic survey
   b) Soil investigation (including boring)

2) Overview of the coastal area at the planned power plant construction site
   a) Bathymetric survey

3) Various forms of meteorological data (wind direction, wind velocity, precipitation, ambient temperature, humidity, atmospheric components, etc.)

4) Various forms of oceanographic data (tide level, seawater temperature, waves, hydraulic regime, drift sand, and water quality)

5) Social and economic activities around the planned power plant construction site

6) Social and economic activities in the planned gas and water pipeline installation area

(4) Study of Adequacy of the Development Size, Site and other Factors related to the Relevant Power Plant Development Program

(5) Study on the Fuel Supply Program (power generation fuel, supply method, supply plan, analysis of properties of natural gas, etc.)

1) Survey and analysis of fuel situation
2) Study on power generation fuel
3) Study on supply method
4) Drafting of fuel supply plan

(6) Study on Power Transmission Method and System Analysis (power flow, fault current, system stability)

As a general rule that the transmitting capability of existing facilities should be utilized to the utmost extent to avoid the reinforcement of transmission network, installable generator capacity will be reviewed from the view point of network by conducting network analysis and study on the new and reinforced facilities required to transmit the power generated by the power plant. Finally the optimum power transmission method for the power plant will be determined as viewed from economic factors and reliability. The following shows the specific analysis items to be conducted:

1) Power flow analysis
2) Fault current analysis
3) Stability analysis

(7) Implementation of Facility Design

Implement basic facility design including facility layout, foundation structure, specifications of the power generation and substation facilities and control system, connection to the existing transmission line and its control, need for installing cooling tower facilities, cooling water intake and discharge method, study of water level and route, and study of raw water treatment method. Further, the transportation method and route of the heavy equipment and material to the specified site shall be studied.

(8) Formulation of Yen Credit-based Project

1) Confirmation of the scope of the project and adequacy of design standards
   This item includes the study of the power plant, substation facilities, transmission line and other auxiliaries.
   a) Study on the overall program and implementation method
   b) Site layout plan
   c) Plant type and size, and unit capacity
   d) Fuel supply and processing system
   e) Cooling water and make-up water supply system
   f) Substation facilities
   g) Study on transmission line route
   h) Civil engineering and construction facilities
   i) Other auxiliaries

2) Estimation of the project costs and amount of yen credit

3) Study of the project implementation schedule
   In the construction of the relevant power plant, close coordination among different types of work is important to ensure smooth implementation of the overall construction work. In the Survey, implementation program reflecting the result of the facility design shall be worked out from this viewpoint. In this case, the plan shall take into consideration the procurement and removal of the construction equipment and material, as well as the arrangement of the operation personnel.

4) Study on project implementation and operation maintenance management system

5) Economic and financial analysis (EIRR, FIRR and operation effect indicators)

(9) Survey of Environmental and Social Considerations

1) Implementation of environmental survey

The natural environmental survey shall cover the items related to topographic features, groundwater, hydrology, river area, meteorology, landscape, flora and fauna, and global warming.

The survey of the natural environment shall be conducted based on the existing data and through interviews with the related personnel at the site. Further, the investigation of pollution control measures shall cover the items related to air quality (including prediction of air pollution), water quality (including prediction of diffusion of warm wastewater), waste, noise/vibration, land subsidence and accidents.

2) Confirmation of environmental impact

a) Confirmation of assistance in creating the EIA Report, compatibility with the Mozambican domestic law (including confirmation of procedures), and compatibility with the JICA environmental and social consideration guidelines
b) Confirmation of the required supplementary items and implementation of supplementary surveys
c) Recommendations regarding the environmental management and environmental monitoring procedures
d) Support for discussion with inhabitants regarding EIA-related items
e) Drafting and explanation of materials for the environmental and social consideration stakeholder meetings, and support for responding to the question-answer session in the meetings

3) Confirmation of social considerations

The social and environmental survey shall cover the items related to the local economy, financial relationships in the community, utilization of water in the community, water rights, sanitation and infectious diseases. Further, the resident relocation program shall include implementation of the following items:

a) Confirmation of the need for creating a resettlement action plan (RAP) report
Review of the RAP, confirmation of compatibility with the Mozambican domestic law (including confirmation of procedures), and compatibility with the JICA environmental and social considerations guidelines, wherever applicable
b) Confirmation of the required supplementary items and implementation of supplementary surveys
c) Recommendations regarding the living condition monitoring method after land acquisition and resident resettlement
d) Support for implementation of discussions with the residents regarding the resettlement action plan

4) Review of the environmental checklist

(10) Implementation of Workshop

During the final site survey, a workshop shall be conducted. In the workshop, the results of the Survey shall be reported by the Survey Team selected by JICA. Further, comments from the Mozambican side shall be collected. The results of handling these comments shall be reflected in the Draft Final Report.

(11) Items to be Locally Subcontracted

The following work items are assumed to be undertaken using local subcontractor(s):

1) Data collection of the topographic and geological features at the planned power plant construction site (see (3), 1, a) and b), "Overview of topographic and geological features at the planned power plant construction site" described above)
2) Data collection of the coastal area at the planned power plant construction site (see (3), 2), a) "Overview of the coastal area at the planned power plant construction site")
3) Assistance in the collection of various forms of meteorological data (see (3), 3) "Various forms of meteorological data (wind direction, wind velocity, precipitation, atmospheric temperature, humidity, atmospheric components, etc."))
4) Assistance in the collection of various forms of oceanographic data (see (3), 4) "Various forms of oceanographic data (tide level, seawater temperature, waves, hydraulic regime, drift sand, water quality, etc."))
5) Assistance in the collection of environmental and social consideration survey (see (9) "Survey of environmental and social considerations")

Chapter 5 Data Collection and Review on the Environmental and Social Considerations

5.1 Laws and Regulations regarding Environmental and Social Considerations

The Constitution of the Republic of Mozambique (2004) addresses matters relating to the environment and quality of life and it provides humans the right to live in a balanced environment, and commits "the State and local authorities, in collaboration with other appropriate partners, to adopt policies for the protection of the environment and care for the rational utilization of all natural resources."

5.2 Laws and Regulations

(1) Laws

The Environmental Law (Lei do Ambiente), Law No. 20/97, is the foundation for the whole set of legal instruments regarding the preservation of the environment. This is an umbrella law for environmental matters and there are a number of individual regulations, rules and programs, etc. established under this law. The ambit of the Environment Law comprises all activities public or private, which directly or indirectly may influence the environment.

Article 15 of the Environmental Law states that the licensing and registration of activities which may cause a significant impact on the environment must be carried out according to the Environmental Impact Assessment (EIA) regulations and that the issuance of an Environmental License must be based upon an approved EIA of the proposed activity. The Environmental License is a pre-requisite to the issuance of any other license or permit that may be legally required. The activity for which an Environmental License has been issued has to start within 2 years from the date of issue of the license. If the developer fails to commence his activity within that period, he can request permission from the Ministry of Coordination of Environmental Affairs (MICOA, see Chapter 5.3), who vest the license, to extend the license period, in writing, not later than 90 days before the license expires.

(2) Regulations

The EIA process is set out in Regulations on the EIA Process, Decree No. 45 of 2004. These regulations replace those of Decree No. 76 of 1998. The regulations apply to all public or private activities that may have a direct or indirect impact on the environment; however, specific regulations may be made for activities relating to the prospecting, exploration and production of petroleum, natural gas and mineral resources. The Regulations require carrying out a screening in order to categorize the activity into A, B or C, which will determine the depth of impact assessment related to the degree of impact. The developer shall fill in the Preliminary Environmental Information Form (Appendix IV of the Regulations) and submit it to MICOA for the decision of categorization. The definition of each category is as below.

Category A Projects that may cause negative impacts due to the proposed activities or due to the sensitivity of the area. This project category requires the elaboration of an environmental prefeasibility study and scoping definition, followed by execution of an EIA, including an Environmental Management Plan (EMP).

Category B Projects that may cause negative impacts of short duration, intensity, extent, magnitude and/or significance, compared to Category A, and that those impacts are not likely to be irreversible. This project category requires the elaboration of a Simplified Environmental Report (SER).

Category C Projects that do not need to undergo a formal Environmental Assessment, since the negative impacts are negligible, insignificant, minimal or nonexistent and can be considered reversible. These projects are exempt from an EIA or SEA (Simplified Environmental Assessment) since the benefit obtained from the project obviously exceeds the abovementioned negative impact.

The Regulations on EIA Process set out categorization criteria for power generation, transmission, and gas pipeline projects as shown in the table below.

Table 5.2-1 Categorization Criteria for Power and Gas Pipeline Projects

Project Type	Scale of Project	Category
Power Generation	Hydro, thermal (coal, gas and others)	A
Transmission Line	Voltage 110 kV or more and length 10 km or more	A
	Voltage less than 110 kV or length less than 10 km	B
Gas Pipeline	Length 5 km and more	A

(Source: Regulations on the EIA Process, Decree No.45 of 2004)

5.3 Ministry of Coordination of Environmental Affairs (MICOA)

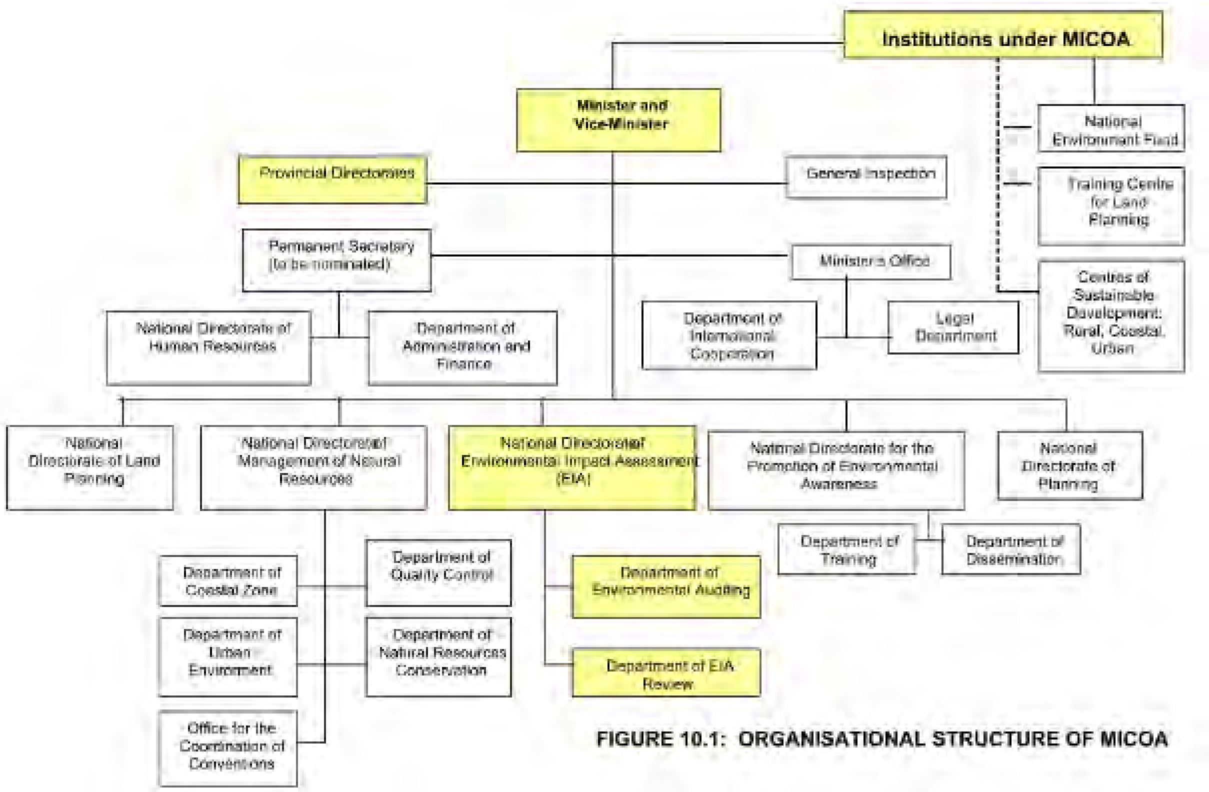
In Mozambique, MICOA is in charge of administration of environmental and social issues. MICOA has two broad domains of responsibility as shown below.

1. Implementing the National Environmental Management Plan (NEMP) and associated environmental policy and legislation, and

2. Coordinating with other ministries on environmental matters to integrate environmental aspects into their projects, programs and policies.

In addition, MICOA is responsible for regulating EIAs, which involves approving the terms of reference for EIAs, reviewing completed EIAs and implementing an audit process. The organization of MICOA is shown in the Figure 5.3-1. The Environmental Impact Assessment Authority at the national level is the National Directorate of Environmental Impact Assessment (DNAIA). Category A projects require that an Environmental Pre-Feasibility and Scoping Study

(EPDA) report and Terms of Reference (TOR) must be prepared and submitted for consideration and possible approval by the DNAIA. At the provincial level, the Provincial Directorates for the Co-ordination of Environmental Affairs (DPCA), which has been set up in all ten provinces, has the role to facilitate the local implementation of centrally developed environmental legislation, policies and programs, including the EIA regulations and guidelines. Category B projects require the review of the specific TOR for the SER and approval of the SER from DPCA.



(Source: MICOA)

Figure 5.3-1 Organization of MICOA

5.4 Environmental Standards

Standards for environmental quality and effluent emissions in Mozambique are shown in the following tables.

(1) Air Quality

Table 5.4-1 Air Quality Standards

(mg/Nm3)

Parameter	Sampling time							
	1 hour		8 hours		24 hours		Annual arithmetical mean	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
SO_2	800				365		80	
NO_2	400				200		100	
CO	40,000		10,000					
O_3	160				50		70	
Total suspended particles					200			

(Source: Handbook on Environmental Assessment Legistration in SADC Region)

(2) Emission of Gas from Thermal Power Generation

Table 5.4-2 Emission of Gas from Thermal Power Generation

(mg/Nm3)

Total suspended particles	SOx	NOx
50	0.2/day (500MW) 0.1/day (<500MW)	Coal : 750 Diesel : 460 Gas : 320

(3) Domestic Liquid Effluents

Table 5.4-3 Standards of Emission of Domestic Liquid Effluents

Parameter	Permissible maximum value	Unit
Color	Dilution 1:20	Presence / absence
Odor	Dilution 1:20	Presence / absence
pH, 25°C	6.0 – 9.0	Sorensen scale
Temperature	35°C	°C
Chemical Oxegen Demand (COD)	150.0	mg/L
Total Suspended Solids (TSS)	60.0	mg/L
Phosphorus (P)	10.0	mg/L
Nitrogen (N)	15.0	mg/L

(Source: Handbook on Environmental Assessment Legislation in SADC Region)

5.5 Procedure for EIA

The steps to be taken in conducting an EIA are set out in the EIA Regulations No. 45/2004 and are summarized below. The process to be followed is different depending whether the project is in Category A, B or C.

Table 5.5-1 EIA Components and Project Category

EIA Components	Category A	Category B	Category C
Application (Screening)	●	●	●
Pre-Assessment	-	●	-
Environmental Pre-Feasibility Study and Scope Definition (EPDA)	●	-	-
Terms of Reference (TOR)	●	●	-
Environmental Impact Study (EIS)	●	-	-
Simplified Environmental Report (SER)	-	●	-
Public Participation Programme	●	△	-
Review by Technical Assessment Commission	●	●	-

The process for Category A, which is basically in the case for thermal power plant projects, is described below.

(1) Application (Screening)

The developer must complete and submit the screening form (preliminary environmental information sheet attached as Appendix IV of the Regulations) to MICOA and then, MICOA will determine the Category of the project. The screening form requires information such as, description of the activity, need and desirability of the project, current land use on the proposed site, resource of construction materials and labors, ownership of land, consideration of alternative location, etc.

(2) Environmental Pre-Feasibility Study and Scope Definition (EPDA) and Terms of Reference (TOR)

The main purpose of EPDA is to determine any fatal flaws in the project and if none, to determine the scope of the EIA and the design of the TOR. The EPDA must be submitted to MICOA together with the TOR for the EIA. The EPDA will be reviewed by the Technical Assessment Commission (TAC).

(3) Environmental Impact Study (EIS)

The EIS consists of an EIA and Environmental Management Plan (EMP). It shall contain at least the following:

- Non-technical summary with the main addressed issues, conclusions and proposals;
- The legal scope of the activity and its insertion in the land use plans existing for the direct buffering of the activity;

- The description of the activity and that of the different actions foreseen therein in the stages of planning, construction, exploration and, should it be a temporary activity, its inactivation;
- The geographic boundary marking and representation, as well as, the environmental situation of reference of the buffering of the activity;
- The detailed description and comparison of the different alternatives and the forecast of the future environmental situation with and without mitigation measures;
- Identification and assessment of the impacts and identification of mitigation measures;
- The environmental management plan of the activity, which includes the monitoring of the impacts, environmental education program and contingency plans in case of accidents;
- The identification of the multi-subject team that elaborated the EIS report;
- The report of public participation.

(4) Public Participation Programme

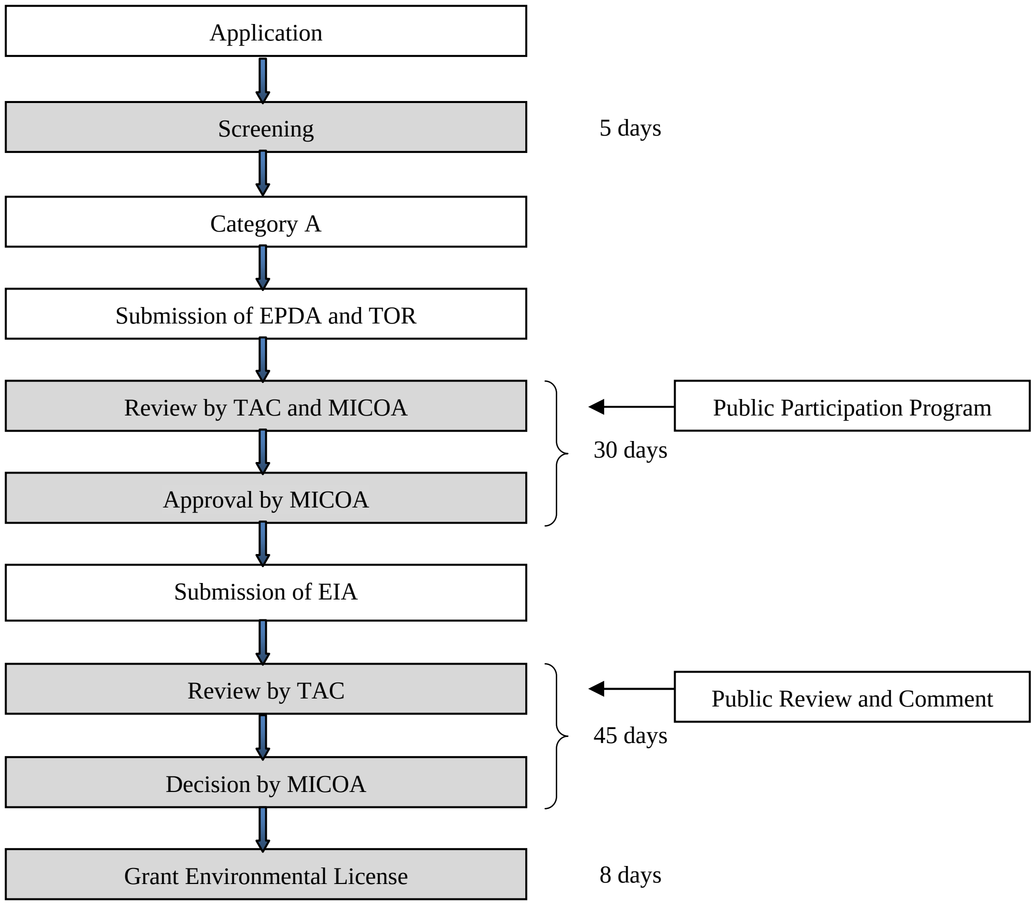
Public participation is mandatory for Category A projects and the developer must hold a public meeting to receive comments on the EIS. Furthermore, MICOA may seek public comments or hold public hearings during the review process.

(5) Review by Technical Assessment Commission

The EIR will be reviewed by the same TAC that reviewed the EPDA. The TAC will submit a report on its comments to the EIA Authority, taking into account all the comments and submissions made by the public during the review period. The findings of the TAC's report will form the basis for the decision taken by the EIA Authority regarding the granting of an Environmental License.

(6) Number of Days Required for Approval

The following figure shows the process flow of approval and a timetable of decision-making (in accordance with Regulation on the Environmental Impact Assessment Process Decree No. 45/2004).



(Source: Prepared by JICA Study Team based on the Regulations on the Environmental Impact Assessment Process Decree No. 45/2004)

Figure 5.5-1 Process Flow and Timetable of EIA Approval

The numbers of days shown in the figure are the timetable described in the regulations for the days for MICOA's part of the work, which adds up to 88 days. In practice, the entire EIA process, including the work by the developer, is said to take somewhere around 10 months. A realistic number of months necessary for the whole process is shown in the table below.

Table 5.5-2 Timetable of the Whole EIA Process

Process	Estimated Months	Implementing Body
Screening	0.5	MICOA
Selection of EIA consultant	2.0	Developer
Preparation/Submission of EPDA & TOR	1.0	Developer, Environmental Consultant
Review approval of EPDA & TOR	1.5	MICOA
Preparation/Submission of EIA	3.0	Developer, Environmental Consultant
Review/Approval of EIA	2.0	MICOA
Total	**10.0**	-

(Source: JICA Study Team)

Chapter 6 Current Situation of Energy Resource (Gas and Coal) Development Plan

6.1 Energy Situation in Mozambique

6.1.1 Overview

Mozambique is favored with a wealth of natural resources and fertile land. It is confirmed that the following are present in Mozambique: mineral resources such as deposits of coal, gold, heavy sand, graphite and bauxite, in addition to natural gas and water resources capable of permitting large-sized power generation. The government has been making positive efforts to invite foreign investment, resulting in large-sized projects for aluminum refining, natural gas development and coal development.

6.1.2 Mining

In Mozambique, active efforts have been being made for the development of natural resources. A high growth rate is estimated in this field. For natural gas, the world's greatest deposits have been confirmed. For coal, a new development project is under way to obtain high-quality coking coal used for steel and ion production. On a global scale, new development of coking coal is anticipated only in Mongolia and Mozambique, as highlighted in this project. The development situation of petroleum, natural gas and coal will be discussed later. In Mozambique, deposits of gold, heavy sand, graphite and bauxite have also been confirmed.

6.1.3 Large-sized Projects

The natural resources still untapped in Mozambique are calling for overseas investment. This section introduces the projects already put into commercial operation, as well as some promising projects to be put into commercial operation in the future.

(1) Mozal Aluminum Smelter

This is the largest Mozambican project approved by Cabinet decision in December 1997 immediately after the end of the civil war. The plant is located at Beluluane, Matola city of Maputo province. Mozal was awarded the status of a special industrial zone, and has been enjoying preferential tax treatment during the construction of the Mozal aluminum smelter and since commencement of production. The shareholders include BHP Billiton (47%), Mitsubishi Corporation (25%), South African Industrial Development Corporation IDC (24%) and the Government of Mozambique (4%). The annual production volume of aluminum is 560,000 tons, which accounts for approximately half the export volume (2010: 2,333 million US dollars) of Mozambique. Accordingly, the fluctuation in the international price of aluminum has a serious impact on the trade balance of Mozambique.

In the construction of the Mozal smelter, infrastructural upgrading and development was essential. This is the reason Beluluane Industrial Park was constructed adjacent to Mozal. Thus, infrastructure investment has been made for tapped water and electricity in this estate as an industrial supply base. Ports and harbors were developed in Matola city, and a 440 km expressway was constructed in 2000 to connect Maputo and Johannesburg.

(2) Exploration of the Petroleum and Natural Gas Field

For petroleum, exploration licenses have been awarded in a total of eleven cases consisting of five cases in the Rovuma sedimentary basin and six cases in the Mozambique sedimentary basin. Operators include DNO International of Norway, Ente Nazionale Idrocarburi (ENI) of Italy, Petronus of Malaysia, Wentworth Resources of Canada, Anadarko of USA, and Sasol and Petro SA of South Africa.

For natural gas, development projects are currently underway in the Rovuma sedimentary basin and the Mozambique sedimentary basin. Sasol and Hydrogen Carbide Corporation (ENH) of Mozambique financed the project of the Pande/Temane gas field in Inhambane province, where a pipeline was laid in 2001 and commercial operation started in 2004. A gas pipeline exporting natural gas was laid over a total distance of 865 km from the gas field to Secunda of South Africa where there is a Sasol chemical plant. At present, 147 million GJ per year, accounting for 95 percent of the total production volume, is exported to South Africa. Incidentally, the order for manufacturing the electro-resistance-welded tube for this project was received by Kawasaki Steel, Marubeni - Itochu Steel Inc., Hole Long More of South Africa and Europipe of France.

In a joint venture with Electricidade De Mocambique (EDM), Sasol is planning to build a 140 MW-scale natural gas power plant in Ressano Garcia close to the national boundary by 2013. Further, Hydrogen Carbide Corporation (ENH), having a 30% interest in the Pande Temane gas field, installed a pipeline for household consumption from this gas field to Goblot of Inhambane province and the county of Bilancloak in Inyasolo. Installation of a pipeline is also planned for consumption of gas in Matowutowuine and Maputo city.

In Rovuma, mining region 1 of the Rovuma offshore area where Mitsui & Co., Ltd. has a 20% interest will be financed by Anadarko of USA (36.5% interest), ENH (15% interest), an Indian state-run petroleum company BPRL (10% interest), Hydeocon Industries (10% interest) of India, and Anglo-Yogo Energy (8.5% interest) of the UK. The world’s greatest deposits (more than 15 to 30 trillion cubic feet) have been confirmed so far. ENI of Italy, having an interest in mining region 4 of the Rovuma offshore area, has been engaged in a prospecting project jointly with ENH, Galp of Portugal and the Korean Gas Corporation KOGAS. Deposits of more than 15 trillion cubic feet have been confirmed so far.

(3) Coal Development

See 6.3.1.

6.2 Natural Gas Supply Plan

6.2.1 Overview of Natural Gas in Mozambique

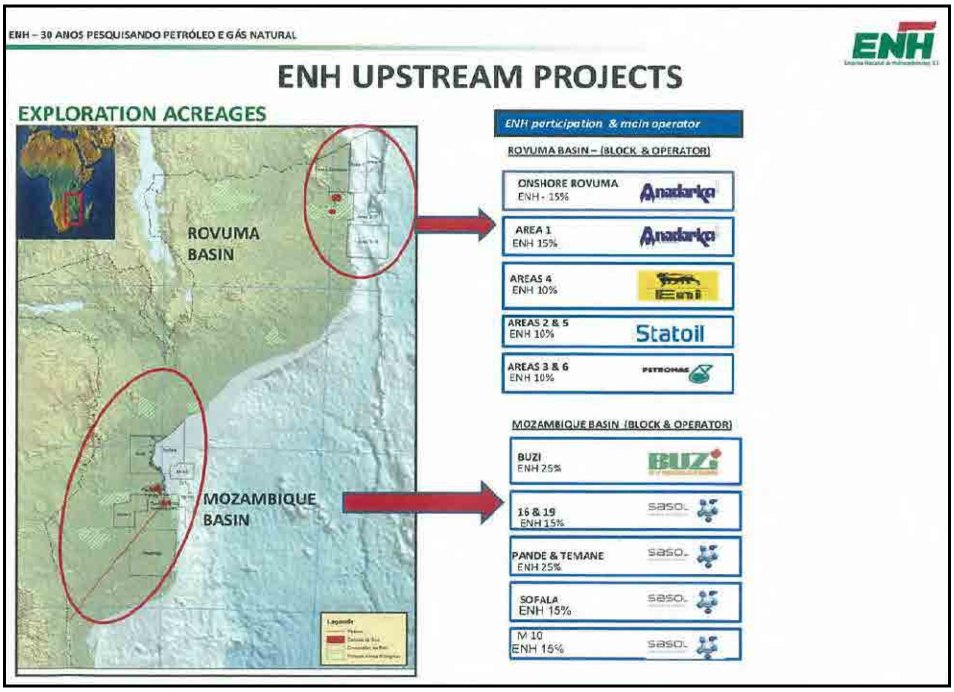
At present, Mozambique has two gas fields: one in the Rovuma Basin of Cabo Delgado province in the north and the other in the Mozambique Basin of Inhambane province in the south. Their locations are illustrated in Figure 6.2-1.

In the Mozambique Basin, gas was first found out in the Pande area in 1961, then in the Buzi area in 1962 followed by the Temane area in 1967. After that, natural gas development has been sluggish since the 1970s due to the absence of demand and political instability in Mozambique. In 2003, gas was found in the Inhassoro area, and natural gas development has been promoted by the enactment of the Petroleum Law (3/81) and establishment of the Mozambican National Hydrocarbon Company (ENH) since the 1990s. Since the mid-1990s, PSA and EPC agreements have been signed with international oil developers (Arco in 1997, BP in 1998, and Sasol, Petronas, Hydro and DNO in 2000 and onward). Thus, natural gas development has been promoted, including the construction of gas pipelines leading to South Africa by Sasol.

In the Rovuma Basin, tenders for development licensing have been invited since 2005. As a result, development and licensing agreements were signed with global developers such as Anadarko (U.S.A.), ENI (Italy), Petronas (Malaysia) and Artumas (Canada). Since then, natural gas development has been promoted.

In the Pande and Temane areas in the Mozambique Basin, natural gas sources have been developed and natural gas has been produced under the PPA agreement between Sasol Petroleum Temane and ENH.

In 2004, the first commercial production was initiated in the Temane area. In 2009, production started in the Pande area.



(Source: ENH)

Figure 6.2-1 Gas Fields in Mozambique

The following table lists the development and production areas with developers and producers in the Rovuma Basin and Mozambique Basin.

Table 6.2-1 Development and Production Areas in the Rovuma Basin and Mozambique Basin

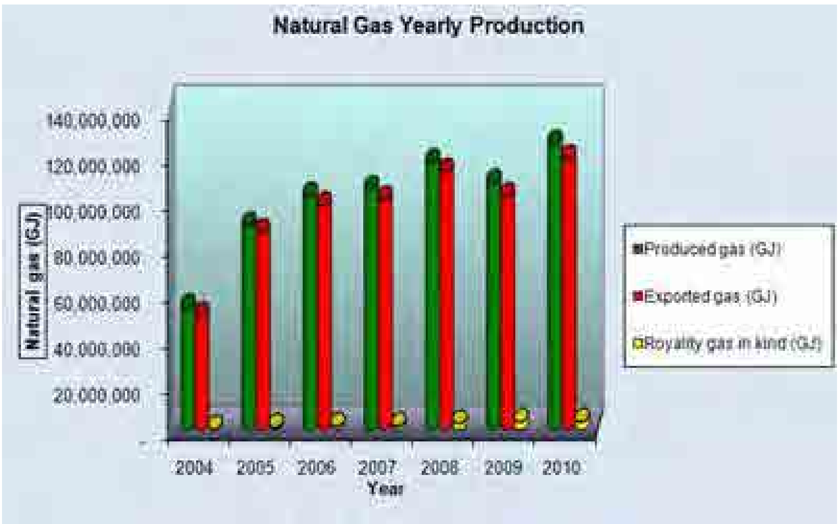
Rovuma Basin	
Block	**Partners**
Onshore Rovuma	Anadarko (35.7%), Wentworth (15.3%), Maurel & Prom (24%), ENH (15%), Cove Energy (10%)
Area 1	Anadarko (36.5%), Mitsui (20%) ENH (15%), Bharat Petroleum Corporation (10%), Videocon Energy Resources (10%), Cove Energy (8.5%)
Area 4	Eni (70%), ENH (10%), Galp (10%), Kogas (10%)
Area 2 & 5	Statoil (90%), ENH (10%)
Area 3 & 6	Petronas (90%), ENH (10%)
Mozambique Basin	
Block	**Partners**
Pande - Temane	Sasol (70%) ENH (25%), IFC (5%)
16 & 19	Sasol (50%), Petronas (35%), ENH (15%)
Sofala	Sasol (85%), ENH (15%)
M10	Sasol (42.5%), Petronas (42.5%), ENH (15%)
Buzi	Buzi Hydrocarbons (75%), ENH (25%)
Area A	Sasol (90%), ENH (10%)

(Source: ENH)

According to available data, reserves of the natural gas in Mozambique are 4.8 to 8.8 TCF in the Mozambique Basin and 52.5 to 110 TCF in the Rovuma Basin. There are several sources of data showing recoverable reserves, which lie in the range of 5.504 to about 10 TCF, seven percent of which has already been found. The area-wise recoverable reserves in the Mozambique Basin are 2.321 to 2.7 TCF in the Pande area, 0.618 to 1.0 TCF in the Temane area and 14 BCF in the Buzi area.

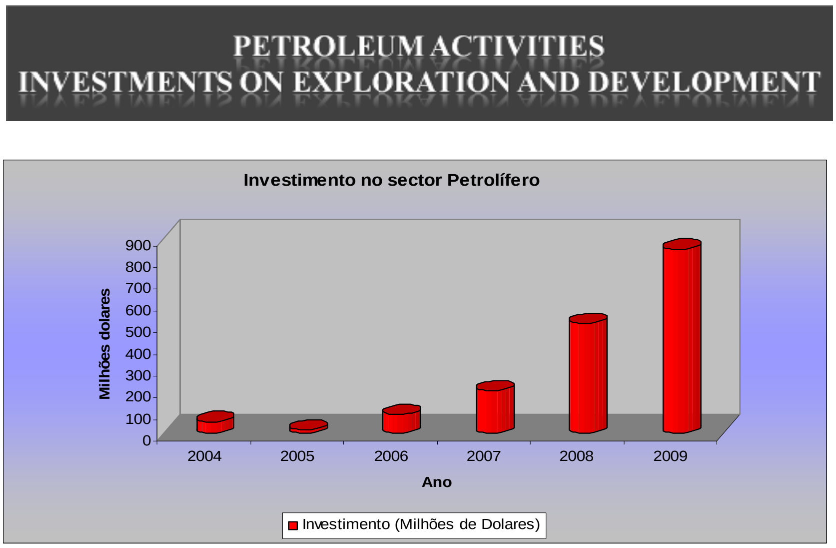
The current production volume in Mozambique is approximately 130 MGJ per annum from the Pande and Temane areas of the Mozambique Basin. More than 95 percent of the gas produced is sent through the 865 km-long pipeline to South Africa, and is consumed in a Sasol factory. Approximately 3 MGJ is consumed in Mozambique per year. (Approximately 3 MGJ per annum in the Matola area (by Mozal and others) and 0.3 MGJ each year in the Vilankulo and Inhassoro areas close to a gas field (80% of which is for EDM power generation.)

Figure 6.2-2 shows yearly gas production in Mozambique and Figure 6.2-3 shows investment in the oil and gas sector.



(Source: INP)

Figure 6.2-2 Yearly Gas Production in Mozambique

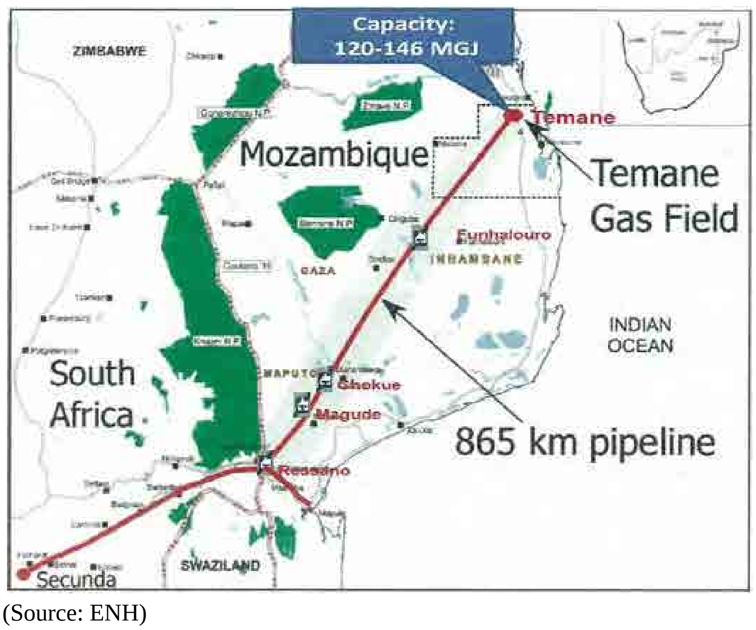


(Source: MMR)

Figure 6.2-3 Investment in the Oil and Gas Sector

6.2.2 Gas Supply in the South

(1) In 2004, a gas pipeline leading from the Pande and Temane gas fields of Mozambique to Secunda of South Africa (ROMPCO pipeline, where a 50-percent interest is owned by the Government of Mozambique (ENH) and the Government of South Africa (iGas), and the remaining 50-percent interest by Sasol of South Africa) was constructed and was put into commercial operation. This pipeline has a total length of 865 km with a diameter of 660 mm. The current gas feed capacity is approximately 150 MGJ per annum, which can be increased to 240 MGJ per annum by installation of additional compressor stations. The production volume in the Pande and Temane gas fields for fiscal 2011 (July 2010 to June 2011) was approximately 130 MGJ per annum. According to the MMR report of January 2012, the production volume for 2012 is anticipated to reach the level of 149 MGJ per annum. The pipeline from the Pande and Temane gas fields to Secunda is provided with five takeoff points (also called tap-off points) in Mozambique; however, only the Ressano Garcia takeoff point of Maputo province was working as of 2011, and in the current stage, a detailed usage plan of the Chokwa takeoff point is being developed. In 2006, construction of a pipeline was completed from the takeoff point of Ressano Garcia close to the national boundary with South Africa to Matola city. This pipeline is currently in commercial service. This pipeline is run by the Matola Gas Company (MGC), established as a joint venture between ENH and private capital. The current gas demand in Matola city comes mainly from the Mozal aluminum smelter plant and Ciementos de Mozambique (cement plant), and amounts to approximately 3 MGJ per annum. This demand is expected to grow due to a firm increase in the future demand for switching from petroleum over to gas in the Industrial Park in the suburbs of Maputo city (Vidreira (glass industry) and CDM (beverage manufacturer)), and due to the gas demand for household (residential) use and for power generation.



(Source: ENH)

Figure 6.2-4 Temane–Secunda Gas Pipeline Route

(2) Extension work of the Pande and Temane gas fields has already been completed (gas supply volume of ROMPCO gas pipeline has been increased from 156 MGJ/year to 183 MGJ/year), and new equipment and plants will put into operation in this June. It is expected that the gas production volume will be increased to 183 MGJ/year in 2014.

The maximum gas supply volume of the ROMPCO gas pipeline is 240 MGJ/year. The pipeline still has a surplus capacity of 57 MGJ/year since the expansion work has been completed. But, further expansion work has not been planned.

<u>Gas Sales Agreement one (GSA 1)</u>

1) 120 MGJ per annum (for South Africa)

<u>Gas Sales Agreement two (GSA 2)</u>

2) 27 MGJ per annum (for South Africa)
3) 27 MGJ per annum (for domestic power generation and other consumers (residential, commercial, industrial and NGV))

<u>Royalty paid to the Government of Mozambique</u>

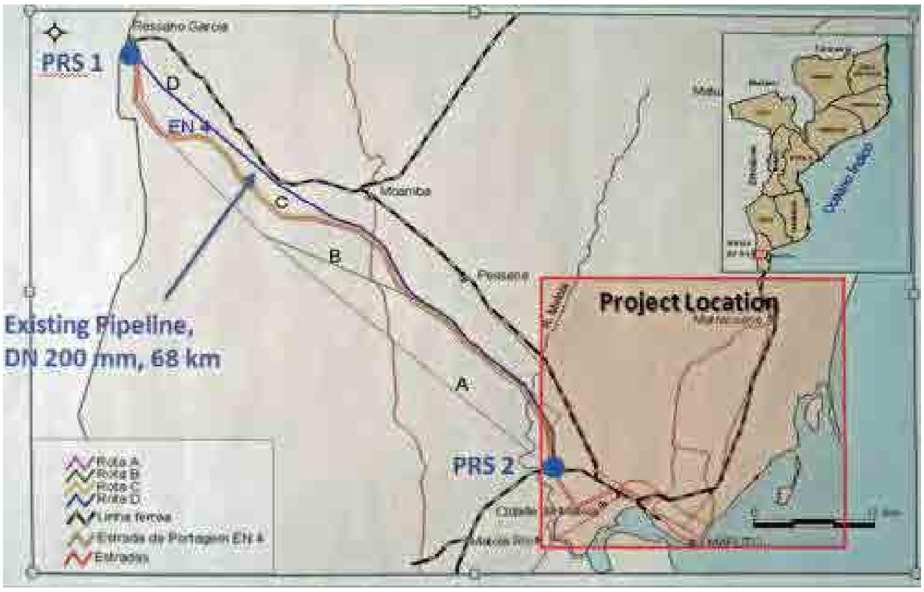
4) Approx. 9 MGJ per annum (= 120 x 5% + (27 + 27) x 6%)

Total: 183 MGJ per annum

The Government of Mozambique retains the right to receive approximately 9 MGJ per annum as loyalties in 2014 and onward; the volume currently received (amount of gas consumed domestically) amounts to 3 to 4 MGJ per annum (with the remainder received in cash). In the National Strategy for the Development of the Natural Gas Market in Mozambique (Resolution No. 64/2009) published in 2009, the Government of Mozambique expressed a plan to supply, on a priority basis, royalty gas to the projects that would contribute to economic development in Mozambique and whose profitability cannot easily be ensured on a purely commercial basis.

The gas volume for domestic power generation described in 3) above is broken down into: (1) 6 MGJ per annum for power generation for EDM and other consumers (residential, commercial, industrial) and NGV, (2) 11 MGJ per annum for power generation for an IPP at Ressano Garcia (by Gigawatt-Mozambique), and (3) 10 MGJ per annum for another IPP at Ressano Garcia (by Sasol New Energy and EDM). At present, there are negotiations ongoing between ENH and EDM on the agreement for the supply of the above-mentioned 6 MGJ per annum.

(3) Gas is branched off at the Pressure Reducing Station (PRS 1) at Ressano Garcia, where the gas pressure is reduced from 100 to 40 bar, and is fed to the Pressure Reducing Station (PRS 2) located in Matola city, where the pressure is further reduced to 10 bar. After that, gas is supplied to the users in Matola city. Figure 6.2-5 illustrates the existing pipeline route.



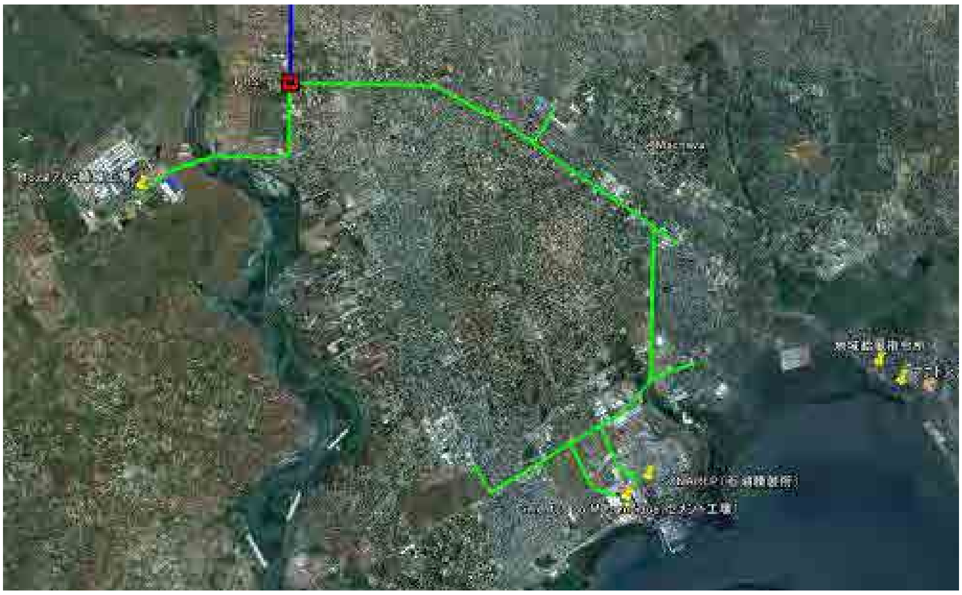
(Source: ENH)

Figure 6.2-5 MGC Gas Pipeline Route

The following are the basic specifications of the pipeline from Ressano Garcia to the PRS 2.

1) Pipe diameter: 8" (200 mm)
2) Total length: Approx. 68 km
3) Gas feed capacity: 40,000 m^3/h at 25°C, 1 atm (currently in operation at 12,000 m^3/h)
4) Maximum allowable gas pressure: 70 bar (currently in operation at 40 bar)

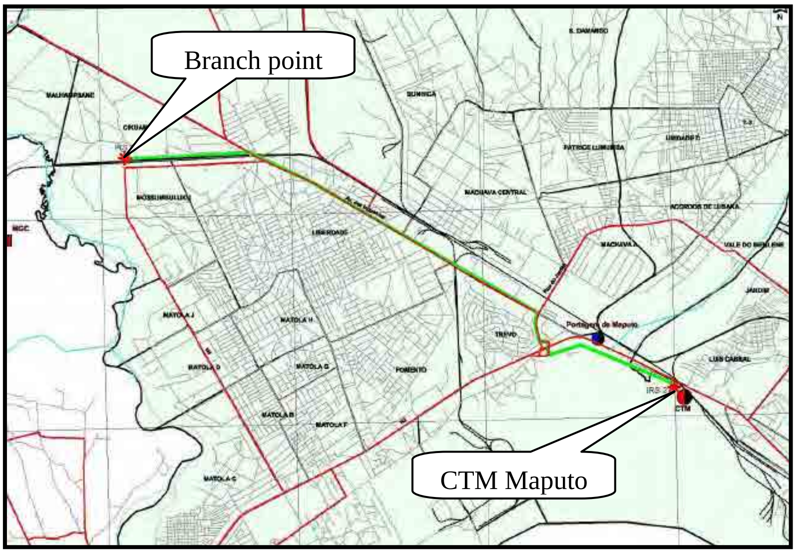
At present, 10-bar gas is supplied from the PRS 2 of Matola city to gas users through a 22 km-long piping network. Most (92%) of the gas supplied is consumed by the Mozal aluminum smelter plant and Ciementos de Mozambique (cement plant). Figure 6.2-6 illustrates the existing gas pipeline network in Matola city.



(Source: Prepared by JICA Study Team based on ENH data)

Figure 6.2-6 Existing Gas Pipeline Network (green) in Matola City

It is decided that ENH and KOGAS jointly implement the natural gas pipeline project in Matola area. The project will complete at latest until November 2013. Since it is confirmed with EDM that this project includes pipeline work to CTM Maputo, it is not necessary to include the pipeline work to new Maputo power plant in Japanese ODA project. In this case, gas pressure in the MGC pipeline upstream will be increased from 40 to 70 bar to meet the increase in gas demand by laying new pipeline. Figure 6.2-7 illustrates the new pipeline route（from the branch point situated 1.8 km upstream of the existing PRS-2 to CTM Maputo）and Figure 6.2-8 illustrates the gas pipeline route near the CTM Maputo and the location of new pressure reducing station in CTM Maputo..



(Source: ENH)

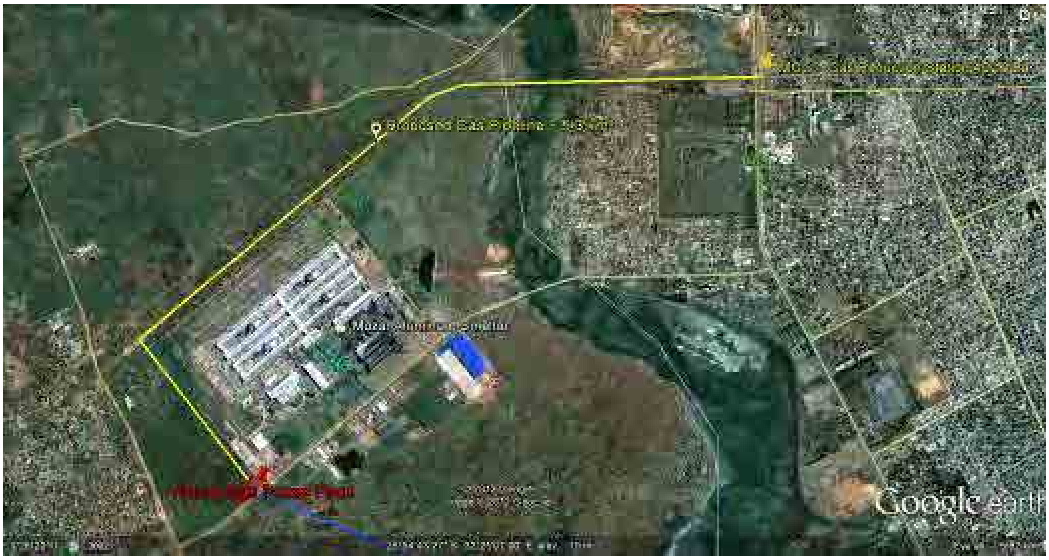
Figure 6.2-7 Route of New Pipeline Linking MGC Pipeline and CTM Maputo (ENH/KOGAS)

(Source: ENH)

Figure 6.2-8 Pipeline Route near CTM Maputo and Location of Pressure Reducing Station in CTM Maputo

(4) The natural gas for which the pressure has been reduced to 10 bar at the PRS 2 is supplied to Beluluane Industrial Park through a pipeline with a diameter of 200 mm (8"). A metering station is installed on the side of the front gate of the Mozal aluminum smelter plant. Although the distance from the metering station to the candidate site of the Beluluane Thermal Power Plant is only approximately 1 km, the pressure of 10 bar is too low to be the inlet pressure of a gas turbine. Further, since it will probably be difficult to raise the pressure of the gas being supplied to the users in the existing Industrial Park, it will be difficult to supply gas to the Beluluane Power Plant through the existing pipeline. In fact, the gas pipeline route (Figure 6.2-9) obtained from EDM assumes installation of a new pipeline (which is 3.5 km long). It can be considered that the new pipeline will be branched off (hot-tapped) immediately upstream of the existing PRS 2 to reach the power plant at a pressure of 40 bar. The pipeline from this PRS 2 to the candidate site of the Beluluane Power Plant needs to cross a highway (EN4) and Matola River. Since a railway running on the side of the PRS 2 crosses the highway and Matola River to lead close to Mozal, it is necessary to consider utilizing these crossing sections of the railway as a means to carry the gas pipeline across the highway and the river. The pipeline direct to the existing Beluluane Industrial Park is laid along EN4 highway (south-north) and the access road (east-west) and is directly buried under the riverbed at the river crossing (see Figure 6.2-6). Since water flow through the year in the Matola River is very light and there is no possibility of local scouring due to riverbed erosion, it is expected that embedded piping will be adopted.

(5) It can be considered that new gas pipeline will be embedded under the riverbed because it is difficult to get permission for gas pipelines to cross roads and railways.



(Source: EDM)

Figure 6.2-9 Possible Route for Gas Supply Line to Beluluane Site

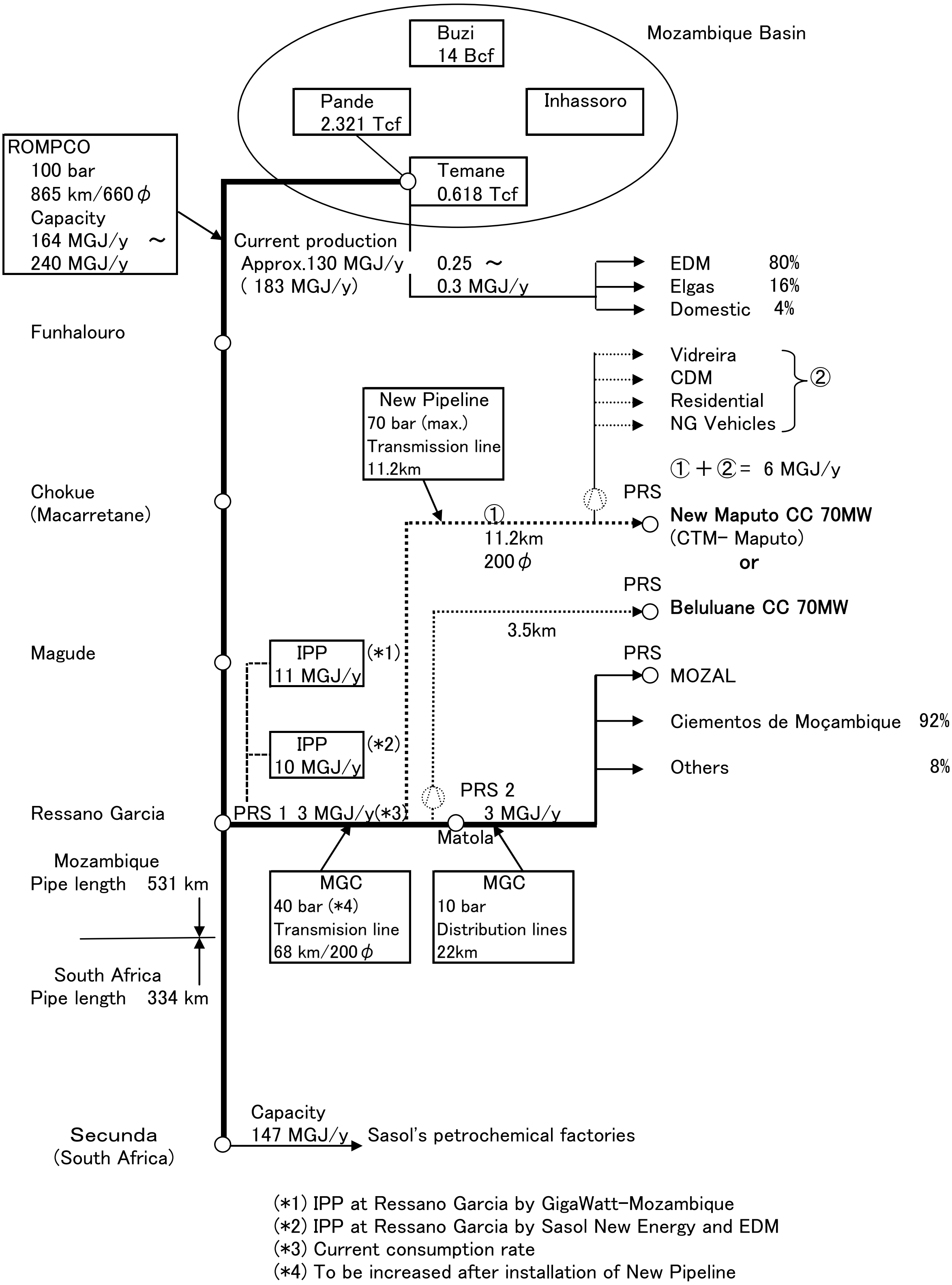
(6) Gas supply volume to the gas-fired thermal power plant in the southern region

Gas (6 MGJ/year) for the new gas pipeline mentioned above is planned to supply to the power plants owned by EDM and customers in Maputo city. The available gas volume for the gas-fired thermal power plant is 3.2 MGJ/year.

In the meantime, there is a possibility to increase the gas supply volume to CTM Maputo depending on the future situation because the gas off-take for customers has not been decided yet. If 3.2 MGJ of gas per annum can be supplied to the power plant, generation capacity of the combined cycle power plant at the base load is estimated at approximately 70 MW, which exceeds the generation capacity of 50 MW originally planned by EDM.

Figure 6.2-10 shows the overall gas flow schematic in the southern region.

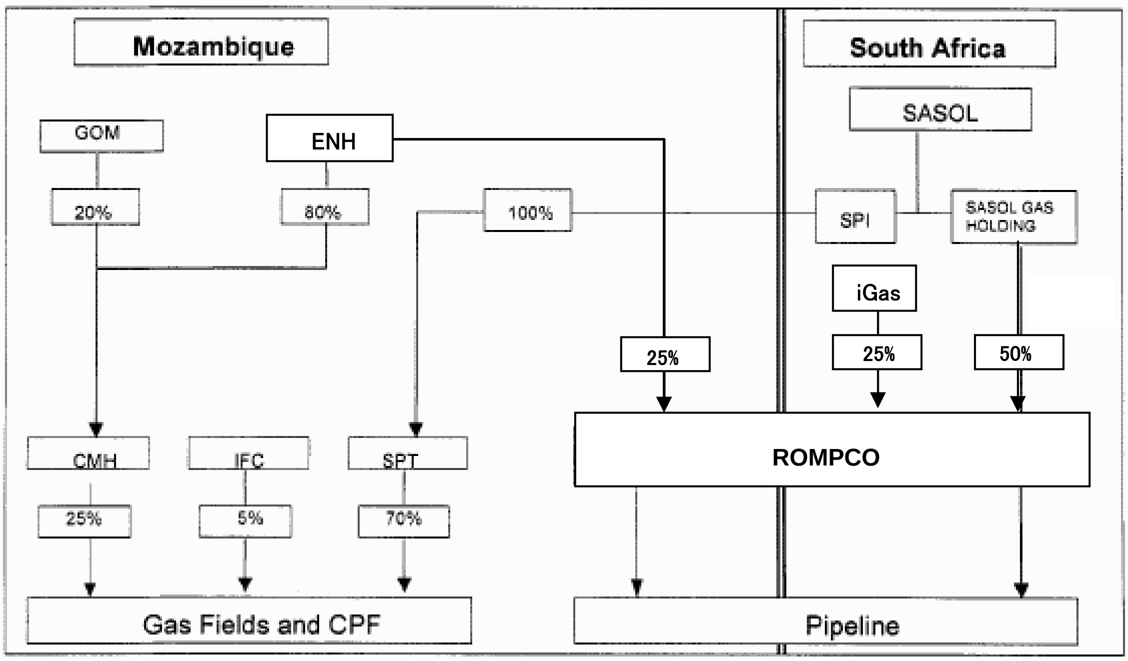
The broken line indicates the pipeline to be installed in the future. The values enclosed in parentheses indicate the future gas volume.



(Source: Prepared by JICA Study Team based on information and data obtained from ENH)

Figure 6.2-10 Overall Gas Flow Schematic in the Southern Region

Figure 6.2-11 shows the organization structure for gas production and pipeline operations of Pande-Temane Gas Fields.



(Source: World Bank)

Figure 6.2-11 Organization Structure for Gas Production and Pipeline Operations of Pande-Temane Gas Fields

6.2.3 Gas Properties

See Table 4.3-7 Properties of Natural Gas.

6.2.4 Gas Costs

INP presents the gas costs at the takeoff point located at Ressano Garcia, as follows: (as of April 2009)

1) Energy value (natural gas wellhead value): US$0.67/GJ (depends on gas market price)
2) Extraction and processing of natural gas (CPF price): US$0.70/GJ
3) Transmission tariff from Temane to Ressano Garcia: US$1.00/GJ

Total of the above: US$2.37/GJ (wholesale price)[12]

The details of the gas price that MGC charges for the end user are not clear at present. If this price is at the same level as the retail price of gas in South Africa, this gas price will be in the range of US$4 to 5/GJ[13].

It should be noted that EDM considers that the price of gas supplied to CTM from ENH will be in the range of about US$4 to 5/GJ.

12 Since transmission tariff and some margins for the distributor (such as MGC) are added to this wholesale price, general end consumers including EDM could not purchase natural gas at this price level.

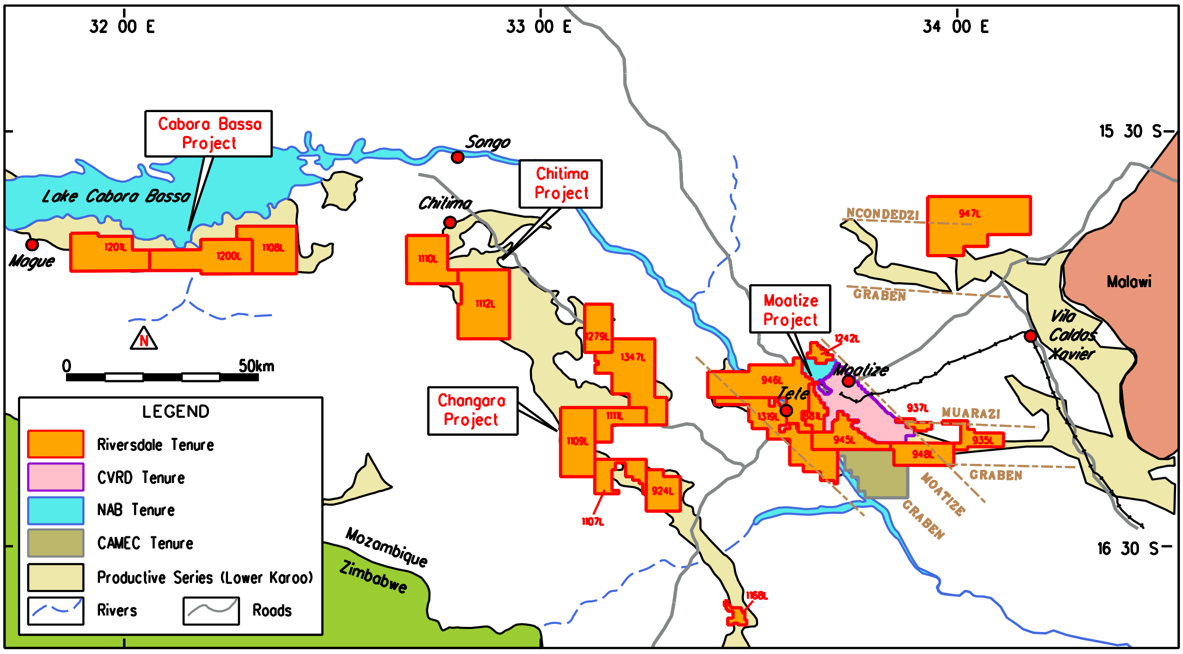
13 Methodology to Approve Maximum Prices of Piped-Gas in South Africa, October 2011 (NERSA)

6.3 Coal Development Plan

6.3.1 General Situation of Coal Development in Mozambique

Coal development has advanced mainly in four coal mines (Moatize, Benga, Zambeziand Revuboe) in Tete province. The Moatize coal mine is regarded as the world's second largest open pit coal mine, whose commercial production was commenced by Vale of Brazil in July 2011. They plan to increase the production to an annual production volume of 11,000,000 tons by 2014. They further plan to increase the annual production volume to 22,000,000 tons through additional investment. Riversdale of Australia participated in the coal development of the Benga coal mine through joint investment with Tata Steel of India, but the shares of Riversdale were purchased by Rio Tinto in August 2011. The annual production volume of the coking coal is planned at 20,000,000 tons, and that of clean coal is planned at 12,000,000 tons. Shipment of the products will start in 2012. Rio Tinto acquired a 60% interest in the coal development in the Zambezi coal mine, and exploration is currently under way in a joint effort with Wuhan Gangtie Team and Zhongguo Jiaotong Jianshe Co., Ltd. of China (40% interest in total). In the Revuboe coal mine, exploration was initiated in 2004 by a joint investment by Talbot Group of Australia (58.9% share), Nippon Steel Corporation (23.3% share), Nittetsu Trading Company (10% share) and Posco of Korea (7.8% share). It was reported in July 2014 that Anglo American purchased all of the shares held by Talbot Group, who became the lead shareholder. The deposits at the mine are estimated to be approximately 1.4 billion tons and the annual production target of coking coal is set at 6 to 9 million tons. Shipment is planned to start between 2014 and 2015.

The following figure shows the coal development areas in Tete province, which is one of the major coal producing sites in Mozambique.



(Source: MMR Oil, Gas and Mining Investment Policy and Business Opportunities in Mozambique)

Figure 6.3-1 Coal Development Areas in Tete Province

6.3.2 Volume of Coal Resources in Mozambique

Coal production in Mozambique was initiated by licensing of the mining rights in the Moatize coal mine in 2004. This was implemented by Carbomoc EE.

Table 6.3-1 illustrates the volume of coal resources in Mozambique:

Table 6.3-1 Volume of Coal Resources in Mozambique

(Unit: Million tons)

Company	Confirmed or Estimated Volume of Coal	Expected Volume of Coal	Sub-total
Vale	1,870	416	2,286
Rio Tinto - Benga - Zambeze - Sub-total	 1,072 2,365 3,437	 2,960 6,680 9,640	 4,032 9,045 13,077
ENRC	672	362	1,034
Eta-Star	-	30	30
Essar	-	31.8	31.8
JSPL (Zindal Steel and Power)	898	754	1,652
Ncndezi	644	1,164	1,808
Revuboe	-	-	798
Total	**10,958**	**22,037.8**	**33,793.8**

(Source: PowerPoint data "Possibility of coal resource development in Mozambique" announced in the Clean Coal Symposium held in Japan on September 6, 2011)

Three to six years from now, the development phase of several new coal mine projects (Revuboe, Ncondezi, ENRC, Changara, Zambezi) will start.

The coal export capability is estimated to reach approximately 5 million tons in 2011 when the project starts.

6.3.3 Coal Production Volume in Mozambique

Table 6.3-2 illustrates the volume of coal produced by the major coal business operators in Mozambique.

Table 6.3-2 Coal Production Volume in Mozambique

(Unit: 10,000 tons)

Company	2011	2012	2015/17	>2025
Vale	120	530	1,100	1,200
Rio Tinto	75	200	2,700	3,950
Ncndezi	-	-	200	1,000
JSPL	30	75	700	2,200
Revuboe	-	-	340	700
Total	**225**	**805**	**5,040**	**9,050**

(Source: PowerPoint data "Possibility of coal resource development in Mozambique" announced in the Clean Coal Symposium held in Japan on September 6, 2011)

6.3.4 Coal Development Situation in Mozambique

The following introduces two representative projects currently being implemented in Mozambique.

(1) Overview of the Moatize Coal Mine

The Brazil-based Vale owns coal-mining rights in the Moatize area located in Tete province of northern Mozambique, and commenced development of the coal mine in 2010. The Moatize coal mine is located 17 km from Tete, the capital of the province expanding along the River Zambezi in Tete province of northern Mozambique. The area measures 23,780 ha. The Moatize coal mine is located at the same site as the Moatize power plant illustrated in Figure 6.3-1. The overview of the Moatize coal mine is given in Table 6.3-3. Figures 6.3-2 and 6.3-3 illustrate a complete view of this coal mine and the current situation of coal mining.

Table 6.3-3 Overview of Moatize Coal Mine

Deposits	954 million tons (air dry base)
Capital	US$ 1.882 billion
Valid term of interest	35 years
Annual coal production volume	11 million tons per year
Production volume	Coking coal: 8.5 million tons per year Thermal coal: 2.5 million tons per year
Coal mining method	Open pit mine
Transportation means	By Sena railway, Beira Port and Transshipment

(Source: Vale Moatize Coal Mine 3rd Mozambique Mining and Energy Conference & Exhibition)

(Source: Vale Moatize Coal Mine 3rd Mozambique Mining and Energy Conference & Exhibition)

Figure 6.3-2 Overhead View of Moatize Coal Mine

(Source: Vale Moatize Coal Mine 3rd Mozambique Mining and Energy Conference & Exhibition)

Figure 6.3-3 Current Coal Mining Situation at Moatize Coal Mine

(2) Benga Project

Riversdale has been mining for coal in the Benga area of Tete province. The following gives the overview:

- Coal mining started in 2011
- Annual coal production: 20 million tons
- Coal type: Coking coal and general coal
- Power plant project: 250 MW (Phase 1)
- Investment for mining project: 850 million US dollars

Chapter 7 Conclusion and Recommendations

7.1 Conclusion

(1) This survey is intended to collect and analyze data and information necessary for the implementation of the strategic cooperation to the power sector of Mozambique. The results of the survey are described in each of the deliverables; thus, it can be said that the objectives of the survey are fulfilled.

(2) Collected data and information are organized in a list, which can be easily referred to in electronic format. Interviews with officials of various organizations, ME and EDM in particular, were held to collect a wide range of data and information.

(3) The survey area covers the whole country and reconnaissance took place at the sites of priority projects. The results of the reconnaissance were included in the deliverables. The data and information are organized in the deliverables to enable formulation and implementation of the priority projects in the near future.

(4) The projects whose priority is considered high by EDM and significance and effectiveness of aid by the Government of Japan are deemed as sufficient are the following two projects (the names of the projects at the time of request from EDM are provided in parentheses):
- ✓ New Maputo Thermal Power Station Project (50 MW Power Plant at Beluluane)
- ✓ Reinforcement and Expansion of Nacala Transmission Network (Reconfiguration of Nampula-Monapo-Nacala and Nampula-Metoro-Pemba at Namialo and Build New 40 MVA, 110/33 kV at Namialo)

(5) There is a possibility that the priority of any other priority projects (particularly, Caia – Nampula – Nacala 220kV Transmission Line Project) may increase depending on the development and situation in the future. It is suggested, therefore, that continuous data collection activities should be in place.

(6) A full-scale feasibility study is required for the New Maputo Thermal Power Station Project, with the highest priory in terms of the necessity and urgency. It has been decided through consultations among the parties concerned that specific investigation into the facilitation of the detailed study is needed.

7.2 Recommendations

(1) The feasibility study should be conducted on the New Maputo Thermal Power Station Project at an early stage under the framework of JICA’s preparatory survey to investigate the necessity, suitability, expected effects, etc. as a Japan yen loan project.

(2) Results of the updated project of the Master Plan for the power sector of Mozambique, which has been conducted under assistance from a donor country, are expected to provide valuable reference data when the Government of Japan considers extending assistance to the

power sector of Mozambique. From this point of view, data collection activities on the updated project of the Master Plan should be continued.

(3) In order to facilitate and maximize the effectiveness of supporting the power sector of Mozambique, there is a strong need for strengthening cooperation with other donors.

Appendices

1. Itinerary for the First Site Survey
2. Itinerary for the Second Site Survey
3. Itinerary for the Third Site Survey
4. List of Key Persons whom the Survey Team Met
5. List of Collected Data and Information

Itinerary for the First Site Survey

No.	Date		Activities	Ka	Ki	Ok	Ni	Mi	Ma	Sa
1	Feb. 26	Su	Ka/Ni/Mi/Ma: 16:20 Leave Narita (by CX521) 20:35 Arrive at Hong Kong 23:45 Leave Hong Kong (by CX749) Ki: 11:10 Leave Narita (by SQ637) 17:45 Arrive at Singapore	x	 x		x	x	x	
2	Feb. 27	Mo	Ka/Ni/Mi/Ma: 06:35 Arrive at Johannesburg Ki: 02:35 Leave Singapore (by SQ478) 07:10 Arrive at Johannesburg All: 09:40 Leave Johannesburg (by SA142) 10:45 Arrive at Maputo 14:00 JICA (Mr. Nasu)	x x	 x x		x x	x x	x x	 x x
3	Feb. 28	Tu	09:00 EDM 14:00 Embassy of Norway	x x	x x		x x	x x	x x	x x
4	Feb. 29	We	10:00 ENH 14:00 ME	x x	x x		x x	x x	x x	x x
5	Mar. 1	Th	14:00 GAZEDA	x	x		X	x	x	X
6	Mar. 2	Fr	09:00 EDM & site survey at Beluluane 14:40 EOJ	x	x		X	x	x	x
7	Mar. 3	Sa	(reports)							
8	Mar. 4	Su	(off)							
9	Mar. 5	Mo	08:30 EDM 09:00 MICOA 14:00 ME	x x x	x x x		x x x	x x x	x x x	x x x
10	Mar. 6	Tu	08:30 GAZEDA & site survey at Beluluane industrial park 14:00 EDM project planning	x x	x x		x x	x x	x x	x x
11	Mar. 7	We	Ki/Ni/Mi: 09:00 Leave Maputo (by SA7094) 10:15 Arrive at Johannesburg Ki: 14:35 Leave Johannesburg (by SQ479) Ni/Mi: 12:35 Leave Johannesburg (by CX748) Ka/Ma: 09:00 EDM power generation at CTM - Continuing data collection & follow-up	 x	x x		x x	x x	 x	x

No.	Date		Activities	Ka	Ki	Ok	Ni	Mi	Ma	Sa
12	Mar. 8	Th	<u>Ki:</u> 07:05 Arrive at Singapore 09:25 Leave Singapore (by SQ012) 17:05 Arrive at Narita <u>Ni/Mi</u>: 07:05 Arrive at Hong Kong 09:05 Leave Hong Kong (CX504) 14:10 Arrive at Narita <u>Ka/Ma</u>: 09:00 EDM power transmission - Continuing data collection & follow-up	 x	x		 x	 x	 x	
13	Mar. 9	Fr	- Continuing data collection & follow-up	x					x	
14	Mar. 10	Sa	(reports)							
15	Mar. 11	Su	(off)							
16	Mar. 12	Mo	- Continuing data collection & follow-up 16:00 JICA	x					x	
17	Mar. 13	Tu	<u>Ka/Ma</u>: 09:00 Leave Maputo (by SA7094) 10:15 Arrive at Johannesburg 12:35 Leave Johannesburg (by CX748)	x					x	
18	Mar. 14	We	<u>Ka/Ma</u>: 07:05 Arrive at Hong Kong 09:05 Leave Hong Kong (CX504) 14:10 Arrive at Narita	x					x	
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23	Mar. 19	Mo	17:10 Leave Narita (by SQ5901) 23:50 Arrive at Singapore			x				
24	Mar. 20	Tu	02:35 Leave Singapore (by SQ478) 07:10 Arrive at Johannesburg 08:40 Leave Johannesburg (by SA7099) 09:40 Arrive at Maputo 14:00 EDM			x x				 x x
25	Mar. 21	We	09:00 EDM			x				x
26	Mar. 22	Th	09:00 Site survey at Beluluane (power plant site)			x				x
27	Mar. 23	Fr	09:00 EDM			x				x
28	Mar. 24	Sa	(reports)			x				
29	Mar. 25	Su	(off)							
30	Mar. 26	Mo	09:00 (various agencies) 15:00 JICA			x x				x x
31	Mar. 27	Tu	11:45 Leave Maputo (by SA143) 12:55 Arrive at Johannesburg 14:35 Leave Johannesburg (by SQ479)			x				X
32	Mar. 28	We	07:05 Arrive at Singapore 09:25 Leave Singapore (SQ012) 17:05 Arrive at Narita			x				

Remarks:

1) Personnel symbol: Ka: Mr. Kasai, Ki: Mr. Kinoshita, Ok: Mr. Okano, Ni: Mr. Nimiya, Mi: Mr. Miyashita, Ma: Ms Matsuzaki (Interpreter 1), Sa: Mr. Sambo (Interpreter 2)

Itinerary for the Second Site Survey

No.	Date		Activities	Ka	Ki	Ok	Ni	Mi	Ma	Sa
1	May 13	Su	All: 18:20 Leave Narita (by SA7139/ NH911) 22:05 Arrive at Hong Kong 23:50 Leave Hong Kong (by SA287)	x	x	x	x	x	x	
2	May 14	Mo	All: 07:05 Arrive at Johannesburg 09:45 Leave Johannesburg (by SA142) 10:50 Arrive at Maputo 13:30 JICA (Mr. Nasu)	x	x	x	x	x	x	x x
3	May 15	Tu	All: 10:00 EDM (generation dept.) 14:30 EDM (projects dept.)	x	x	x	x	x	x	x
4	May 16	We	All: 09:00 CTM-Maputo & Beluluane power plant sites, followed by power plant construction sites (three sites) at RG	x	x	x	x	x	x	x
5	May 17	Th	All: 06:45 Leave Maputo (by TM130) 08:55 Arrive at Tete 11:00 Matambo substation	x	x	x	x	x	x	
6	May 18	Fr	All: 08:00 Leave Tete by car 10:30 Arrive at Songo for HCB hydro power plant and substation survey 14:30 Leave Song 17:00 Arrive at Tete	x	x	x	x	x	x	
7	May 19	Sa	All: 08:00 Leave Tete 08:30 Arrive at Moatize (presentation & coal mine site tour arranged by Vale) 13:30 Leave Moatize 14:00 Arrive at Tete 15:25 Leave Tete (by TM133) 17:35 Arrive at Maputo	x	x	x	x	x	x	
8	May 20	Su	All: (off)	x	x	x	x	x	x	
9	May 21	Mo	All: 08:30 EDM (Mr. Jonas) 14:00 EDM (Pr/R discussion)	x	x	x	x	x	x	x
10	May 22	Tu	All except Ok: 09:00 INAHINA 10:30 Local consultant A 14:00 GAZEDA 15:30 Local consultant B Ok: 11:50 Leave Maputo (by SA143) 13:00 Arrive at Johannesburg 17:25 Leave Johannesburg (by SA286)	x	x	x	x	x	x	x

No.	Date		Activities	Ka	Ki	Ok	Ni	Mi	Ma	Sa
11	May 23	We	All except Ok: 08:30 Leave Maputo (by TM462) 10:35 Arrive at Nampula 11:00 Leave Nampula by car 14:30 GAZEDA at Nacala & survey on the industrial park, followed by visit to EDM at Nacala for data collection & substation survey Ok: 12:10 Arrive at Hong Kong 14:30 Leave Hong Kong (by NH1172) 19:40 Arrive at Haneda	x	x	x	x	x	x	
12	May 24	Th	All except for Ok: 07:30 Leave Nacala by car for visit to proposed substation site at Namialo and substations (220 & Central) at Nampula 13:00 Arrive at Nampula 14:05 Leave Nampula (by TM153) 16:10 Arrive at Maputo	x	x		x	x	x	
13	May 25	Fr	All except for Ok: 09:00 ME 10:30 ENH 15:00 JICA/EOJ @EOJ	x	x		x	x	x	x
14	May 26	Sa	All except for Ki: (reports) Ki: 11:50 Leave Maputo (by SA143) 13:00 Arrive at Johannesburg 17:25 Leave Johannesburg (by SA286)	x	x		x	x	x	
15	May 27	Su	All except for Ki: (off) Ki: 12:10 Arrive at Hong Kong 14:30 Leave Hong Kong (by NH1172) 19:40 Arrive at Haneda	x	x		x	x	x	
16	May 28	Mo	Ka/Mi/Ma: 11:50 Leave Maputo (by SA143) 13:00 Arrive at Johannesburg 17:25 Leave Johannesburg (by SA286) Ni: Stay at Maputo for continuing work	x			x	x	x	
17	May 29	Tu	Ka/Mi/Ma: 12:10 Arrive at Hong Kong 14:30 Hong Kong (by NH1172) 19:40 Arrive at Haneda Ni: Stay at Maputo for continuing work	x			x	x	x	

Remarks:

1) Personnel symbol: Ka: Mr. Kasai, Ki: Mr. Kinoshita, Ok: Mr. Okano, Ni: Mr. Nimiya, Mi: Mr. Miyashita, Ma: Ms Matsuzaki (Interpreter 1), Sa: Mr. Sambo (Interpreter 2)

Itinerary for the Third Site Survey

No.	Date		Activities	Ka	Ki	Ok	Sa
1	July 1	Su	All: 18:25 Leave Narita (by SA7139/NH911) 22:05 Arrive at Hong Kong 23:50 Leave Hong Kong (by SA287)	x	x	x	-
2	July 2	Mo	All: 06:35 Arrive at Johannesburg 09:45 Leave Johannesburg (by SA142) 10:50 Arrive at Maputo 16:30 JICA (Mr. Sakaguchi)	x	x	x	x x
3	July 3	Tu	All: 10:30 EDM (Mr. Jonas)	x	x	x	x
4	July 4	We	All: 09:00 EDM (Power Generation Dept)	x	x	x	x
5	July 5	Th	All: 09:00 WB (Dr. Dalili) 11:00 ME	x	x	x	
6	July 6	Fr	All: 15:00 JICA & EOJ	x	x	x	
7	July 7	Sa	(final reporting)	x	x	x	-
8	July 8	Su	All: 11:50 Leave Maputo (by SA143) 13:00 Arrive at Johannesburg 17:00 Leave Johannesburg (by SA286)	x	x	x	-
9	July 9	Mo	All: 12:10 Arrive at Hong Kong 14:30 Hong Kong (by NH1172) 19:40 Arrive at Haneda	x	x	x	-

Remarks:

1) Personnel symbol: Ka: Mr. Kasai, Ki: Mr. Kinoshita, Ok: Mr. Okano, Sa: Mr. Sambo (Interpreter)

List of Key Persons whom the Survey Team Met

Organization	Department	Name	Position	Contact number
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Ditto	Electrification & Projects Directorate	Luis Amado (Mr.)	Director	Tel: 2142-6911 Mobile: 82-310-3990 Mail: lamado@edm.co.mz
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Ditto	Generation Directorate	Ildo R. (Rufino) A. Domingos (Mr.)	Director	Tel: 2148-1515 Mobile: 82-310-4460 Mail: irufino@edm.co.mz
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Ditto	Ditto	Abraao Rafael (Mr.)	Head of Project Planning Department	Tel: 2148-1527 Mobile: 82-311-1170 Mail: arafael@edm.co.mz
Ditto	Environmental Unit	Jeronimo Marrime (Mr.)	Environmental Manager (Electrical Engineer)	Tel: 2135-3614 Mobile: 82-326-4860 Mail: jmarrime@edm.co.mz
Empresa Nacional de Hidrocarbonetos (ENH)	Management Board for Engineering and Project Development	Paulino Gregorio (Mr.)	Member of Management Board for Engineering and Project Development	Tel: 2132-3076 Mobile: 82-230-3230 Mail: paulino.gregorio@enh.co.mz
Ditto	Engineering Department	Joao Venancio (Mr.)	Head of Engineering Department and Manager for Pande & Temane Gas Project	Tel: 2142-9456 or 2142-9467 Mobile: 82-940-6329 Mail: joao.venancio.@enh.co.mz
Ministry of Energy (ME)	Electric Energy Bureau (DNEE)	Ortígio Nhanambe (Mr.)	Vice Director	Mobile: 82-395-9740 Mail: oln@me.gov.mz
Ditto	International Relation Dept.	Telma Matavel (Ms.)	Chief	Mobile: 82-491-4300 Mail: telmamatavel@gmail.com
Ditto	Licencing Dept., DNEE	Maximo Mandava (Mr.)	Chief	Mobile: 82-160-4227 Mail: jcuna@gazeda.gov.mz
Ditto	Analysis and Policies Department, DNEE	Antonio Chicachana (Mr.)	Chief	Mobile: 82-396-1538 or 84-538-9997 Mail: age@me.gov.mz

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Ditto	-	Simão Pedro Santos Joaquim (Mr.)	Director	Tel: 2140-0635 Mobile: 82-634-0550 Mail: sjoaquim@gazeda.gov.mz
Beluluane Industrial Park and Free Zone (Beluzone)	-	Nelson Ventura (Mr.)	C.E.O/Chairman of Board of Director	Tel: 2173-1382 Mobile: 84-836-8872 Mail: jnventura@beluzone.co.mz
Ministry of Co-ordination of Environmental Affairs (MICOA)	National Directorate for Environmental Impact Assessment (DNAIA)	Josefa Jussar (Ms.)	Chede de Departamento	Mobile: 82-430-4070
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Ditto	Maintenance Planning Division	Luis Simon (Mr.)	Electrical Engineer Systems	Tel: 25-282-221/4 Mobile: 82-509-5630 Mail:luisimone.sng@hcb.co.mz

Organization	Department	Name	Position	Contact number
Vale Mozamcique, S.A.	Energy Business Development EMEA	Cedric Lemarie (Mr.)	General Manager	Tel: 21-243-200 Mail:cedric.lemarie@vale.com
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List of Collected Data and Information

ID. No,	Name (or Description) of Information/Data	Document type	Issued or Presented by
EP	**Information and data regarding power**		
EP-1	Annual Report 2011 (preliminary version)	Microsoft Word	Norad
EP-2	Characterization of the Transmission Network 2010	Book	EDM
EP-3	Technical Quality Report of the Transmission Network Performance 2010	Book	EDM
EP-4	Desempenho Da Rede De Distribuição, Relatório Estatístico 2010 (Distribution Network Performance, Statistical Report 2010)	Book	EDM
EP-5	Project Proposal ; Caia - Nampula - Nacala 220kV Transmission Line	Microsoft Word	EDM
EP-6	Plano de Expansão e Reforço da Rede de Transporte de Energia Eléctrica 2012 - 2021	Powerpoint	EDM
EP-7	Rehabilitation of Beira and Dondo Distribution Networks, Final Project Document	Microsoft Word	EDM
EP-8	Rehabilitation of Chimoio, Tete and Quelimane Distribution Networks, Final Project Document	Microsoft Word	EDM
EP-9	Rehabilitation of Lichinga,Cuamba and Pemba Distribution Networks, Final Project Document	Microsoft Word	EDM
EP-10	Rehabilitation of Maputo and Matola Distribution Networks, Final Project Document	Microsoft Word	EDM
EP-11	Rehabilitation of Nampula, Nacala and Monapo Distribution Networks, Final Project Document	Microsoft Word	EDM
EP-12	Rehabilitation of Xai Xai, Chokwe and Inhambane Distribution Networks, Final Project Document	Microsoft Word	EDM
EP-13	Electrification of the Limpopo Valley Area, Gaza Province Final Feasibility Study	Microsoft Word	EDM
EP-14	Electrification of the Vilanculos Area, Inhambane Province Final Feasibility Study	Microsoft Word	EDM
EP-15	Consultancy Services For Mozambique Electricity Master Plan Study (Update of 2004 Report); Terms Of Reference	Microsoft Word	EDM
EP-16	Alto Malema Hydropower Project Description and Further Steps; Final Project Document	Microsoft Word	EDM
EP-17	Massingir Hydropower Project, Description and Further Steps; Final Project Document	Microsoft Word	EDM
EP-18	Rehabilitation of Mavuzi and Chicamba Hydropower Plants; Final Project Document	Microsoft Word	EDM
EP-19	Quedas and Ocua Hydropower Projects on Lúrio River, Description and Further Steps; Final Project Document	Microsoft Word	EDM
EP-20	Electrification of the Vilanculos Area, Inhambane Province; Final Feasibility Study	Microsoft Word	EDM

ID. No,	Name (or Description) of Information/Data	Document type	Issued or Presented by
EP-21	Electrification of the Chibabava Area, Sofala Province; Final Feasibility Study	Microsoft Word	EDM
EP-22	Electrification of the Chimuara,Chupanga and Chinde Areas, ZambéziaProvince; Final Feasibility Study	Microsoft Word	EDM
EP-23	Electrification of the Furancungo/ Luia Area, Tete Province; Final Feasibility Study	Microsoft Word	EDM
EP-24	Electrification of the Gilé and Pebane Areas, Zambézia Province; Final Feasibility Study	Microsoft Word	EDM
EP-25	Electrification of the Limpopo Valley Area, Gaza Province; Final Feasibility Study	Microsoft Word	EDM
EP-26	Electrification of the Marrupa and Mecanhelas Areas, Niassa Province; Final Feasibility Study	Microsoft Word	EDM
EP-27	Electrification of the Mocímboa da Praia Area, Cabo Delgado Province; Final Feasibility Study	Microsoft Word	EDM
EP-28	Electrification of the Mogincual and Mecuburi Areas, Nampula Province; Final Feasibility Study	Microsoft Word	EDM
EP-29	Electrification/Rehabilitation of Distribution Networks, Maputo Province, Final Project Document	Microsoft Word	EDM
EP-30	Electrification of the Vilanculos Area, Inhambane Province; Final Feasibility Study	Microsoft Word	EDM
EP-31	Intensification of Distribution Networks in Sub-Urban Areas	Microsoft Word	EDM
EP-32	Load Dispatch Centers in the Northern/Central Regions Final Feasibility Study	Microsoft Word	EDM
EP-33	Network Reinforcement in the Beira Corridor ; Final Project Document	Microsoft Word	EDM
EP-34	Infulene – Manhiça - Macia 110 kV Transmission Project; Final Project Document	Microsoft Word	EDM
EP-35	Maputo-Infulene Reinforcement Project, Final Project Document	Microsoft Word	EDM
EP-36	Nampula & Monapo Reinforcement Project ; Final Project Document	Microsoft Word	EDM
EP-37	Phombeya-Nampula 220 kV Transmission Project; Final Project Document	Microsoft Word	EDM
EP-38	Voltage Control Facilities in the North-Eastern System; Final Project Document	Microsoft Word	EDM
EP-39	Feasibility Report on Exploration of Natural Gas for Power Generation in Maputo Mozambique	PDF	EDM
EP-40	Load Forecasting of Power System	Microsoft Excel	EDM
EP-41	Master Plan Update Project: Presentation Workshop, System Analysis and Load Precast, Maputo 9 May 2012 (presentation material prepared by Norconsult and Vatenfall)	PDF	EDM
EP-42	Volume I-A Main Report; Mozambique Regional Transmission Backbone Project (Final Feasibility Report)	PDF	EDM
EP-43	Volume I-B Appendices to Main Report; Mozambique Regional Transmission Backbone Project Final Feasibility Report)	PDF	EDM

ID. No,	Name (or Description) of Information/Data	Document type	Issued or Presented by
EP-44	Volume II Economic Impact Study; ; Mozambique Regional Transmission Backbone Project (Final Feasibility Report)	PDF	EDM
EP-45	Volume III-A Preliminary Design Report – HVAC and HVDC Transmission Lines ; Mozambique Regional Transmission Backbone Project (Final Feasibility Report)	PDF	EDM
EP-46	Volume III-B Preliminary Design Report HVAC and HVDC Substations; Mozambique Regional Transmission Backbone Project (Final Feasibility Report)	PDF	EDM
EP-47	Volume IV Line Route Report - HVDC Line; Mozambique Regional Transmission Backbone Project (Final Feasibility Report)	PDF	EDM
EP-48	Volume V 400 kV HVAC Line; Mozambique Regional Transmission Backbone Project (Final Feasibility Report)	PDF	EDM
EP-49	Section 5 – Terms of Reference - Amendment No. 1 Feasibility Study for Reinforcement of Central – Northern Transmission System Caia-Nacala Transmission Project	Microsoft Word	EDM
EP-50	Statistical Summary 2011	PDF	EDM
EP-51	List of Power Projects (updated version)	Microsoft Excel	EDM
EP-52	Project Proposal For Reinforcement Of Nampula Transmission System (Namialo Substation)	PDF	EDM
EP-53	Terms of Reference (TOR) for Technical Assistance to Strengthen EDM's Capacity for Investment and Development Planning	Hardcopy	EDM
EG	**Information and data regarding energy in general (especially those on natural gas)**		
EG-1	Petroleum Exploration and Production Activities in Mozambique	PowerPoint	ENH
EG-2	Feasibility Study for a Natural Gas Distribution Network in Maputo City and Marracuene Final Report March 2009	PDF	ENH
EG-3	Preliminary Study Of Alternatives For Supplying Natural Gas To Maputo City, December 2010	PDF	ENH
EG-4	Strategy For New And Renewable Energy Development (Edenr) 2011-2025	MS-Word	ME
EG-5	Energy Strategic Plan (2009-2013)	MS-Word	ME
EG-6	Energy Strategy	MS-Word	ME

ID. No,	Name (or Description) of Information/Data	Document type	Issued or Presented by
ES	**Information and data regarding environmental and social consideration**		
ES-1	Mozambique Regional Transmission Backbone Project; Environmental and Social Impact Assessment - Volume II	PDF	EDM
ES-2	Draft Environmental Guidelines For Transmission Lines December 2006	PDF	ME
ES-3	DRAFT 1c RESETTLEMENT GUIDELINES, December 2006	PDF	ME
ES-4	Mozambique Gas Engine Power Plant (MGEPP) Project in Ressano Garcia, Mozambique; Environmental Pre-Feasibility Study and Scope Definition & Terms of Reference	PDF	Sasol New Energy Group (Pty) Ltd & EDM
ES-5	Southern African Power Pool Environmental and Social Impact Assessment Guidelines for Transmission Infrastructure within the Southern African Power Pool Region; Final Report, Sept 2010	PDF	SAPP ESC
ES-6	SAPP Guidelines On The Management Of Oil Spills (Final)	PDF	SAPP ESC
ES-7	SAPP PCBs Management Guidelines	PDF	SAPP ESC
ES-8	Southern African Power Pool Position On Climate Change	PDF	SAPP ESC
ES-9	Guideline for the Safe Control, Processing, Storing, Removing and Handling of Asbestos and Asbestos Containing Materials and Articles for the Southern African Power Pool (Final)	PDF	SAPP ESC
ES-10	SAPP Occupational Health, Safety and Environmental Guideline	PDF	SAPP ESC
ES-11	Operational Manual - BP 4.01	PDF	World Bank
ES-12	Operational Manual - OP 4.01	PDF	World Bank
ES-13	Operational Manual - BP 4.04	PDF	World Bank
ES-14	Operational Manual - OP 4.04	PDF	World Bank
ES-15	Operational Manual - BP 4.10	PDF	World Bank
ES-16	Operational Manual - OP 4.10	PDF	World Bank
ES-17	Operational Manual - BP 4.12	PDF	World Bank
ES-18	Operational Manual - OP 4.12	PDF	World Bank
ES-19	Operational Manual - BP 4.36	PDF	World Bank
ES-20	Operational Manual - OP 4.36	PDF	World Bank

ID. No,	Name (or Description) of Information/Data	Document type	Issued or Presented by
ES-21	Operational Manual - BP 4.37	PDF	World Bank
ES-22	Operational Manual - OP 4.37	PDF	World Bank
ES-23	Operational Manual - BP 7.37	PDF	World Bank
ES-24	Operational Manual - OP 7.37	PDF	World Bank
ES-25	Operational Manual - BP 7.60	PDF	World Bank
ES-26	Operational Manual - OP 7.60	PDF	World Bank
ES-27	Decree number 45/2004: Passes the Regulation on the Environmental Impact Assessment Process and revokes the Decree number 76/98, of 29 December.	PDF	Cabinet Council
ES-28	Avaliação De Impacto Ambiental Para O Projecto De Distribuição De Gás Natural Em Maputo E Distrito De Marracuene Egasoduto Maputo-Matola	PDF	ENH
ID	**Information and data regarding investment promotion and industrial development**		
ID-1	List of tenants in Nacala Special Economic Zone	Hardcopy	GAZEDA
ID-2	List of Tenants in Beluluane Industrial Park	Hardcopy	GAZEDA
ID-3	Legislation on Investment; Special Economic Zones and Industrial Free Zones	PDF	GAZEDA
ID-4	Code of Fiscal Benefits; Law nr. 4/2009 of 12th January	PDF	GAZEDA
ID-5	Special Economic Zones Office; Decree nr. 75/2007 of 24th December	PDF	GAZEDA
ID-6	Law on Investment; Decree nr. 43/2009 of 21st August	PDF	GAZEDA
ID-7	Regulation of the Investment Law; Decree nr. 43/2009 of 21st August	PDF	GAZEDA
ID-8	Regulations on the Customs Regime of the Industrial Free Zone; Ministerial Diploma Nr. 14/2002 Of 30th January	PDF	GAZEDA
ID-9	Regulations on the Fiscal Benefits Act; Decree Nr. 56/2009 Of 30th January	PDF	GAZEDA