The Republic of Mozambique

Electtriccidade de Mocambique (EDM)

Data Collection Survey on Electrical Grid and Generation Development in Southern Mozambique

Final Report

June 2022

Japan International Cooperation Agency

Tokyo Electric Power Services Co., Ltd. (TEPSCO)

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Acronym

Abbreviations	English	Original Language (Portugal Language)
AAGR	Average Annual Growth Rate	—
AfDB	African Development Bank	—
ARENE	—	Autoridade Reguladora de Energia
BC	Big Customers	—
BS	Balance Sheet	—
CNELEC	—	Conselho Nacional de Electricidade
EDM	—	Electricidade de Moçambique
Eskom	South African Electric Utility Supplier	—
FUNAE	—	Fundo de Energia
GDP	Gross Domestic Product	
HCB	—	Hidroeléctrica de CahoraBassa
HV	High Voltage	—
IMF	International Money Fund	—
IPP	Independent Power Producer	—
JICA	Japan International Cooperation Agency	—
JOGMEC	Japan Oil, Gas and Metals National Corporation	—
L/A	Loan Agreement	—
LNG	Liquefied Natural Gas	—
LV	Low Voltage	—
MIREME	—	Ministerio de Recursos Minerais e Energia
MOTRACO	Mozambique Transmission Company	—
MV	Medium Voltage	—
NEXI	Nippon Export and Investment Insurance	—
OPEC	Organization of the Petroleum Exporting Countries	—
P/L	Profit and Loss Statement	—
PSS/E	Power System Simulator for Engineering	
SADC	Southern African Development Community	—
SAPP	Southern African Power Pool	—
SEC	Swaziland Electricity Company	—
USTDA	U.S. Trade and Development Agency	—

Chapter 1
Overview of Information Collection and Verification Survey

Chapter 1 Overview of Information Collection and Verification Survey

1.1 Background of this survey

In the Republic of Mozambique, electricity demand has increased significantly in recent years due to steady economic growth and higher electrification rates, with a CAGR of 12.4% and peak demand expected to increase from 655 MW in 2015 to more than 6,500 MW in 2042 (2018, according to JICA). On the other hand, the total installed power generation capacity as of 2019 is only 3,002.57 MW, with 75% of it generated by the Cahora Bassa hydroelectric company, mainly for overseas export, resulting in a shortage of domestic power generation capacity. The Electricidade de Moçambique (EDM), the state-owned electric power company responsible for dispatching electricity in the country, generates only 3% of the country's electricity, and the increasing cost of purchasing electricity from independent power producers (IPPs) is putting pressure on EDM's finances. The country's power system is divided into two systems, the southern system and the central and northern systems, and it is necessary to promote power development in each system. In addition, as the demand for electricity increases, the transmission and distribution facilities need to be expanded.

JICA implemented the "Power Master Plan Development Project" (2016-2018) to support the development of a 25-year (2017-2042) master plan for the power sector. The master plan was approved by the Cabinet of Ministers and is now the basis for power sector development in the country. In addition, as part of the power supply development in the southern part of the country, including the capital city of Maputo, the project "Maputo Gas Combined Cycle Power Plant Development Project" (signed in January 2014) was implemented, and a 106 MW gas combined cycle power plant fueled by domestic natural gas has been in operation since August 2018. However, the Master Plan also states that the future increase in electricity demand in the southern grid will require an increase in contracts with existing IPPs or electricity imports, and securing power sources in the southern grid continues to be an issue. As for power transmission and distribution, the reinforcement of transmission lines and substations is an urgent issue, and several projects are planned, but there are many projects in the southern system for which it is difficult to secure funding, and there is no way to solve the problem.

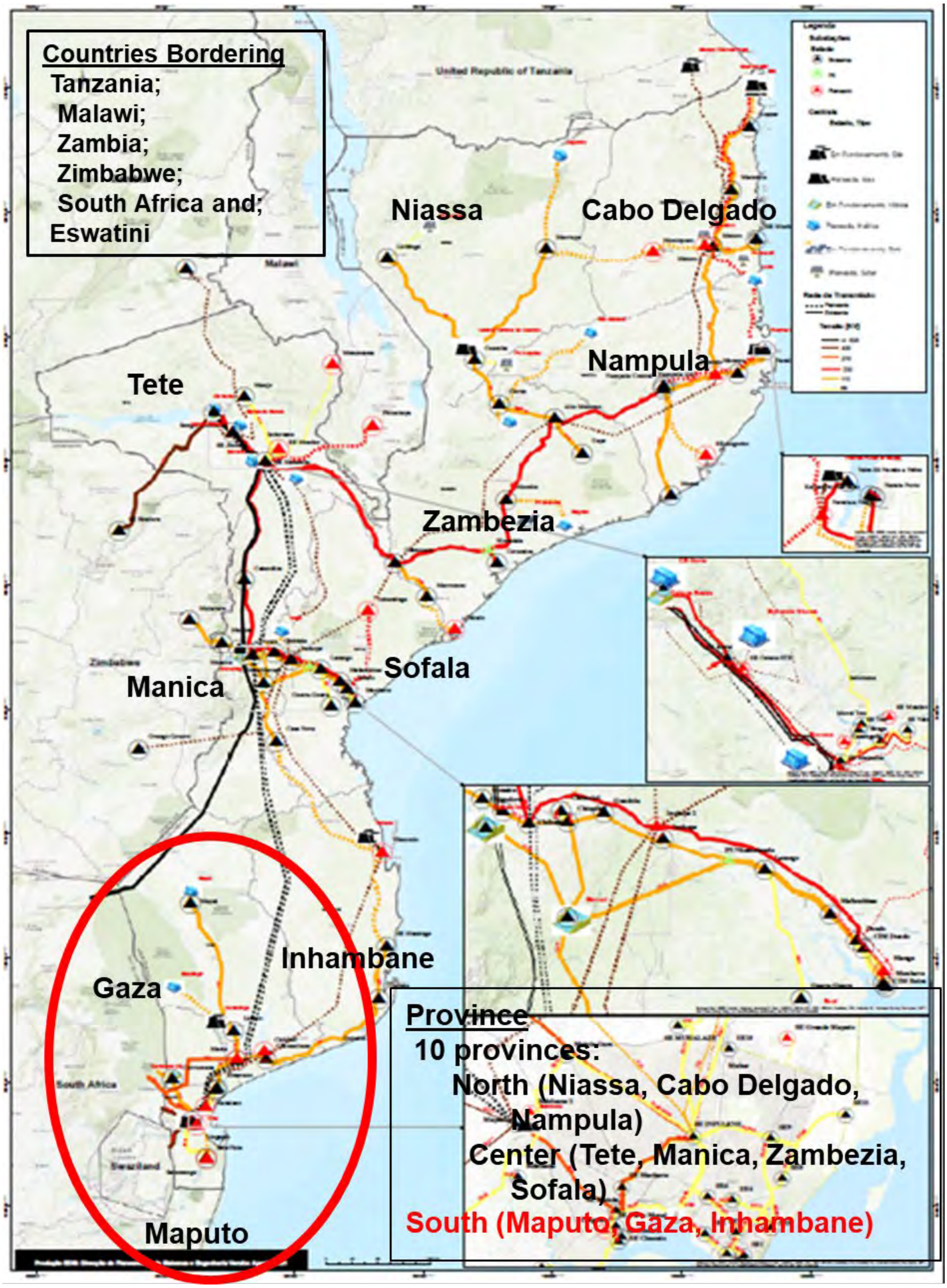
Based on these circumstances, this study will be conducted to comprehensively understand the latest status of power supply development and transmission/distribution facilities in the southern grid of the country and to examine the possibility of JICA's support in the future.

1.2 Overview of the survey

(1) Objectives of the survey

The purpose of this study is to comprehensively understand the latest situation regarding the development of power supply, transmission and distribution in the southern system of Mozambique's power sector, and to collect, organize and analyze the information necessary to consider the implementation of future projects.

Figure 1.2-1 shows the survey area of this study.



Source: Prepared by JICA study team based on EDM information.

Figure 1.2-1 Survey area

(2) Study Items

1. Review information of the Electricity Master Plan

   1.1 Electricity demand and supply in the southern system

2. Analyze development plans in the southern system

   2.1 Power development

   2.2 Transmission and substation development

   2.3 Distribution development and off-grid electrification

3. Future development possibilities in the Electric Sector in Mozambique

(3) Survey area

Mozambique Southern Region

(4) Relevant ministries, agencies, and institutions

Ministerio de Recursos Minerais e Energia (MIREME)

EDM

Fundo Nacional de Energia (FUNAE)

1.3 Composition of the study team

The composition of the study team is shown in Table 1.3-1.

Table 1.3-1 Study team

Study Team / Profession	
Mr. Masayoshi ONO	Team Leader / Power Development Plan
Mr. Masahiro OGAWA	Transmission Development Plan
Mr. Koichi MURATA	Electricity Distribution Improvement Plan
Ms. Etsuko KOBAYASHI	Thermal Development Plan
Mr. Hidekazu TAKASE	Sectoral and Business Analysis (No.1)
Mr. Shunpei HAYAKAWA	Sectoral and Business Analysis (No.2)

Source：JICA Study Team

1.4 Study schedule

Project Period: July 2021 – June 2022

A total of four online meetings were held with EDM in the first half of the study to address new coronavirus infections. In October, a field survey was conducted to collect data on power generation, transmission, and distribution through meetings with EDM's system planning, generation, and distribution departments, MIREME, FUNAE, and the African Development Bank (AfDB). After meeting with the power generation department of EDM, the study team inspected the Maputo Thermal Power Plant (106MW, Gas Turbine Combined Cycle) financed by JICA. However, this survey is mainly a desktop study.

Chapter 2
Power Sector Overview

Chapter 2 Power Sector Overview

2.1 Power Sector Overview

The following is an overview of the electricity sector in Mozambique.

- The country of Mozambique is located in southern Africa and covers an area of about 800,000 km2 and more than 2,500 km of coastline. 30 million people live in the country, with about 70% of the population living in rural areas. The national electricity grid has not been extended to rural areas, resulting in a large gap in electricity access between urban and rural areas.
- The power system is divided into two systems: the southern system and the central and northern systems, which are not interconnected and are independent of each other.
- The national average electrification rate stands at a low 35% (2020), and improving it is a major challenge. The need for support for electrification projects that contribute to economic growth and poverty reduction is extremely high.
- The Cahora Bassa hydroelectric power plant (Hidroeléctrica de CahoraBassa, HCB, 2,075 MW), the largest power plant in the country, is connected to the central and northern grid. Part of the power generated is transmitted to the central and northern regions via a 220 kV AC transmission line to supply the country, and to neighboring Zimbabwe via a 400 kV AC transmission line. The majority of the power generated is transmitted via a 535kV DC transmission line to the Apollo substation in South Africa, which transfers the power to the Southern African Power Pool (SAPP).
- The southern grid imports electricity from SAPP via the South African grid and the Eswatini grid, which are interconnected by a 400 kV AC transmission line. This results in about 80% of the domestic demand being met by re-imported electricity.

2.2 Power Sector policy

Mozambique is bordered by six countries (Tanzania, Malawi, Zambia, Zimbabwe, South Africa, and Eswatini), four of which are landlocked and therefore dependent on Mozambique as a window to global markets. Furthermore, the strong ties between South Africa, the economic engine of the region, and Mozambique indicate the importance of the economic, political, and social development of Mozambique countries to the stability and growth of Southern Africa. Furthermore, the country is blessed with natural gas and hydropower development resources.

The government of Mozambique、under its Energy for All Program[1], aims to achieve 64% access to electricity by the end of 2024 and to provide electricity to all citizens by 2030.

EDM is supposed to play a key role in facilitating this transition. To this end, the EDM has developed a five-year (2020-24) business plan that aims to implement projects to strengthen the power grid and rural electrification to ensure universal access and reduce energy losses by 2030. Under this plan, EDM is implementing several major projects/programs to improve transmission infrastructure, promote rural electrification, and build cross-border interconnections.

2.3 Structure, organization and operation of the electricity sector

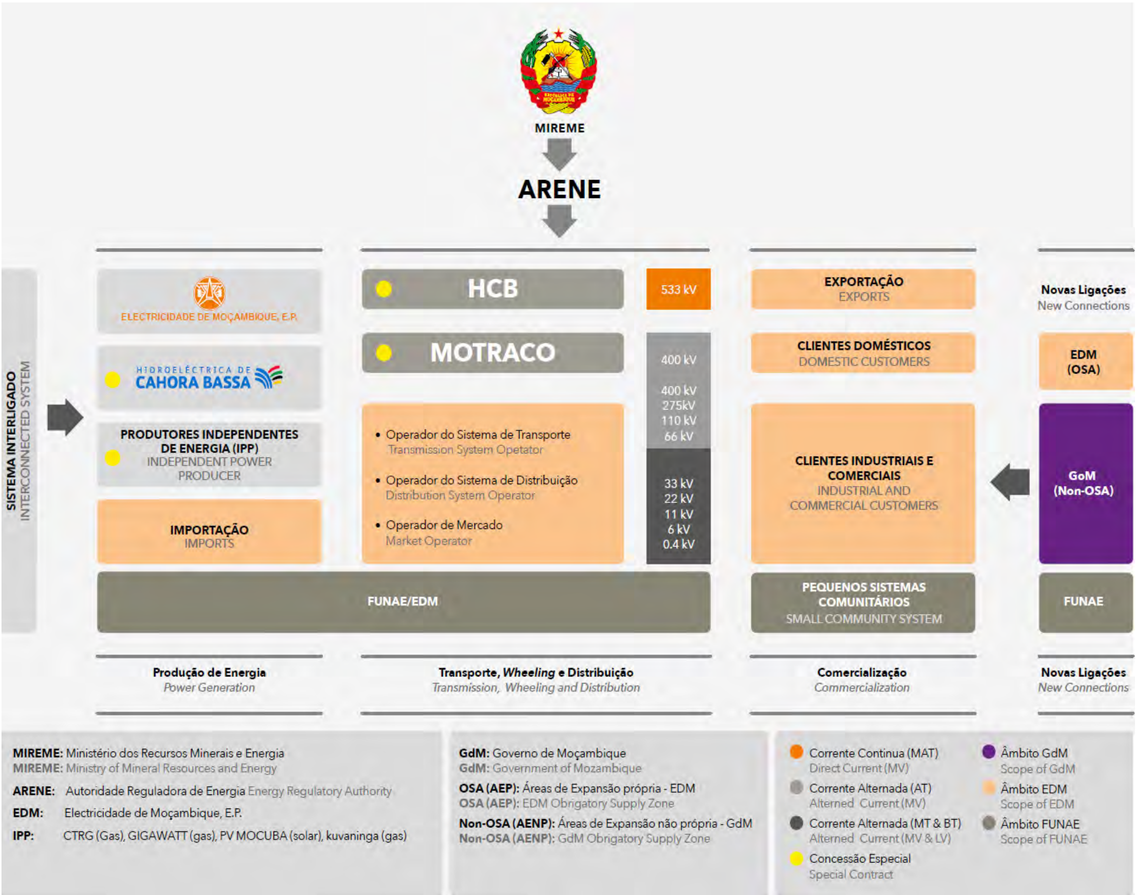
The country's electricity sector is governed by the 1997 Electricity Law, which maintains the state's authority over sector policy and regulation. MIREME is the government agency responsible for overseeing energy sector operations and development, energy planning, and policy formulation. FUNAE is a government agency in charge of off-grid electrification projects, which are expected to contribute to economic and social development in rural areas. The Electricity Law allows for the participation of the private sector in the electricity sector and its activities; in May 2017, the National Assembly approved the creation of the Energy Regulatory Agency (Autoridade Reguladora de Energia: ARENE) to separate regulatory and policy functions from MIREME.

[1] Mozambique Energy for All (Pro Energia)

ARENE is a new regulatory body that replaces the former Consultative Body for Regulation, the Conselho Nacional de Electricidade (CNELEC), which is empowered to regulate electricity prices, promote and monitor competition in the electricity sector, and monitor and enforce the terms and conditions of licenses and concession agreements in the electricity sector. In addition to regulating the electricity sector, ARENE's mandate extends to the storage, distribution, and sale of liquid fuels, and the distribution and sale of natural gas at pressures below 16 bar.

EDM is the state-owned electricity company of the Mozambique country and is wholly owned by the government, which is involved in all parts of the electricity supply business, including generation, transmission, and distribution, connection to consumers, supply and billing. The Mozambique Transmission Company (MOTRACO) is a joint venture between EDM, the South African Electric Utility Supplier (Eskom) and the Swaziland Electricity Company (SEC). HCB is the largest power source in Mozambique

Figure 2.3-1 shows the organizational chart of the power sector.



Source：EDM

Figure 2.3-1 Organizational chart of the power sector

2.4 Economic and financial analysis of power sector implementing agencies

(1) EDM's Financial Status

Financial statements for the past three years (2018, 2019, and 2020) were collected to understand EDM's financial situation (Annual Report 2017 for 2018, Activities Plan and Budget 2021 for 2019 and 2020).

(2) Balance Sheet (B/L)

The balance sheet is shown in Table 2.4-1.

Table 2.4-1 Balance sheet

Balance Sheet			(Unit：million MZN)
	2018	2019	2020
Assets			
Current Assets	25,101	34,740	35,167
Inventory	3,123	2,247	1,798
Trade Debtors	5,937	14,510	13,784
Other Financial Assets	4,887	4,020	3,939
Other Current Assets	7,077	8,244	9,069
Cash and Banks	4,077	5,719	6,577
Non-Current Assets	190,169	193,953	207,177
Tangible Assets	186,063	190,312	203,089
Financial Assets Held for Sale	763	777	777
Other Financial Assets	1,587	1,587	1,587
Deferred Tax Assets	1,756	1,277	1,724
Total Assets	215,270	228,693	242,344
Liabilities			
Current Liabilities	36,273	48,457	57,000
Provisions	135	28	30
Loands Obtained	1,051	551	496
Suppliers	24,906	25,896	30,400
Other Financial Liabilities	8,574	19,692	22,869
Other Current Liabilities	1,607	2,290	3,205
Non-Current Liabilities	93,135	97,098	107,615
Provisions	8,109	11,958	12,914
Loans	1,357	1,016	914
Other Financial Laibilities	32,931	34,103	39,603
Other Non-Current Liabilities	10,500	11,070	13,284
Deferred Tax Liabilities	40,238	38,951	40,900
Total Liabilities	129,408	145,555	164,615
Equity			
Share Capital	6,197	6,197	6,197
Reserves	349	349	349
Share Premium	11,648	11,648	11,648
Revaluation Surplus	77,111	71,111	74,232
Retained Earnings	-5,976	-9,443	-10,802
Net Income for the Year	-3,467	-2,132	-3,895
Total Equity	85,862	77,730	77,729
Liabilities and Equity	215,270	223,285	242,344

Source： EDM（Annual Report 2017, Activities Plan and Budget 2021）

The balance sheet revealed the following.

- Accounts renewable (trade debtors) doubled in 2019 from the previous year.
- Tangible assets increased due to increasing capital investment.
- Accounts payable have remained high.
- Non-current liabilities are gradually increasing.
- Self-funding is being reduced. In other words, net losses continue.

(3) Profit and Loss Statement (P/L)

The income statement is shown in Table 2.4-2.

Table 2.4-2 Income Statement

Income Statement			
	2018	2019	2020
Sales	31,145	39,549	39,008
Cost of Sales	−23,341	−27,571	−29,266
Sales Profit/Loss	7,804	11,978	9,742
Supplemental Income	38	284	334
Personnel Expenses	−3,467	−4,663	−4,836
Third Party Serivce Supplies	−3,383	−4,970	−3,073
Depreciation and Amortization	−4,445	−4,727	−5,003
Reversals	4	37	
Impairment Expenses on Finaical Assets	−2		
Provisions	−995	−1,216	−1,255
Inventory Adjustment			
Financial Investment	0		
Gain/Loss from Impairment on Account Receivables	−1,321	−970	
Other operational Income and Expenses	2,692	1,622	−181
Operating Profit/Loss	−3,075	−2,625	−4,272
Financial Income	5,995	6,131	
Financial Expenses	−6,755	−6,447	
Net Profit Before Tax	−3,835	−2,941	−4,272
Income Tax	368	809	
Net Profit After Tax	−3,467	−2,132	−4,272

：EDM（Annual Report2017, Activities Plan and Budget 2021）

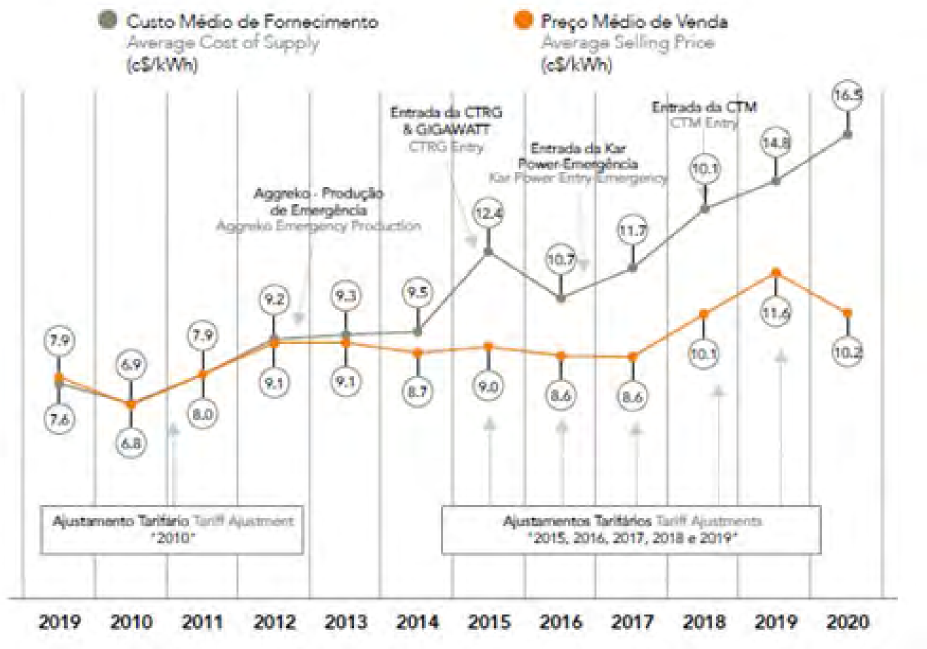
The followings were observed from the income statement.

- Revenue from electricity sales has been growing year by year. From what we hear, it shows the number of subscribers are increasing as the electrification rate increases.
- Operating losses are incurred every year.
- The company recorded losses on accounts receivable impairment in 2018 and 2019.
- Amount of financial expenses is high.
- In 2018 and 2019, the company received an income tax refund due to a net loss.

In summary, the current ratio needs to be improved in terms of financial safety, but there seems no problem in terms of long-term repayment capacity as far as the indicators are concerned, but both fixed liabilities and equity capital are in excess of tangible fixed assets. Profitability, on the other hand, tends to be low, with the ratio of sales to total capital being 4%.

2.5 Electricity charges and collection

Between 2015 and 2019, electricity prices in Mozambique were revised and increased five times. However, this was not enough to cover the cost of energy supply. Because of operating IPPs to respond to the energy shortage, the cost of energy supply increased. This has become a significant burden for EDM and has adversely affected their financial situation. Figure 2.5-1 shows the average supply costs and electricity prices.



: EDM

Figure 2.5-1 Average cost of supply and electricity prices

EDM has adopted a different fee structure depending on the needs of the customer. Table 2.5-1 on the next page shows the results.

Table 2.5-1 EDM Price Structure

Tarifas Tariffs	Fins a que se destina a instalação Purpose for which it is intended to
Social Social	Casas de habitação, com potência contratada de 1,1kVA e um consumo mensal não superior a 125kWh. Residential houses, with contracted power of 1.1kVA and monthly consumption not exceeding 125kWh
Doméstica Domestic	Casas de habitação, arrecadações ou garagens de uso particular, localizadas em anexos ou dependências de casas de habitação, ainda que medidos por contador próprio. Residential houses, storerooms or garages for private use, located in annexes or outhouses of residential houses, even if measured by its meters.
Agrícola Agricultural	Actividade de produção agrícola, nomeadamente nos sistemas de bombagem e irrigação, bem como as habitações e dependências localizadas no perímetro do local. Agricultural production activity, namely in the pumping and irrigation systems, as well as the houses and facilities located in the perimeter of the site.
Geral General	Actividade comercial, por exemplo: Estabelecimentos comerciais, Restaurantes, Salões de Cabeleireiro, Bancas de Mercado, etc... Commercial activity, for example, Commercial Stores, Restaurants, Hairdressing salons, Market stalls, etc...
Grandes Consumidores de Baixa Tensão Low Voltage Large Consumers	Fornecimentos em Baixa Tensão, com Potência Contratada superior a 19,8kVA e inferior a 39.6kVA Low Voltage Supplies with Contracted Power greater than 19.8KVA and less than 39.6KVA
Média Tensão Medium Voltage	Fornecimentos em Tensão superior a 1kV e inferior a 66kV Supplies with Voltage Greater than 1kV and less than 66kV
Média Tensão Agrícola Agricultural Medium Voltage	Fornecimentos em Tensão superior a 1kV e inferior a 66kV para a actividade de produção agrícola Voltage supplies of more than 1kV and less than 66kV for agricultural production activities
Alta Tensão High Voltage	Fornecimentos em Tensão superior a 66kV Supplies at Voltages greater than 66kV
Cliente Especial Special Customers	Fornecimentos em Média e Alta Tensão, sendo que as tarifas aplicadas resultam de um acordo entre o cliente e a EDM, mediante a aprovação do Ministro de tutela, ouvida a ARENE Medium and High Voltage supplies, the applied tariffs being the result of an agreement between the customer and EDM, subject to the approval of the supervising Minister, after hearing ARENE
Exportação Exports	Fornecimento de energia eléctrica a outros concessionários ou consumidores operando nos países da região da SADC abrangidos pelos acordos da SAPP. Electricity Supply for concessionaires or consumers operating in the countries of the SADC region covered by the SAPP agreements

Source：EDM

The specific electricity rates are shown in Table 2.5-2.

Table 2.5-2 EDM Electricity Rates

Electricity Tariffs

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

Recorded Consumption (kWh)	Sale Price				Flat Rate (Mt/kWh)
	Social Tariff (Mt/kWh)	Household Tariff (Mt/kWh)	Farming Tariff (Mt/kWh)	General Tariff (Mt/kWh)	
From 0 to 100	0.97				
From 0 to 200		6.00	3.69	9.32	233.37
From 201 to 500		8.49	5.26	13.31	233.37
Above a 500		8.91	5.75	14.56	233.37
Pre-Payment	0.97	7.64	5.11	13.34	

Major Consumers of Low, Medium and High Voltage

Class of Consumers	Sale Price		Flat Rate (Mt)
	(Mt/kWh)	(Mt/kW)	
Major Cons. LV (GCBT)	5.74	441.12	683.29
Medium Voltage (MV)	4.78	497.03	3,207.25
Medium Voltage agricultural	2.72	313.29	3,207.25
High Voltage (HV)	4.70	600.10	3,207.25

Source：EDM

The tariffs are set according to the type of customer and the amount of electricity consumption for low-voltage receiving customers. Large-scale customers are categorized according to the voltage at which they receive power. Large-scale customers are also charged a connection fee.

The types of customers receiving low-voltage power are set for public facilities, households, agriculture, general commercial use, and flat rate customers. Large-scale customers are charged two rates, a basic rate and a metered rate, depending on the scale of electricity received.

2.6 Status of master plan utilization and future technical issues

(1) Status of master plan utilization

The master plan supported by JICA has been approved by the Cabinet of Ministers and has become the basis for the development of the power sector in the country of Mozambique. In order to understand the status of utilization of this master plan, interviews were conducted with MIREME and EDM, and the following was found.

- The four-year medium-term power development plan (2020-2023) aims to increase power generation capacity by 620 MW, 420 MW of which will come from gas-fired power plants and 200 MW from renewable energy sources.
- A notable project in the south is the construction of a 420 MW thermal power plant in Temane, which is expected to be operational in 2023. 560 km of 400 kV transmission lines will connect Vilanculos (near Temane) to Maputo, thereby improving the stability of the southern grid. This will improve the stability of the southern grid. In conjunction with this work, we confirmed plans to upgrade three substations between Vilanculos and Maputo. In the central part of the country, we also confirmed the plan to connect Malawi with a 400kV transmission line.
- Regarding the Mphanda Nkuwa hydropower plant, this is a long-term project that is expected to be operational by 2030, and it is an important project that will be involved in the stability of the grid in Mozambique. The status of the project is under FS and environmental assessment of the transmission line and market study of electricity, and we confirmed that they are planning to start bidding for the construction of the transmission line soon.
- As discussed in Chapter 3, the growth in demand from 2015 to 2020 is low and does not match with the demand forecast in the Master Plan. Therefore, a request has been raised within EDM to revise the master plan to bring the demand forecast in line with reality.

(2) Future technical issues

The power sector in Mozambique has seen a significant increase in electricity demand in recent years due to steady economic growth and increased electrification rates. On the other hand, the total installed power generation capacity as of 2019 stood at 3002.57 MW, 75% of which is accounted for by hydropower generated by HCBs, which mainly export to foreign countries, resulting in a shortage of domestic power generation capacity. EDM generates only 3% of the country's electricity, and the increasing cost of purchasing electricity from IPPs is putting pressure on EDM's finances. The country's power system is divided into two systems: the southern system and the central and northern systems, and it is necessary to promote power development in each system. In addition, as the demand for electricity increases, the transmission, transformation and distribution facilities need to be expanded. However, its solution has been difficult for many years due to aging network facilities, financial constraints, high power loss, and weak institutional framework. These issues have resulted in poor access to electricity, which in turn has resulted in low economic growth rates for the country.

In the future, the country will have to diversify its generation mix and complement it with a strong transmission network to fully draw power from existing and future power plants and further increase electrification rates in both urban and rural areas. Between 2015 and 2019, Mozambique's electricity prices were revised and increased five times, but it was not enough to cover the cost of power supply. In order to maintain the financial viability of EDM projects, policies such as adequate funding for planned projects, a regulatory framework that attracts IPPs and other private-sector projects, and tariffs that reflect actual electricity sales prices are necessary. The EDM has raised most of the necessary funds from multilateral lending institutions, but it is important to attract private sector participation, such as the Temane project, in order to accelerate project development.

The country borders six countries, four of which are landlocked, which makes Mozambique a strategic location. It is time to establish itself as a power hub in the Southern African region and prepare for massive economic growth.

2.7 Mozambique's Electricity Development Strategy

EDM has identified the following three strategic priorities[2].

- Achieving universal access in line with the Sustainable Development Goals
- Establishing a position as an energy hub in southern Africa

[2] EDM(2020), EDM STRATEGY 2018-2028

- Ensuring sustainable human capital

In the "promotion of infrastructure development," which is one of the concrete measures to achieve this goal, the EDM states the following concrete measures.

Energy Mix：

Use untapped temporary resources to diversify supply and enhance power supply from different sources to meet future demand projections.

Gas power Generation：

Contribute to the optimal use of proven gas reserves and the further investment required to convert to gas power generation.

Hydroelectric Power：

Research existing watersheds to develop further hydropower plants.

Renewable energy：

Develop a strategic plan for renewable energy, giving priority to an integrated on-grid and off-grid approach to achieve universal access by 2030.

Private power generation：

To augment its own power generation and transmission systems, focus on developing medium-scale power generation projects (50-100 MW) with the support of international financial partners and using donor funds and concessional loans.

Chapter 3
Electricity demand and supply in the southern system

Chapter 3 Electricity demand and supply in the southern system

3.1 Electricity demand in the southern grid

(1) Electricity Demand in Mozambique

Table 3.1-1 and Figure 3.1-1 show the demand for electricity at the receiving end in Mozambique from 2006 to 2020, and Table 3.1-2 shows the details of the demand categories in the table. Demand grew steadily at a rate of more than 9% until 2014, reaching 4,050 GWh in 2016, including Special Customers. However, since 2017, demand has declined or stagnated and has remained around 4,000 GWh. The reasons for the sluggish demand growth were found to be the following four points through interviews with related organizations.

- The Mozambique country's hidden debt problem and its uncertainty, which was uncovered in 2016, continues to make it difficult to obtain foreign loans and raise funds for power development projects and other purposes.
- The security situation in the northern part of the country has deteriorated due to the outbreak of armed insurgency in 2017. As a result, many residents have been forced to evacuate the northern region.
- The landfall of a powerful cyclone in 2019, causing extensive damage.
- COVID-19 infection has been prevalent since 2020, causing economic activity to stagnate.

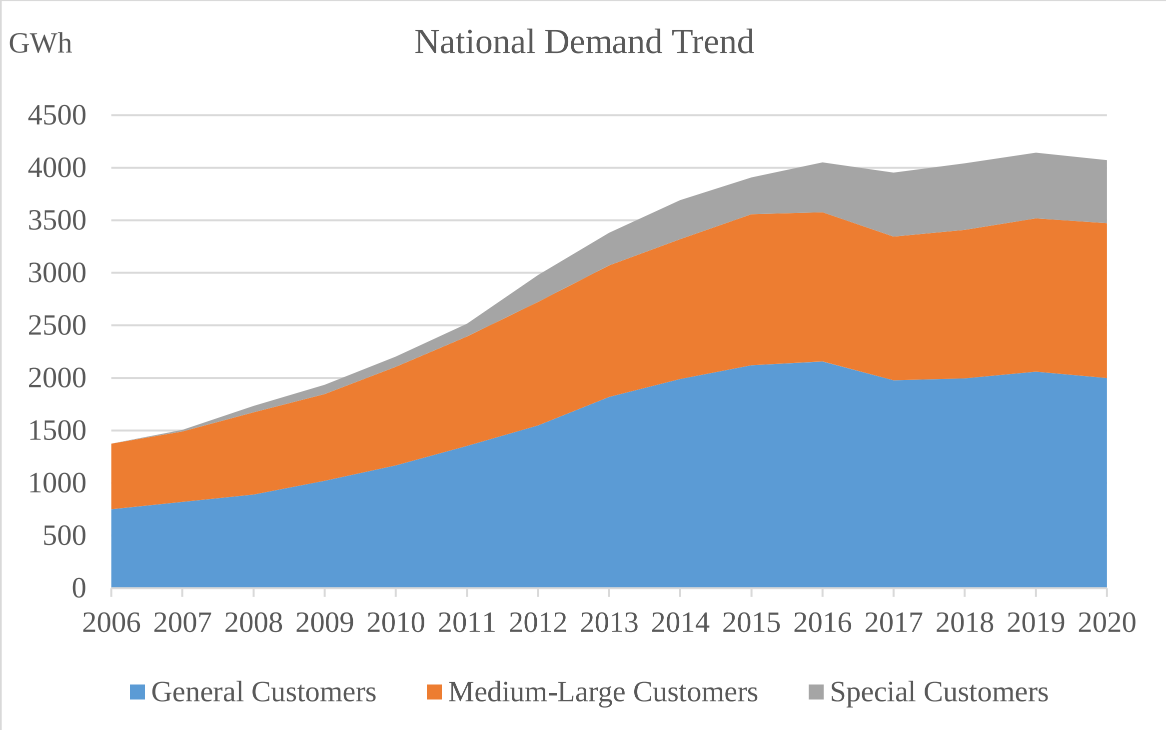
Of these, the armed forces in the northern region have been disarmed by the government, and people are returning to the northern region and reconstruction is beginning.

Table 3.1-1 Demand from 2006 to 2020 (nationwide)

(GWh)

Year	General Customers						Medium-Large Customers			Special Customers	Total (Excluding Special Customers)	Total (Including Special Customers)	Growth [%]
	LV-General	Domestic	LV-Agriculture	Public-lighting	EDM's Consumption	General Customers Sub Total	LV-Big Customers	MV/HV Customers	Medium-Large Customers Sub Total				
2006	183	517	0	42	10	751	89	535	624	0	1,375	1,375	-
2007	195	581	0	39	6	820	103	567	671	14	1,491	1,505	9.5%
2008	198	648	0	38	6	890	112	672	784	60	1,674	1,734	15.2%
2009	222	751	0	42	6	1,021	125	701	826	88	1,847	1,935	11.6%
2010	219	897	0	45	6	1,168	143	795	938	96	2,106	2,202	13.8%
2011	245	1,052	1	50	6	1,354	150	890	1,040	122	2,395	2,517	14.3%
2012	258	1,233	0	53	6	1,550	169	1,007	1,175	253	2,725	2,978	18.3%
2013	322	1,416	25	52	6	1,821	170	1,080	1,250	310	3,071	3,381	13.5%
2014	369	1,538	26	52	6	1,991	174	1,156	1,330	371	3,321	3,692	9.2%
2015	421	1,653	29	17	2	2,121	173	1,263	1,436	351	3,557	3,908	5.9%
2016	406	1,688	22	27	13	2,156	171	1,249	1,420	474	3,577	4,050	3.6%
2017	387	1,539	19	20	14	1,978	175	1,191	1,366	610	3,344	3,954	-2.4%
2018	365	1,576	20	25	10	1,996	169	1,244	1,413	632	3,409	4,041	2.2%
2019	415	1,585	26	27	8	2,061	146	1,312	1,458	625	3,519	4,143	2.5%
2020	416	1,508	34	36	6	1,999	137	1,337	1,474	598	3,473	4,071	-1.7%

: JICA Study Team



Source： JICA Study Team

Figure 3.1-1 Trends in country-level demand from 2006 to 2020

Table 3.1-2 Voltage classification and customer classification

Voltage		Customer	
LV	≦1kv	Domestic	Household
		LV-General	Small consumer supplied by 0.4 kV
		LV-Big Customers	Large consumer supplied by 0.4 kV Contract is more than 0.38kW
MV	＞1kV, 66kV＜ （6.6kV、11kV、22kV、33kV）	MV-Customers	
HV	≧66kV	HV-Customers	
		Special Customers	Contract is more than 1MW

：MME Integrated Master Plan Mozambique Power System Development, November 2018

(2) Electricity demand in the southern system

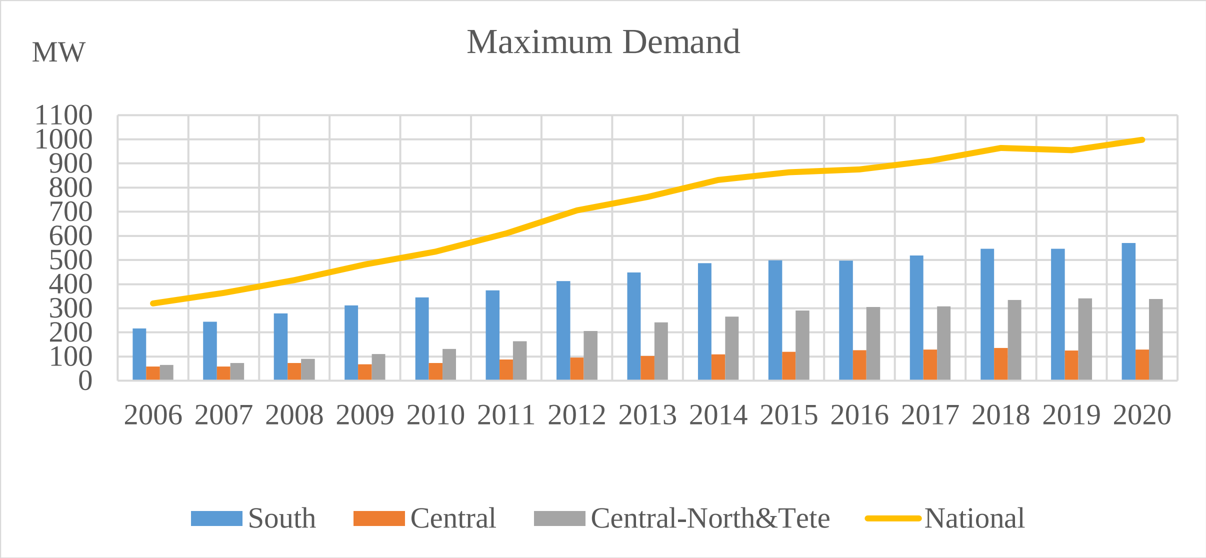
Table 3.1-3 and Figure 3.1-2 show the maximum power (generation end) of the national, southern, central, and northern systems from 2006 to 2020. The national maximum power is 998 MW in 2020. Of this, the southern grid, which includes the capital Maputo, accounts for about 60% of the total. As of 2006, demand in the central and northern systems was similar, but in the northern system, which includes the provinces of Tete, where the coal industry is developing, and Nampula, which has a large port, there has been significant growth compared to the central system. A comparison of the five-year Average Annual Growth Rate (AAGR) for 2011-2015 and 2016-2020 shows that the overall growth rate has decreased significantly in the last five years, and demand growth has stagnated. This is due to the unstable situation in Mozambique mentioned previously.

Table 3.1-3 Maximum power from 2006 to 2020 (generation end)

(MW)

Year	South	Central	Central-North&Tete	National
2006	216	58	65	320
2007	244	59	73	364
2008	279	73	90	416
2009	312	68	110	481
2010	345	73	131	534
2011	374	88	164	610
2012	412	96	206	706
2013	448	103	241	761
2014	487	109	265	831
2015	499	119	291	863
2016	497	126	305	876
2017	519	129	308	911
2018	546	135	334	964
2019	546	125	341	955
2020	571	129	338	998
AAGR (2011-2015)	7.7%	10.4%	17.5%	10.2%
AAGR (2016-2020)	2.8%	1.7%	3.1%	3.0%

: EDM Annual Stastical Report



Source：EDM Annual Stastical Report

Figure 3.1-2 Maximum power (generation end) from 2006 to 2020

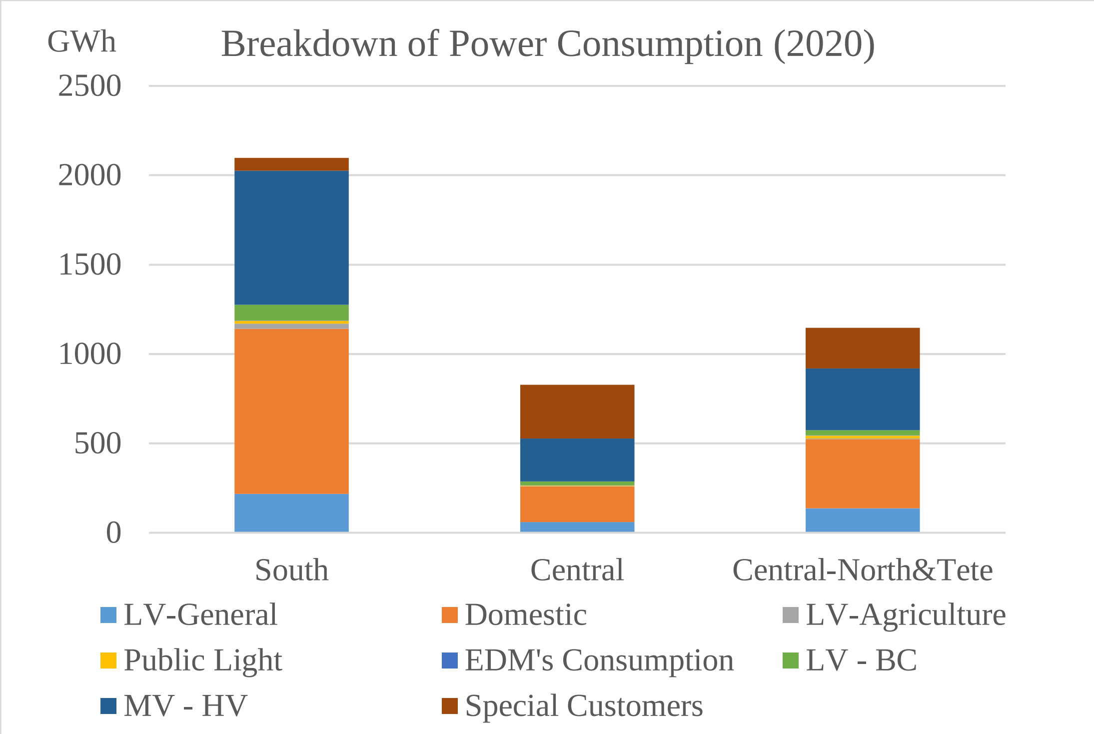
Next, Table 3.1-4 and Figure 3.1-3 show the use and breakdown of electricity consumption in each region in 2020. The southern grid region consumes 2,097 GWh of electricity, which accounts for about half of the total electricity consumed nationwide. Due to the presence of urban areas such as the capital city of Maputo, the southern region is characterized by its high consumption of domestic power and medium-voltage/high-voltage power (MV-HV) used in buildings and small and medium-sized factories. The consumption of Special Customers is lower than that of the Northern and Central regions, but this is due to the large consumption by mining and extraction companies such as MOMA and VALE that operate in the Northern and Central regions.

Table 3.1-4 Use and breakdown of electricity consumption in each region in 2020

(GWh)

	South		Central		Central-North&Tete	
LV-General	218	10.4%	60	7.3%	138	12.0%
Domestic	924	44.0%	199	24.0%	386	33.6%
LV-Agriculture	29	1.4%	1	0.2%	3	0.3%
Public Light	16	0.8%	3	0.4%	16	1.4%
EDM's Consumption	2	0.1%	1	0.1%	3	0.3%
LV - Big Customers	86	4.1%	23	2.7%	28	2.4%
MV - HV	751	35.8%	240	28.9%	346	30.2%
Special Customers	71	3.4%	301	36.3%	226	19.7%
Total	2,097	100.0%	828	100.0%	1,146	100.0%

：EDM Annual Stastical Report



Source：EDM Annual Stastical Report

Figure 3.1-3 Use and breakdown of electricity consumption in each region in 2020

(3) Comparison with demand forecast

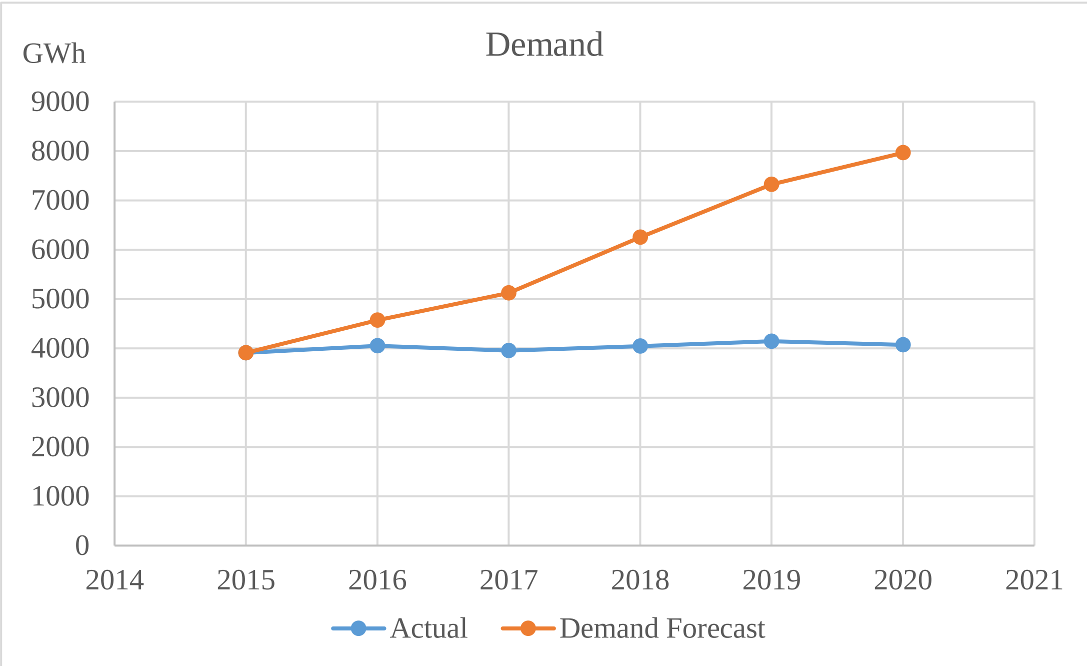
Table 3.1-5 and Figure 3.1-4, Figure 3.1-5 show the comparison between the actual electricity demand at the national level from 2015 to 2020 and the demand forecast in the basic scenario of the Master Plan. Also, Table 3.1-6 shows the demand forecast scenarios in the Master Plan, and Table 3.1-7 shows the population and real GDP (based on 2015) of Mozambique from 2006 to 2020.

The achievement of electricity demand and maximum power against the demand forecast as of 2020 is low at 51% and 61%. The reason for the lower than projected demand growth is due to the unstable situation in Mozambique, which has stalled economic activity and growth. In the demand forecast scenarios, the base scenario is set based on the average GDP growth rate of 7.38% between 2002 and 2015 in the Mozambique, and the low growth scenario and high growth scenario are set based on a variation of ±1%. However, the GDP growth rate of the Mozambique in recent years was 3.8% as of 2016, lower than the growth rate of 6.38% in the low growth scenario, and has continued to decline since then; in 2020, GDP was lower than the previous year, with a growth rate of -1.2%. This discrepancy between the scenario and reality has led to calls within the EDM for a review of the demand forecast to bring it in line with reality. On the other hand, the actual population growth rate is 2.8 - 3.0%, which is higher than the 2.1 - 2.7% growth rate in the demand forecast scenario. In the future, when the problem of Mozambique is resolved and economic activity increases, it is estimated that demand growth will equal or exceed the demand forecast.

Table 3.1-5 Comparison of actual values and demand forecasts for 2015-2020

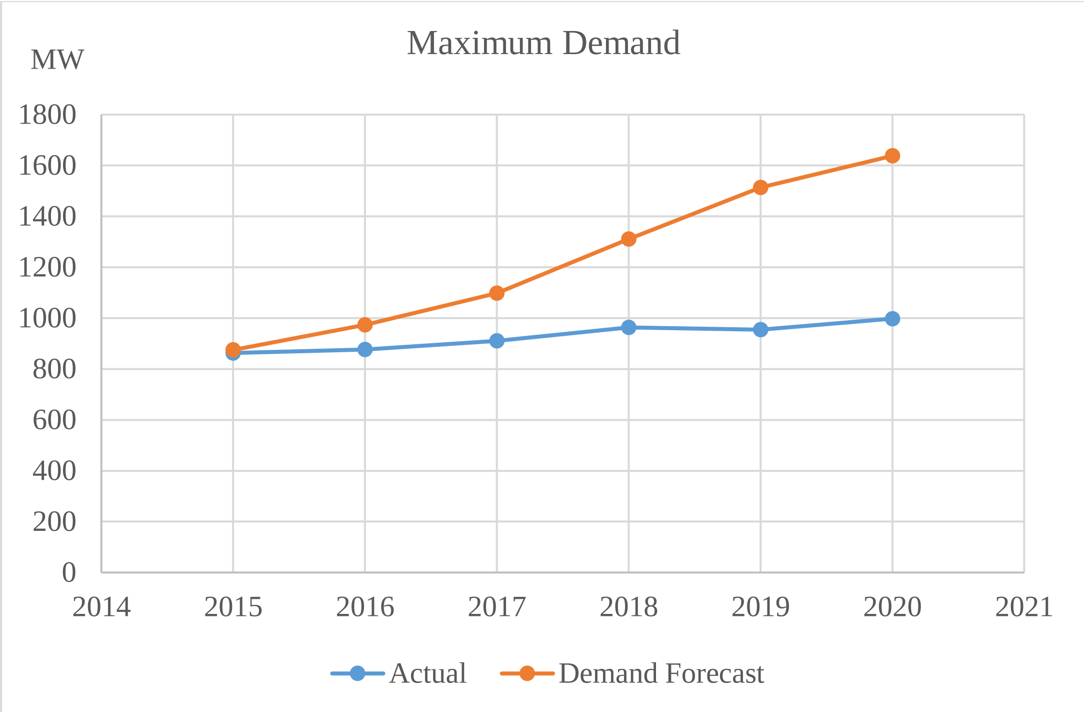
Year	Demand (GWh)			Maximum Demand (MW)		
	Actual	Forecast	Achievement(%)	Actual	Forecast	Achievement(%)
2015	3,908	3,908	100%	863	875	99%
2016	4,050	4,569	89%	876	974	90%
2017	3,954	5,119	77%	911	1,098	83%
2018	4,041	6,249	65%	964	1,311	74%
2019	4,143	7,325	57%	955	1,514	63%
2020	4,071	7,962	51%	998	1,638	61%

: JICA Study Team



Source : JICA Study Team

Figure 3.1-4 Comparison of actual demand and demand forecast



Source：JICA Study team

Figure 3.1-5 Comparison of actual maximum power and demand forecast

Table 3.1-6 Scenario summary table for demand forecasting

	General Customers	M-L Customers	Special Customers
Low Case	GDP increase ratio：6.38% Population increase ratio：2.1-2.7% Electrification ratio（On-grid）：29%→78%	GDP increase ratio：6.38% Population increase ratio：2.1-2.7%	2016-2020：Add-up After 2020：Constant increase keeping annual average increase volume between 2016 and 2020 Employing ratio：30%
Base Case	GDP increase ratio：7.38% Population increase ratio：2.1-2.7% Electrification ratio（On-grid）：29%→78%	GDP increase ratio：7.38% Population increase ratio：2.1-2.7%	
High Case	GDP increase ratio：8.38% Population increase ratio：2.1-2.7% Electrification ratio（On-grid）：29%→78%	GDP increase ratio：8.38% Population increase ratio：2.1-2.7%	

：MME Integrated Master Plan Mozambique Power System Development, November 2018

Table 3.1-7 Population and real GDP of Mozambique, 2006-2020

	Population [thousand]	Growth [%]	GDP [Million USD]	Growth [%]
2006	21,080	-	8,626	-
2007	21,673	2.8%	9,293	7.7%
2008	22,277	2.8%	9,973	7.3%
2009	22,895	2.8%	10,603	6.3%
2010	23,532	2.8%	11,292	6.5%
2011	24,188	2.8%	12,130	7.4%
2012	24,863	2.8%	13,010	7.3%
2013	25,561	2.8%	13,916	7.0%
2014	26,286	2.8%	14,946	7.4%
2015	27,042	2.9%	15,951	6.7%
2016	27,830	2.9%	16,561	3.8%
2017	28,649	2.9%	17,181	3.7%
2018	29,496	3.0%	17,772	3.4%
2019	30,366	2.9%	18,184	2.3%
2020	31,255	2.9%	17,959	-1.2%

: World Bank

(4) Demand forecast for SAPP member countries

Table 3.1-8 and Table 3.1-9 show the projected electricity demand from 2020 to 2025 for the 12 SAPP member countries. Mozambique's demand appears to be much higher than the values in Table 3.1-1 and Table 3.1-3 since it includes the transmission of electricity to Mozal's aluminum smelter in Mozambique. Mozal has a power purchase agreement with Eskom in South Africa and does not receive direct electricity supply from EDM.

Mozambique transmits most of the electricity generated by the Caohra-Bassa hydroelectric plant to SAPP, which exports electricity mainly to South Africa, Zimbabwe and Botswana. Currently, Mozambique has enough capacity to meet the demand, and the demand in South Africa and Zimbabwe is expected to grow significantly, resulting in the possibility of exporting more electricity from Mozambique to SAPP in the future. In addition, the 1,500MW Mphanda-Nkuwa hydroelectric power plant is currently under construction and the power generated from this plant will also be exported to SAPP.

Looking at demand growth rates for SAPP member countries, Zimbabwe's growth is significantly higher at over 16%, followed by Malawi, Tanzania and Angola with growth rates around 10%. Zimbabwe, like Mozambique, is expected to be the main exporter of electricity to SAPP. South Africa, one of the largest countries in Africa, is expected to see the largest growth in demand, with a maximum power output of about 6,000 MW and a demand growth of about 40,000 GWh over the next five years. Zimbabwe and Angola follow in terms of the amount of growth. Mozambique's electricity demand is expected to be the fifth highest among the 12 SAPP countries in 2020, but by 2025 it is expected to be overtaken by Tanzania and Zimbabwe to become the seventh highest. However, if the problems surrounding Mozambique are resolved in the future, demand will grow even more, so the forecast may not necessarily be correct.

Table 3.1-8 Maximum power forecast for SAPP member countries (2020-2025)

(MW)

Year	Angola	Botswana	Congo	Eswatini	Lesotho	Malawi	Mozambique	Namibia	South Africa	Tanzania	Zambia	Zimbabwe*1
2020	3,717	824	3,787	248	178	627	2,255	742	38,667	2,190	3,432	2,236
2021	4,105	855	3,986	254	183	736	2,350	677	39,893	2,430	3,573	2,618
2022	4,498	914	4,213	259	188	845	2,484	696	41,040	2,690	3,724	3,088
2023	4,909	942	4,431	265	196	954	2,608	707	42,102	2,980	3,886	3,690
2024	5,326	971	4,649	270	201	1,063	2,679	716	43,269	3,300	4,060	4,394
2025	5,759	1,057	4,941	329	204	1,169	2,752	728	44,535	3,660	4,247	-
AAGR	9.2%	5.1%	5.5%	6.1%	2.8%	13.3%	4.1%	-0.3%	2.9%	10.8%	4.4%	18.4%
Growth	2,042	233	1,154	81	26	542	497	-14	5,868	1,470	815	2,158

*1 The 2025 value for Zimbabwe has been removed because it was unnaturally low and inconsistent with Table 3.1-9.
The value was the same as the demand forecast as of 2017, which suggests that there was an omission in the update.

: SAPP Statistics 2019/20

Table 3.1-9 Electricity Demand Forecast for SAPP Member Countries (2020-2025)

(GWh)

Year	Angola	Botswana	Congo	Eswatini	Lesotho	Malawi	Mozambique	Namibia	South Africa	Tanzania	Zambia	Zimbabwe
2020	21,684	5,406	22,610	1,323	819	2,090	15,775	5,019	254,042	13,430	20,721	13,688
2021	23,948	5,609	23,797	1,353	864	2,299	16,342	4,421	262,094	14,890	21,185	16,036
2022	26,243	5,996	25,151	1,381	914	2,529	17,177	4,507	269,634	16,490	22,021	18,693
2023	28,639	6,180	26,452	1,412	962	2,782	17,947	4,557	276,608	18,270	22,894	22,304
2024	31,072	6,370	27,753	1,440	1,015	3,060	18,409	4,725	284,279	20,230	23,715	26,328
2025	33,598	6,930	29,497	1,466	1,069	3,366	18,843	4,793	292,593	22,440	24,667	29,388
AAGR	9.2%	5.1%	5.5%	2.1%	5.5%	10.0%	3.6%	-0.7%	2.9%	10.8%	3.6%	16.5%
Growth	11,914	1,524	6,887	143	250	1,276	3,068	-226	38,551	9,010	3,946	15,700

: SAPP Statistics 2019/20

3.2 Power Supply in the Southern Grid

(1) Electricity supply in Mozambique

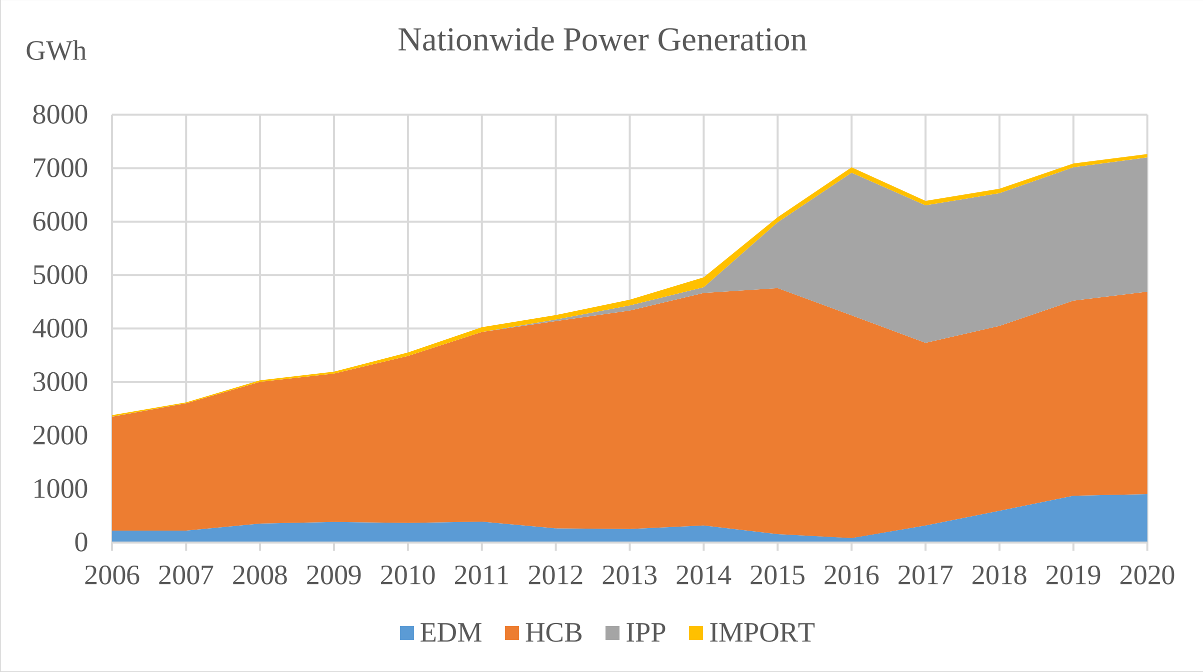
Table 3.2-1 and Figure 3.2-1 show the amount and percentage of electricity generated from 2006 to 2020 at the national level. The electricity supply in Mozambique as a whole has tripled over the past 10 years, comparing 2006 to 2016. In particular, in 2015, IPPs started to generate electricity, and the growth was remarkable. However, electricity supply declined in 2017, and the increase has been gradual since then. This may be due to the impact of the revelation of Mozambique's hidden debt problem in 2016, which made it difficult to obtain financing. HCBs account for the majority of Mozambique's electricity supply, accounting for about 50% in 2020, although less than before the entry of IPPs. EDM's share was only 1.2% in 2016, but Maputo gas combined cycle power plant started operation in 2018, increasing its share to 12.5% by 2020. In addition, construction projects for the 420 MW Temane thermal power plant and the 1500 MW Mphanda Nkuwa hydroelectric power plant are underway and are expected to further increase market share.

Table 3.2-1 Amount and percentage of electricity generated from 2006 to 2020

(GWh)

Year	EDM		HCB		IPP		IMPORT		ENERGY TOTAL	EXPORT	Gross Available for Domestic
2006	224	9.4%	2,130	89.4%	0	0.0%	27	1.1%	2,382	498	1,884
2007	224	8.5%	2,381	90.8%	0	0.0%	17	0.6%	2,622	523	2,099
2008	352	11.6%	2,653	87.5%	0	0.0%	27	0.9%	3,032	670	2,362
2009	386	12.1%	2,775	86.9%	0	0.0%	32	1.0%	3,193	514	2,679
2010	368	10.4%	3,118	87.8%	0	0.0%	67	1.9%	3,553	580	2,973
2011	389	9.7%	3,549	88.2%	0	0.0%	87	2.2%	4,025	669	3,356
2012	263	6.2%	3,874	91.1%	30	0.7%	84	2.0%	4,251	329	3,922
2013	251	5.5%	4,084	90.0%	95	2.1%	109	2.4%	4,538	260	4,278
2014	318	6.4%	4,351	87.7%	102	2.1%	190	3.8%	4,962	160	4,802
2015	158	2.6%	4,599	75.6%	1,229	20.2%	99	1.6%	6,085	862	5,223
2016	83	1.2%	4,167	59.4%	2,666	38.0%	103	1.5%	7,019	1,541	5,478
2017	317	5.0%	3,418	53.5%	2,568	40.2%	84	1.3%	6,387	964	5,423
2018	593	9.0%	3,458	52.3%	2,478	37.5%	87	1.3%	6,616	907	5,709
2019	873	12.3%	3,651	51.5%	2,491	35.1%	74	1.0%	7,089	1,373	5,716
2020	905	12.5%	3,784	52.1%	2,511	34.6%	64	0.9%	7,264	1,424	5,840

: EDM Annual Stastical Report



Source：EDM Annual Stastical Report

Figure 3.2-1 Changes in the amount and percentage of electricity generated from 2006 to 2020

(2) Amount of electricity supplied in the southern system

The EDM-owned power plants currently in operation are listed below, by grid.

<Northern Region>

- Lichinga (Capacity: 0.73 MW, hydroelectric power plant)
- Cuamba (Capacity: 1.09 MW, Hydroelectric power plant)

<Central Region>

- Mavuzi (Capacity: 52 MW, hydroelectric power plant)
- Chicamba (Capacity: 44 MW, hydroelectric power plant)
- Beira (Capacity: 14 MW, gas fired backup power)

<Southern Region>

- Maputo (106 MW capacity, combined cycle gas-fired power plant)
- Temane (Capacity: 11.2 MW, gas-fired off-grid thermal power plant)
- Corumana (Capacity: 16.6 MW, hydroelectric power plant)

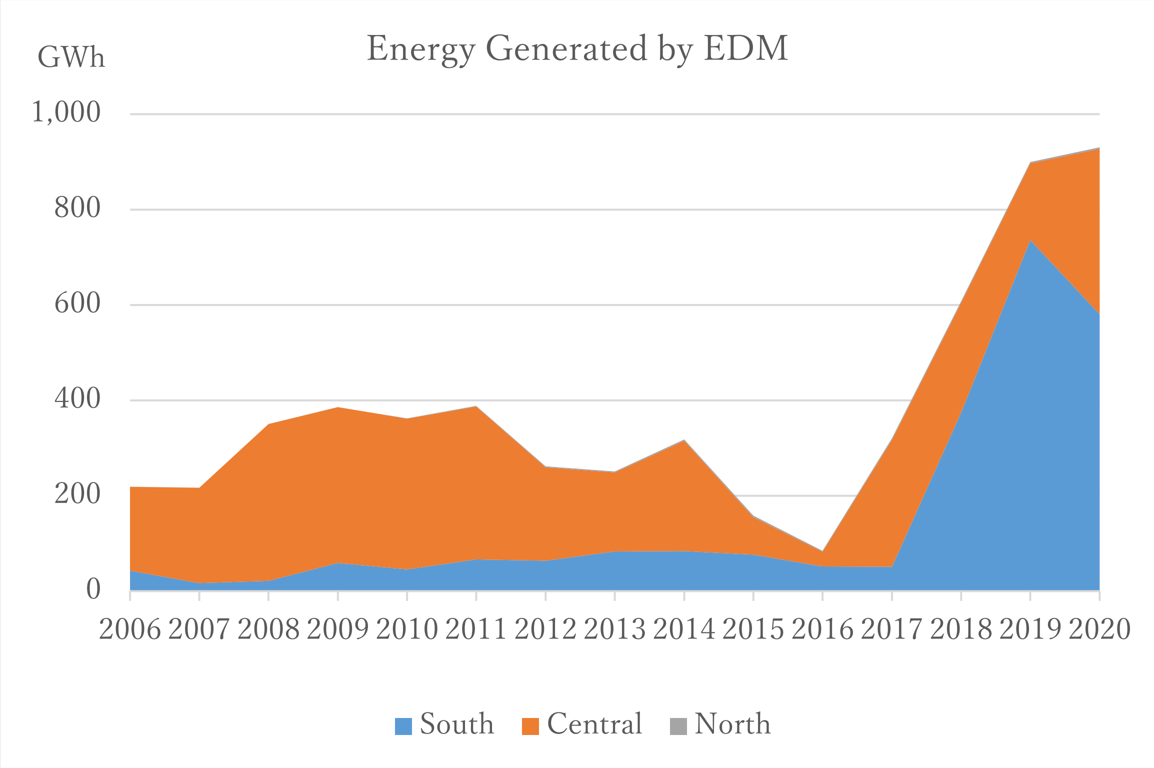
Table 3.2-2 and Figure 3.2-2 show the amount and percentage of electricity generated by EDM by region from 2006 to 2020. Table 3.2-3 and Figure 3.2-3 also show the amount of electricity generated by each power plant. Until 2018, when the Maputo thermal power plant starts operation in the southern region, hydroelectric power plants such as Mavuzi and Corumana in the central region were the main source of EDM's power generation. The drop in power generation in the central region in 2015 and 2016 was due to a severe drought in Mozambique, which reduced the amount of power generated by hydropower. After the Maputo thermal power plant became operational in 2018, power generation in the southern region became the main source of power generation. As of 2020, power generation in the southern region was 581 GWh, which is approximately 20% of the 2026 GWh demand in the southern region, taking into account transmission and distribution losses. With the construction of the 420 MW Temane thermal power plant in the southern region and the 1500 MW Mphanda Nkuwa hydroelectric power plant in the northern region currently underway, power generation in the southern and northern regions is expected to increase significantly in the future. In addition, EDM's power plants are mainly thermal and hydropower plants, but considering the current strong pressure on thermal power globally and the risk of another 2016-like drought, it is necessary to increase energy security by proactively incorporating renewable energy sources such as solar and wind power.

Table 3.2-2 Amount and percentage of electricity generated by EDM from 2006 to 2020

(MWh)

Year	South		Central		North		Total
2006	42,944	20%	175,500	80%	0	0%	218,443
2007	16,805	8%	199,602	92%	0	0%	216,407
2008	21,526	6%	328,659	94%	0	0%	350,185
2009	59,227	15%	326,307	85%	330	0%	385,864
2010	45,932	13%	315,465	87%	841	0%	362,237
2011	66,547	17%	320,335	83%	1,372	0%	388,254
2012	64,009	24%	195,774	75%	1,645	1%	261,428
2013	83,181	33%	165,592	66%	2,004	1%	250,777
2014	83,647	26%	231,702	73%	2,905	1%	318,254
2015	76,415	48%	78,699	50%	2,945	2%	158,060
2016	51,831	61%	30,493	36%	2,234	3%	84,557
2017	50,928	16%	266,300	83%	3,225	1%	320,454
2018	374,447	62%	229,761	38%	3,565	1%	607,774
2019	736,027	82%	160,726	18%	3,145	0%	899,898
2020	580,529	62%	346,908	37%	3,188	0%	930,625

：EDM Annual Stastical Report



Source：EDM Annual Stastical Report

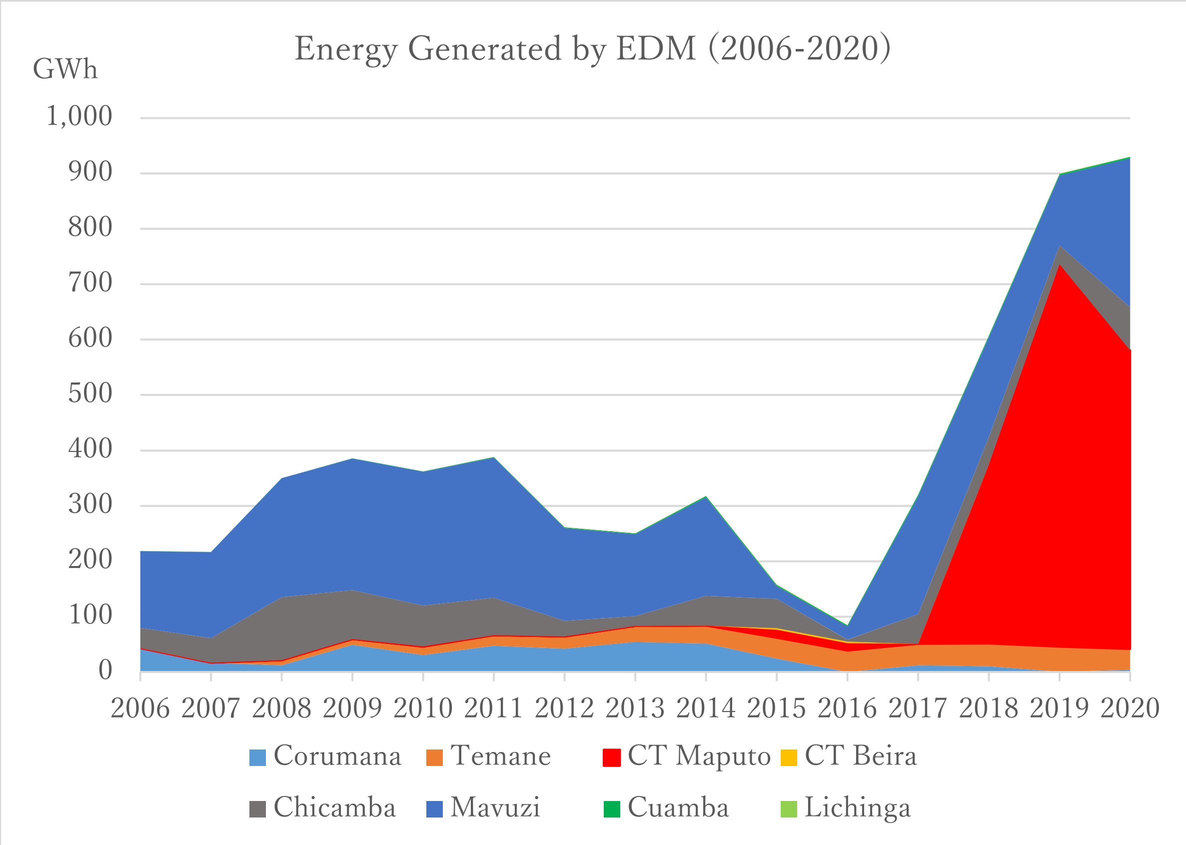
Figure 3.2-2 Changes in the amount and percentage of electricity generated by EDM from 2006 to 2020

Table 3.2-3 Electricity generated by each EDM-owned power plant from 2006 to 2020

(MWh)

Year	South			Central			North		Total
	Corumana	Temane	CT Maputo	CT Beira	Chicamba	Mavuzi	Cuamba	Lichinga	
2006	42,944	0	0	0	36,600	138,900	0	0	218,443
2007	16,805	0	0	0	44,141	155,461	0	0	216,407
2008	11,961	9,565	0	0	113,777	214,882	0	0	350,185
2009	49,032	10,195	0	20	88,624	237,664	143	187	385,864
2010	30,391	15,374	167	0	74,422	241,044	614	227	362,237
2011	47,393	18,760	394	0	67,591	252,744	1,346	26	388,254
2012	42,183	21,580	246	0	28,231	167,543	1,313	332	261,428
2013	54,409	28,773	0	0	17,749	147,842	1,591	413	250,777
2014	51,104	32,543	0	0	53,784	177,918	2,219	686	318,254
2015	24,189	37,476	14,750	2,547	53,107	23,045	2,066	879	158,060
2016	0	38,601	13,230	2,896	3,637	23,960	1,832	402	84,557
2017	11,784	39,145	0	4	53,249	213,047	2,626	600	320,454
2018	10,251	41,098	323,098	0	50,149	179,613	2,964	601	607,774
2019	741	45,053	690,233	43	34,114	126,569	2,140	1,005	899,898
2020	4,179	37,064	539,286	232	77,963	268,712	2,497	691	930,625
Total	397,366	375,227	1,581,403	5,743	797,137	2,568,944	21,352	6,048	5,753,218

：EDM Annual Stastical Report



Source：EDM Annual Stastical Report

Figure 3.2-3 Power generation of each EDM-owned power plant from 2006 to 2020

3.3 Future demand forecast in the southern system

(1) Demand Projection for Mozambique through Master Plan

Projections of electricity demand for the whole of Mozambique can be found in the Integrated Master Plan Mozambique Power System Development published by MIREME in November 2018. The demand forecasts for Mozambique from this report are shown in Table 3.3-1. The actual maximum electricity demand in 2015 was 721 MW across Mozambique; the projected electricity demand in 2020 was expected to be 1,494 MW, almost double the 2015 demand. The actual 2015 electricity demand in the southern region was 386 MW in Inhambane Province, Gaza Province, Maputo Province, and Maputo City. The region's projected electricity demand in 2020 is 765 MW, about twice the 2015 level, which is equal to the national growth rate of electricity demand.

The year-to-year growth rate of maximum electricity demand from 2015 to 2040 based on the Master Plan is summarized in Table 3.3-2 from the maximum electricity demand shown in Table 3.3-1. The growth rate of maximum electricity demand from 2015 to 2020 is above 10% in most regions of the Mozambique, with a smaller growth rate of about 5% in the later years. In later years, the growth rate is smaller, about 5%. Furthermore, Table 3.3-3 shows the results of the five-year average growth rate calculated from the previous year's growth rate for each year shown in Table 3.3-2.

Table 3.3-1 Maximum electricity demand from 2015 to 2040 as indicated in the master plan

(Unit: MW)

Year	Northern			Central				Southern				Total
	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	
2015	21.4	12.5	94.3	33.9	26.6	73.0	73.9	18.0	43.3	160.1	164.1	721.1
2016	32.6	14.5	109.8	33.2	30.5	74.9	79.2	22.4	53.4	169.1	209.6	829.2
2017	39.5	17.9	126.5	39.6	38.3	84.2	88.6	25.8	64.8	196.4	238.9	960.5
2018	45.9	26.0	182.6	43.4	45.5	89.6	160.4	28.6	70.8	223.7	256.1	1,172.6
2019	58.3	29.5	195.0	63.5	49.1	99.4	182.6	31.5	77.1	311.3	277.3	1,374.6
2020	68.0	31.4	207.5	72.5	52.8	105.7	190.8	36.4	83.9	331.5	313.6	1,494.1
2021	77.9	35.3	230.7	81.6	58.4	113.4	215.1	40.0	91.6	367.7	341.4	1,653.1
2022	88.1	39.3	254.6	90.9	64.2	121.4	239.9	43.8	99.7	404.4	370.5	1,816.8
2023	98.7	43.5	279.1	100.6	70.2	129.9	265.1	47.8	108.2	441.8	400.9	1,985.8
2024	109.6	47.8	304.5	110.5	76.4	138.9	290.9	52.1	117.0	479.8	432.6	2,160.1
2025	121.0	52.2	330.6	120.7	83.0	148.3	317.2	56.5	126.3	518.5	465.9	2,340.2
2026	132.8	56.8	357.5	131.3	89.8	158.3	344.0	61.1	135.9	557.9	500.8	2,526.2
2027	145.2	61.6	385.3	142.2	96.9	168.9	371.4	66.0	146.0	598.1	537.3	2,718.9
2028	158.0	66.5	414.1	153.5	104.3	180.0	399.4	71.2	156.6	639.1	575.7	2,918.4
2029	171.3	71.6	443.8	165.1	112.1	191.9	428.0	76.6	167.7	681.0	616.0	3,125.1
2030	185.3	76.8	474.6	177.2	120.3	204.4	457.4	82.4	179.4	723.8	658.3	3,339.9
2031	199.9	82.3	506.4	189.7	128.8	217.7	487.5	88.4	191.6	767.8	702.8	3,562.9
2032	215.0	87.9	539.1	202.6	137.5	231.5	518.2	94.8	204.3	813.1	749.6	3,793.6
2033	230.8	93.7	572.9	215.8	146.6	246.0	549.6	101.5	217.6	859.7	798.7	4,032.9
2034	247.2	99.6	607.7	229.4	155.9	261.1	581.7	108.5	231.6	907.8	850.4	4,280.9
2035	264.4	105.7	643.8	243.5	165.5	277.0	614.5	115.9	246.1	957.5	904.8	4,538.7
2036	282.3	112.0	681.0	258.1	175.5	293.7	648.2	123.6	261.4	1,008.7	962.1	4,806.6
2037	301.1	118.5	719.6	273.1	185.8	311.2	682.8	131.9	277.4	1,061.5	1,022.6	5,085.5
2038	320.8	125.3	759.7	288.7	196.1	329.6	718.3	140.5	294.2	1,116.2	1,086.6	5,376.0
2039	341.4	132.3	801.2	304.8	207.7	348.9	754.8	149.7	311.8	1,172.6	1,154.0	5,679.2
2040	363.2	139.5	844.4	321.5	219.2	369.2	792.3	159.4	330.4	1,231.0	1,225.3	5,995.4
2041	385.2	146.2	888.1	337.9	230.3	389.3	828.4	169.4	348.6	1,293.3	1,297.0	6,313.7
2042	408.8	153.5	934.0	355.3	242.2	411.0	866.6	180.0	368.3	1,356.7	1,374.5	6,650.9

: MME Integrated Master Plan Mozambique Power System Development, November 2018

Table 3.3-2 Five-year average growth rate of maximum electricity demand from 2015 to 2040 based on the master plan

Year	Northern			Central				Southern				Total
	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	
2015	---	---	---	---	---	---	---	---	---	---	---	---
2016	52.3%	16.0%	16.4%	-2.1%	14.7%	2.6%	7.2%	24.4%	23.3%	5.6%	27.7%	15.0%
2017	21.2%	23.4%	15.2%	19.3%	25.6%	12.4%	11.9%	15.2%	21.3%	16.1%	14.0%	15.8%
2018	16.2%	45.3%	44.3%	9.6%	18.8%	6.4%	81.0%	10.9%	9.3%	13.9%	7.2%	22.1%
2019	27.0%	13.5%	6.8%	46.3%	7.9%	10.9%	13.8%	10.1%	8.9%	39.2%	8.3%	17.2%
2020	16.6%	6.4%	6.4%	14.2%	7.5%	6.3%	4.5%	15.6%	8.8%	6.5%	13.1%	8.7%
2021	14.6%	12.4%	11.2%	12.6%	10.6%	7.3%	12.7%	9.9%	9.2%	10.9%	8.9%	10.6%
2022	13.1%	11.3%	10.4%	11.4%	9.9%	7.1%	11.5%	9.5%	8.8%	10.0%	8.5%	9.9%
2023	12.0%	10.7%	9.6%	10.7%	9.3%	7.0%	10.5%	9.1%	8.5%	9.2%	8.2%	9.3%
2024	11.0%	9.9%	9.1%	9.8%	8.8%	6.9%	9.7%	9.0%	8.1%	8.6%	7.9%	8.8%
2025	10.4%	9.2%	8.6%	9.2%	8.6%	6.8%	9.0%	8.4%	7.9%	8.1%	7.7%	8.3%
2026	9.8%	8.8%	8.1%	8.8%	8.2%	6.7%	8.4%	8.1%	7.6%	7.6%	7.5%	7.9%
2027	9.3%	8.5%	7.8%	8.3%	7.9%	6.7%	8.0%	8.0%	7.4%	7.2%	7.3%	7.6%
2028	8.8%	8.0%	7.5%	7.9%	7.6%	6.6%	7.5%	7.9%	7.3%	6.9%	7.1%	7.3%
2029	8.4%	7.7%	7.2%	7.6%	7.5%	6.6%	7.2%	7.6%	7.1%	6.6%	7.0%	7.1%
2030	8.2%	7.3%	6.9%	7.3%	7.3%	6.5%	6.9%	7.6%	7.0%	6.3%	6.9%	6.9%
2031	7.9%	7.2%	6.7%	7.1%	7.1%	6.5%	6.6%	7.3%	6.8%	6.1%	6.8%	6.7%
2032	7.6%	6.8%	6.5%	6.8%	6.8%	6.3%	6.3%	7.2%	6.6%	5.9%	6.7%	6.5%
2033	7.3%	6.6%	6.3%	6.5%	6.6%	6.3%	6.1%	7.1%	6.5%	5.7%	6.6%	6.3%
2034	7.1%	6.3%	6.1%	6.3%	6.3%	6.1%	5.8%	6.9%	6.4%	5.6%	6.5%	6.1%
2035	7.0%	6.1%	5.9%	6.1%	6.2%	6.1%	5.6%	6.8%	6.3%	5.5%	6.4%	6.0%
2036	6.8%	6.0%	5.8%	6.0%	6.0%	6.0%	5.5%	6.6%	6.2%	5.3%	6.3%	5.9%
2037	6.7%	5.8%	5.7%	5.8%	5.9%	6.0%	5.3%	6.7%	6.1%	5.2%	6.3%	5.8%
2038	6.5%	5.7%	5.6%	5.7%	5.5%	5.9%	5.2%	6.5%	6.1%	5.2%	6.3%	5.7%
2039	6.4%	5.6%	5.5%	5.6%	5.9%	5.9%	5.1%	6.5%	6.0%	5.1%	6.2%	5.6%
2040	6.4%	5.4%	5.4%	5.5%	5.5%	5.8%	5.0%	6.5%	6.0%	5.0%	6.2%	5.6%
2041	6.1%	4.8%	5.2%	5.1%	5.1%	5.4%	4.6%	6.3%	5.5%	5.1%	5.9%	5.3%
2042	6.1%	5.0%	5.2%	5.1%	5.2%	5.6%	4.6%	6.3%	5.7%	4.9%	6.0%	5.3%

: JICA Study team

Table 3.3-3 Average 5-year growth rate from 2015 to 2040 based on master plan

Year	Northern			Central				Southern				Total
	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	
2016 ～ 2020	26.7%	20.9%	17.8%	17.5%	14.9%	7.7%	23.7%	15.2%	14.3%	16.3%	14.1%	15.8%
2021 ～ 2025	12.2%	10.7%	9.8%	10.7%	9.5%	7.0%	10.7%	9.2%	8.5%	9.4%	8.2%	9.4%
2026 ～ 2030	8.9%	8.0%	7.5%	8.0%	7.7%	6.6%	7.6%	7.8%	7.3%	6.9%	7.2%	7.4%
2031 ～ 2035	7.4%	6.6%	6.3%	6.6%	6.6%	6.3%	6.1%	7.1%	6.5%	5.8%	6.6%	6.3%
2036 ～ 2040	6.6%	5.7%	5.6%	5.7%	5.8%	5.9%	5.2%	6.6%	6.1%	5.2%	6.3%	5.7%

: JICA Study team

(2) Material collected to confirm trends in demand forecasts

In examining future demand forecasts, the study team collected materials prepared by EDM. The study team obtained the EDM's BUSINESS PLAN 2020-2024 and the annual statistical report 2020 (hereafter referred to as "statistical data") as documents describing current demand and future demand forecasts.

In-depth demand forecasting requires a variety of data showing social trends related to electricity demand, including population projection data and economic growth projections such as GDP. However, this study was based on the BUSINESS PLAN 2020-2024 and statistical data reviewed by EDM after the Master Plan was issued, in order to ascertain what the demand trends are in the southern region.

(3) Electricity demand according to BUSINESS PLAN 2020-2024

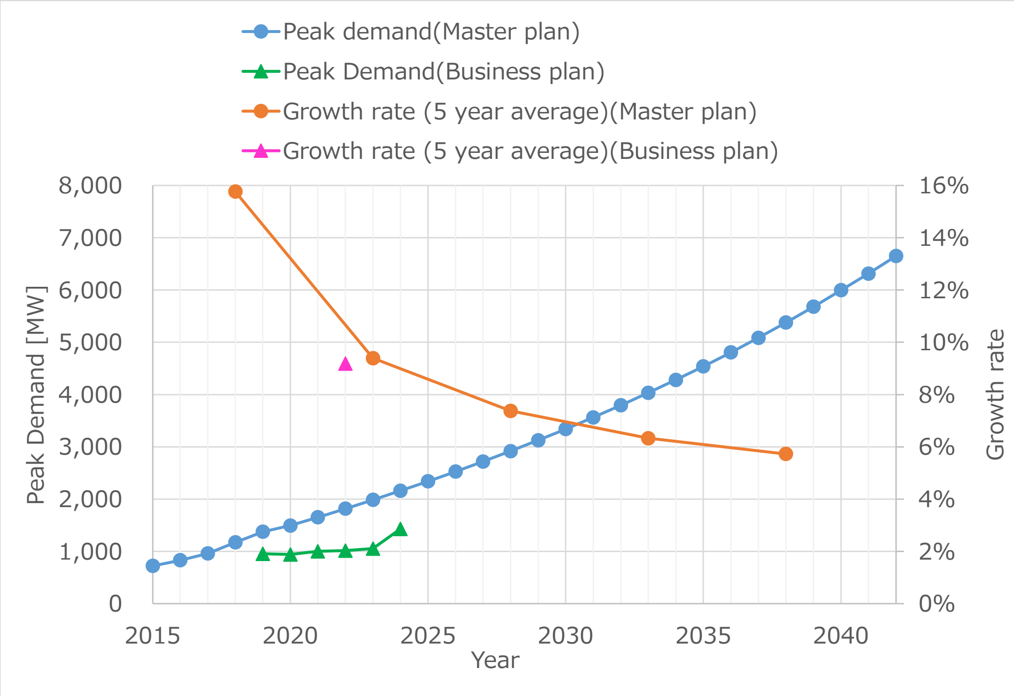
BUSINESS PLAN 2020-2024 organizes the short-term plans for the entire Mozambique for EDM management. BUSINESS PLAN 2020-2024 shows the maximum electricity demand for the entire Mozambique from 2020 to 2024 in Table 3.3-4. From 2019 to 2023, the electricity demand growth rate is low. According to the BUSINESS PLAN 2020-2024, the supply is more available than IPP sources in 2024, and the improved electricity supply will increase the potential electricity demand (electrification of non-electrified villages and expansion of power networks), and the demand for electricity will also grow.

Table 3.3-4 BUSINESS PLAN Maximum electricity demand from 2020 to 2024

Year	Maximum Demand [MW]	Growth Rate/Year	
2019	954	---	
2020	941	-1.4%	
2021	1,000	6.3%	
2022	1,015	1.5%	
2023	1,052	3.6%	
2024	1,429	35.8%	
		Average	9.2%

Source：EDM BUISNESS PLAN 2020-2024

Figure 3.3-1 shows a graph of the electricity demand forecast shown in the BUSINESS PLAN 2020-2024 and the five-year average of the electricity demand and electricity demand growth rate shown in the Master Plan The five-year average growth rate of electricity demand shown in the BUSINESS PLAN 2020-2024 was about 9.2 percent. The growth rate of the electricity demand in the master plan was about 9.2%. The growth rate of electricity demand according to the Master Plan is also around 8% from 2025 onward; it is understood that the BUSINESS PLAN projects that electricity demand will recover from 2024, and that the impact of COVID-19 and economic support from other countries is also expected to recover. It was also confirmed that the BUSINESS PLAN is equivalent to the growth rate of electricity demand in the Master Plan.



Source：JICA Study Team

Figure 3.3-1 Trends in electricity demand from 2015 to 2040 and five-year Average growth rate (Based on BUSINESS PLAN 2020-2024)

(4) Actual demand for statistical data

The electricity demand for Mozambique from 2004 to 2020 is summarized in Table 3.3-5 in the Annual statistical report. The electricity demand in Mozambique in 2020 is 998 MW, which is about 70% of the 1,494 MW electricity demand in 2020 as indicated in the Master Plan. The larger difference between the actual electricity demand and the electricity demand projected in the master plan can be attributed to the hidden debt problem in Mozambique country that was uncovered in 2016, the armed insurrection in the northern region in 2017, and the cyclone damage in 2019, as shown in section 3.1, which reduced electricity demand and statistical data shows.

Table 3.3-5 Actual and previous year's growth rate of maximum electricity demand for the entire Mozambique country as shown in the statistical data

Year	Max Demand [MW]	Growth Rate / Year
2004	266.0	---
2005	285.0	7.1%
2006	320.0	12.3%
2007	364.0	13.8%
2008	416.0	14.3%
2009	418.0	0.5%
2010	534.0	27.8%
2011	610.0	14.2%
2012	706.0	15.7%
2013	761.0	7.8%
2014	831.0	9.2%
2015	863.0	3.9%
2016	876.0	1.5%
2017	911.0	4.0%
2018	964.0	5.8%
2019	955.0	-0.9%
2020	998.0	4.5%

Source：Annual statistical report 2020

The previous year's growth rate of electricity demand shown in Table 3.3-6 does not give an overall picture of the growth rate of electricity demand, since electricity demand also changes significantly when social conditions change widely, such as in COVID-19. For this reason, the average growth rate of electricity demand for each of the five years is organized in Table 3.3-6. while prior to 2015, the growth rate of electricity demand was high, exceeding 10%, the growth rate of electricity demand from 2016 to 2020 was 3%, and it is clear from this that the growth of electricity demand has slowed down in recent years.

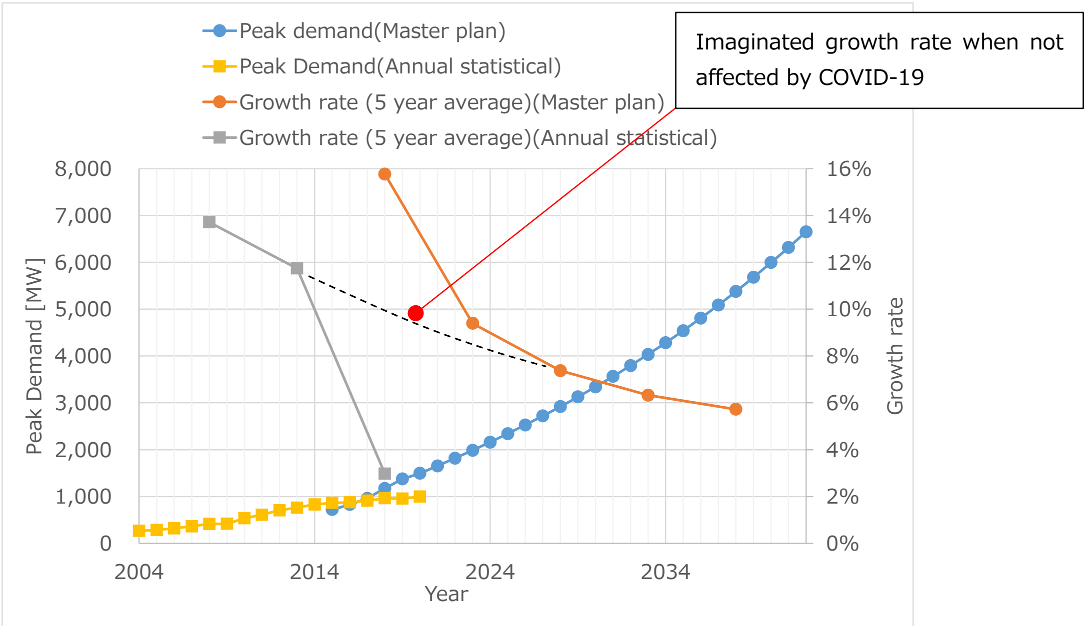
Table 3.3-6 Five-year average growth rate of maximum electricity demand as indicated by statistical data

Year	Growth Rate / 5 Year average
2006 ~ 2010	13.7%
2011 ~ 2015	11.7%
2016 ~ 2020	3.0%

Source：JICA Study Team

(5) Future electricity demand growth based on statistical data demand

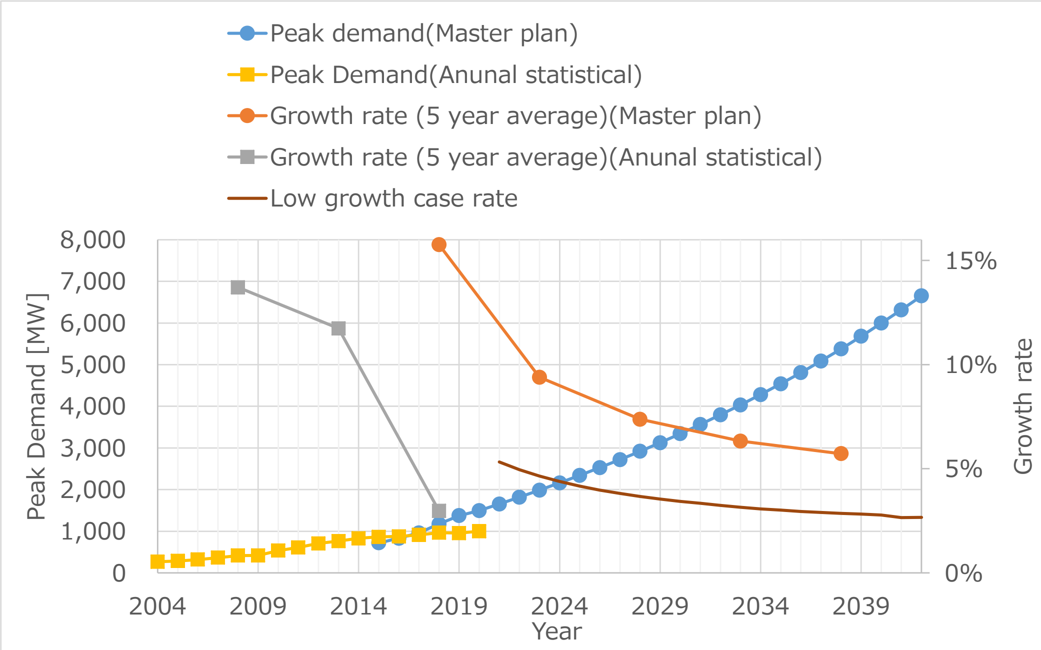
A graph of the electricity demand (actual) shown in the statistical data and the five-year average of electricity demand and electricity demand growth rates shown in the master plan is shown in Figure 3.3-2. Looking at the overall trend, the statistical data shows a similar trend with an electricity demand of 964 MW in 2018 and a projected electricity demand of 1,172 MW in the Master Plan for 2018. However, the power demand growth in 2019 and beyond is expected to slow down and diverge from the master plan's power demand forecast due to changes in social conditions triggered by COVID-19 and other factors. However, looking at the trend of the growth rate of electricity demand, if it is assumed that there is no impact of COVID-19, the growth rate of electricity demand linearly matches that of the master plan when referring to the growth rate of statistical data. Therefore, if the impact of COVID-19 and other factors are mitigated, it is assumed that the future growth rate of electricity demand will be equivalent to the growth rate of electricity demand assumed in the master plan, and this case is treated as a high demand growth rate.



Source：JICA Study Team

Figure 3.3-2 Statistical data and master plan electricity demand trends and 5-year average growth rate

However, even if the impact of COVID-19 and other factors are mitigated, there is a possibility that economic activity will not recover smoothly and that electricity demand growth will also slow. Since it is difficult to assume a future economic recovery at this point based on limited data, we have decided to prepare a case with a lower growth rate of electricity demand. The study team assume that electricity demand will not recover to the growth rate of the master plan, and that the growth rate of electricity demand will be half of the growth rate of the master plan, as shown in Figure 3.3-3. The reason for assuming half the growth rate of electricity demand was based on the delay in economic recovery due to the impact of COVID-19 and the delay in resumption of financial assistance from other countries triggered by the Mozambique debt concealment problem, which will cause economic activities to stagnate.



Source：JICA Study Team

Figure 3.3-3 Statistical data and master plan electricity demand trends and 5-year average growth rate and low growth rate

(6) Country-wide demand forecast for Mozambique

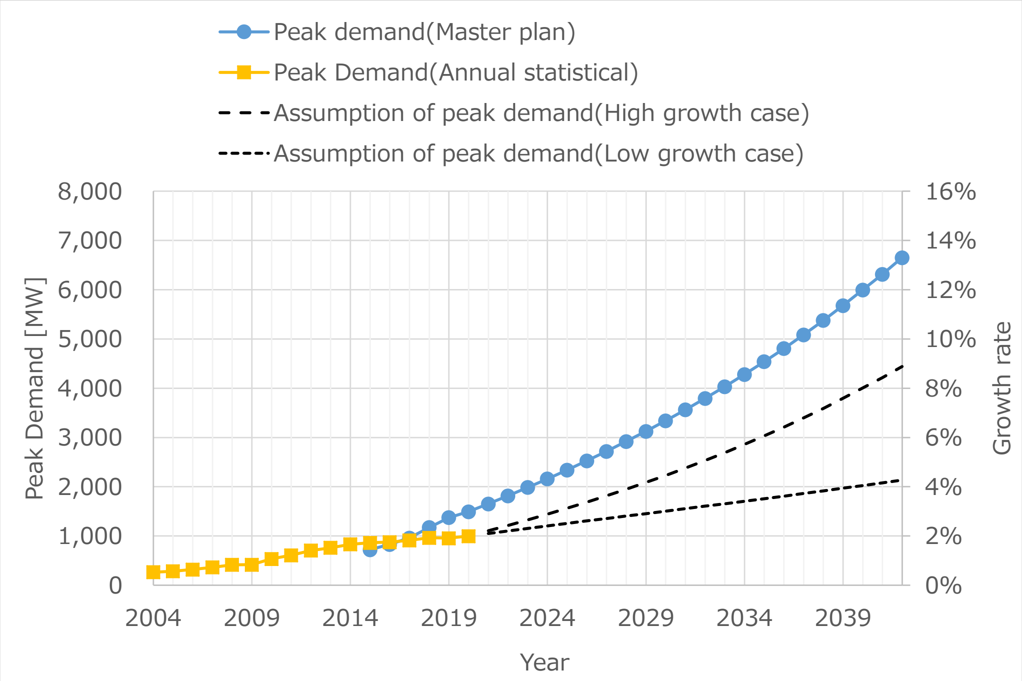
As discussed in the previous section, the demand forecast for the entire Mozambique assumes two cases: a high growth case, in which electricity demand is assumed to grow at the same rate as indicated in the master plan, and a low growth case, in which electricity demand is assumed to grow at half the rate indicated in the master plan, assuming that economic activity will stagnate due to the impact of COVID-19 and other factors. The other is the low growth case, in which electricity demand is assumed to increase at half the growth rate of the master plan, based on the assumption that economic activity will stagnate in the future due to COVID-19 and other factors.

Table 3.3-7 shows the forecasted demand for the entire Mozambique country based on the high and low growth cases. The actual electricity demand based on this table and the results of the master plan and demand forecast for the entire Mozambique are graphed in Figure 3.3-4. While the study team do not believe that future electricity demand projections will be equal to the Master Plan, the study team estimate that electricity demand can be expected to be at most half of the Master Plan. The study team believe that as electricity demand grows, it cannot be ruled out that latent electricity needs will emerge as electricity demand and that electricity demand will increase at an accelerated pace as EDM power sources are secured, villages without electricity are eliminated, and the electricity supply network is developed.

Table 3.3-7 Mozambique Electricity Demand Forecast for the Entire Country

Year	High growth casse		Low growth case	
	Growth rate on Master plan	Assumption of peak demand [MW]	Half of growth rate on master plan	Assumption of peak demand [MW]
2020	---	998.0	---	998.0
2021	10.6%	1,104.2	5.3%	1,051.1
2022	9.9%	1,213.6	5.0%	1,103.1
2023	9.3%	1,326.4	4.7%	1,154.5
2024	8.8%	1,442.9	4.4%	1,205.1
2025	8.3%	1,563.2	4.2%	1,255.4
2026	7.9%	1,687.4	4.0%	1,305.2
2027	7.6%	1,816.1	3.8%	1,355.0
2028	7.3%	1,949.4	3.7%	1,404.7
2029	7.1%	2,087.4	3.5%	1,454.5
2030	6.9%	2,230.9	3.4%	1,504.5
2031	6.7%	2,379.9	3.3%	1,554.7
2032	6.5%	2,534.0	3.2%	1,605.0
2033	6.3%	2,693.8	3.2%	1,655.7
2034	6.1%	2,859.5	3.1%	1,706.6
2035	6.0%	3,031.7	3.0%	1,757.9
2036	5.9%	3,210.6	3.0%	1,809.8
2037	5.8%	3,396.9	2.9%	1,862.3
2038	5.7%	3,591.0	2.9%	1,915.5
2039	5.6%	3,793.5	2.8%	1,969.5
2040	5.6%	4,004.7	2.8%	2,024.4
2041	5.3%	4,217.3	2.7%	2,078.1
2042	5.3%	4,442.5	2.7%	2,133.6

Source：JICA Study Team



Source：JICA Study Team

Figure 3.3-4 Estimated electricity demand forecast for all of Mozambique

(7) Future demand forecast in the southern system

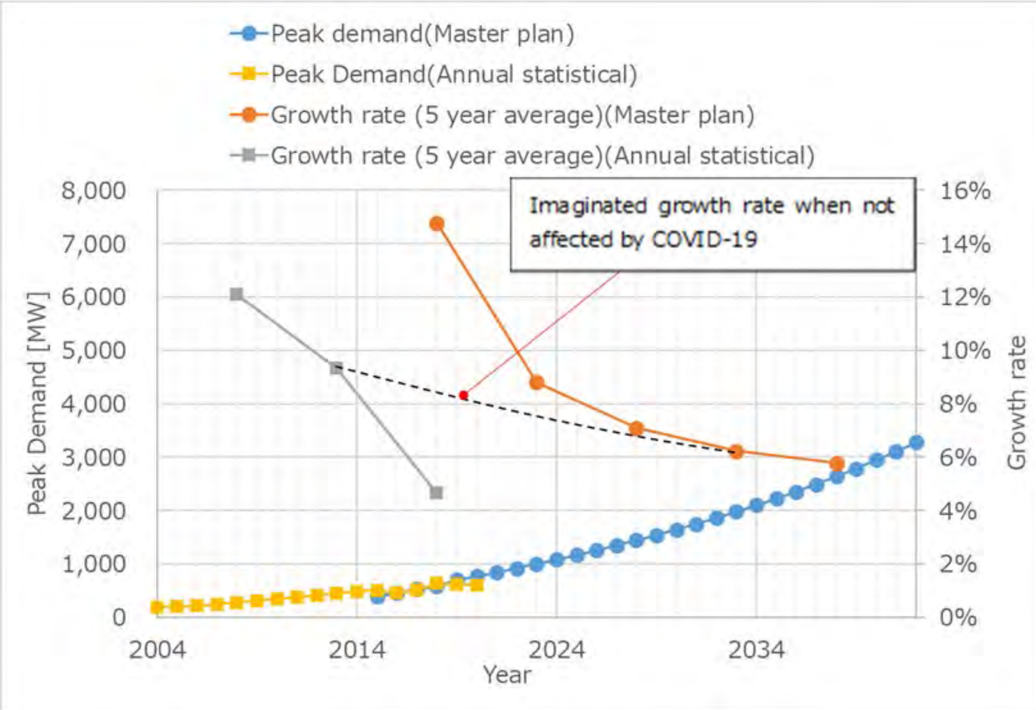
The electricity demand for the Southern System from 2004 to 2020 is shown in Table 3.3-8 in the Annual statistical report. The electricity demand in 2020 for the Southern System is 609 MW, which is about 80% of the 765.4 MW of electricity demand in 2020 indicated in the Master Plan.

Table 3.3-8 Actual and year-over-year growth in maximum electricity demand in the southern region as shown in the statistical data and in the master plan

Year	Annual Statistical report		Master Plan	
	Max Demand [MW]	Growth Rate / Year	Max Demand [MW]	Growth Rate / Year
2004	186.0	---	-	-
2005	195.0	4.8%	-	-
2006	216.0	10.8%	-	-
2007	244.0	13.0%	-	-
2008	279.0	14.3%	-	-
2009	312.0	11.8%	-	-
2010	345.0	10.6%	-	-
2011	374.0	8.4%	-	-
2012	412.0	10.2%	-	-
2013	448.0	8.7%	-	-
2014	487.0	8.7%	-	-
2015	499.0	2.5%	385.5	---
2016	461.0	-7.6%	454.5	17.9%
2017	509.0	10.4%	525.9	15.7%
2018	631.0	24.0%	579.2	10.1%
2019	613.0	-2.9%	697.2	20.4%
2020	609.0	-0.7%	765.4	9.8%

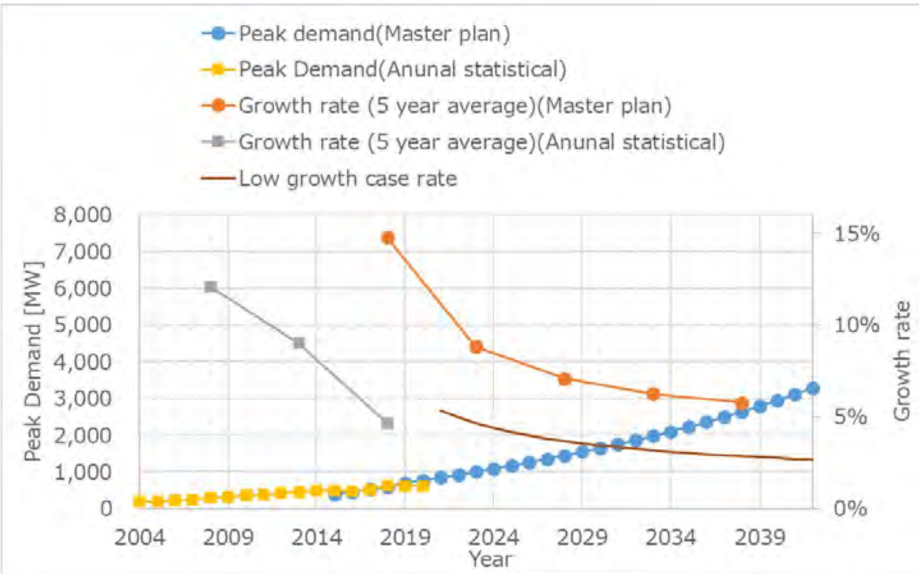
Source：Annual statistical report 2020
MME Integrated Master Plan Mozambique Power System Development, November 2018

As for the future demand forecast for the southern system, two cases were assumed: a high demand growth rate, which assumes electricity demand at the same value as the growth rate of electricity demand shown in the master plan, as in the electricity demand forecast for the whole Mozambique country described in (5), and a low demand growth rate, which assumes stagnation of future economic activity due to COVID-19 and other effects, and assumes electricity demand at half the growth rate of electricity demand shown in the master plan. The graphs for the southern region, corresponding to Figures 3.3-2 and 3.3-3 for the entire Mozambique shown in (5), are shown in Figures 3.3-5 and 3.3-6.



Source：JICA Study Team

Figure 3.3-5 Statistical data and master plan electricity demand for the southern region and 5-five-year average growth rate



Source：JICA Study Team

Figure 3.3-6 Statistical data for the Southern Region and the Master Plan Electricity Demand and 5-year average growth rate and low growth rate

From the demand for each region of the Southern System for the period 2016-2020 as shown in the Annual Statistical Report 2020, the electricity demand for the period 2021-2042 was assumed using the growth rate of electricity demand for each region of the Southern System as shown in the Master Plan. As noted above, the high demand growth rate was assumed to be the same as the master plan electricity demand growth rate and the low demand growth rate was assumed to be half of the master plan electricity demand. The assumed results are shown in Tables 3.3-9 and 3.3-10. Graphs of the master plan data and demand forecast results for each area are shown in Figures 3.3-7 through 3.3-10.

In the southern region, Inhambane Province (Figure 3.3-7) and Maputo City (Figure 3.3-10) have electricity demand similar to the master plan, while Gaza Province (Figure 3.3-8) and Maputo City (Figure 3.3-9) have lower electricity demand than the master plan. Maputo Province, in particular, shows a significant difference between the master plan and actual electricity demand. The difference between the master plan and actual electricity demand can be attributed to the fact that the data shown in the master plan shows that several large users are expected to be contracted in 2019, and no contracts were signed with these large users. The reason why the large consumers indicated in the Master Plan were not contracted in 2019 is unknown, but if the delay in the planning of each large consumer and the restriction of social activities due to COVID-19 had an impact, then if the social situation and economic projects in Mozambique improve, the planned large consumers' contracts We believe that there is a possibility that this may be done in the future.

As shown in Table 3.3-8, the actual maximum electricity demand in the southern system, as shown in the statistical data in 2018, has exceeded the Master Plan's projections, but the growth rate over the last few years has been subdued. However, compared to other regions, the high demand growth rates, especially in Inhambane Province (Figure 3.3-7) and Maputo City (Figure 3.3-10), show a trend consistent with the Master Plan projections, suggesting that electricity demand in the southern region will continue to grow steadily once the impact of COVID-19 and other factors are mitigated. Therefore, it is necessary to develop the power system network while keeping an eye on future power demand and social conditions.

Table 3.3-9 Electricity Demand Projections for the Southern System at High Demand Growth Rates

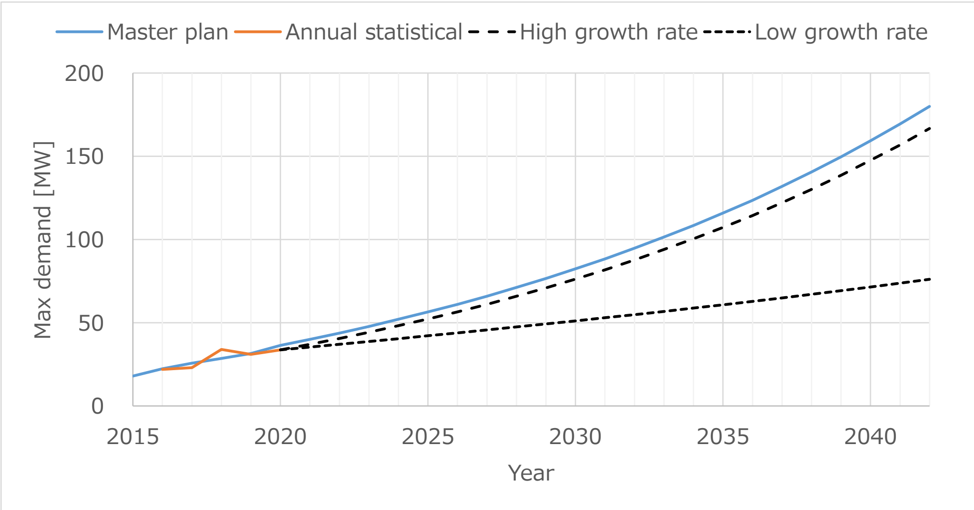
Year	Inhambane		Gaza		Maputo province		Maputo city	
	Growth rate on Master plan	Peak Demand [MW]	Growth rate on Master plan	Peak Demand [MW]	Growth rate on Master plan	Peak Demand [MW]	Growth rate on Master plan	Peak Demand [MW]
2016		22.0		57.0		165.0		217.0
2017		23.0		60.0		207.0		219.0
2018		34.0		59.0		214.0		324.0
2019		31.0		66.0		191.0		325.0
2020		33.7		69.0		210.7		295.7
2021	9.9%	37.0	9.2%	75.3	10.9%	233.7	8.9%	321.9
2022	9.5%	40.6	8.8%	82.0	10.0%	257.0	8.5%	349.4
2023	9.1%	44.3	8.5%	89.0	9.2%	280.8	8.2%	378.0
2024	9.0%	48.2	8.1%	96.2	8.6%	305.0	7.9%	407.9
2025	8.4%	52.3	7.9%	103.9	8.1%	329.6	7.7%	439.3
2026	8.1%	56.6	7.6%	111.8	7.6%	354.6	7.5%	472.2
2027	8.0%	61.1	7.4%	120.1	7.2%	380.1	7.3%	506.6
2028	7.9%	65.9	7.3%	128.8	6.9%	406.2	7.1%	542.8
2029	7.6%	70.9	7.1%	137.9	6.6%	432.8	7.0%	580.8
2030	7.6%	76.3	7.0%	147.5	6.3%	460.0	6.9%	620.7
2031	7.3%	81.8	6.8%	157.6	6.1%	488.0	6.8%	662.7
2032	7.2%	87.8	6.6%	168.0	5.9%	516.8	6.7%	706.8
2033	7.1%	94.0	6.5%	179.0	5.7%	546.4	6.6%	753.1
2034	6.9%	100.5	6.4%	190.5	5.6%	577.0	6.5%	801.9
2035	6.8%	107.3	6.3%	202.4	5.5%	608.6	6.4%	853.2
2036	6.6%	114.4	6.2%	215.0	5.3%	641.1	6.3%	907.2
2037	6.7%	122.1	6.1%	228.1	5.2%	674.7	6.3%	964.2
2038	6.5%	130.1	6.1%	242.0	5.2%	709.5	6.3%	1,024.6
2039	6.5%	138.6	6.0%	256.4	5.1%	745.3	6.2%	1,088.1
2040	6.5%	147.6	6.0%	271.7	5.0%	782.4	6.2%	1,155.4
2041	6.3%	156.8	5.5%	286.7	5.1%	822.0	5.9%	1,223.0
2042	6.3%	166.6	5.7%	302.9	4.9%	862.3	6.0%	1,296.0

Source：JICA Study team

Table 3.3-10 Electricity Demand Projections for the Southern System at Low Demand Growth Rates

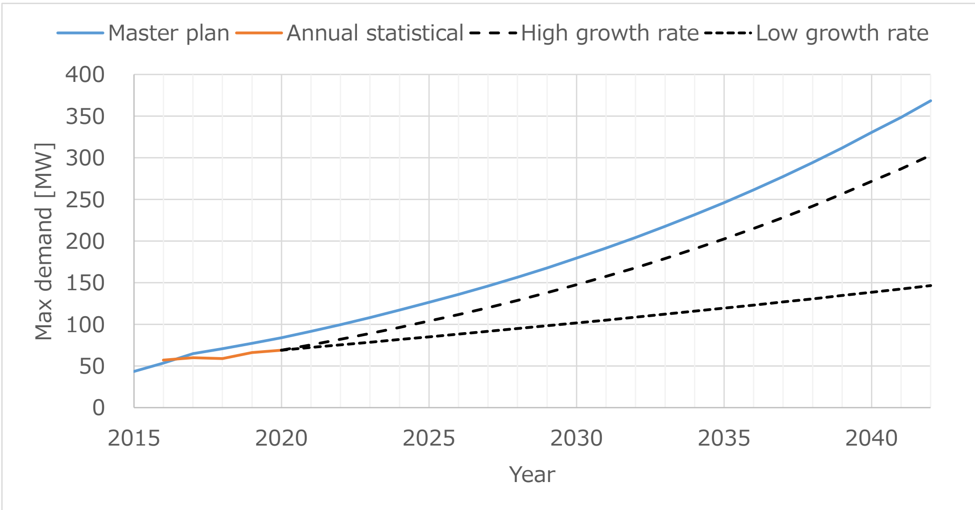
Year	Inhambane		Gaza		Maputo province		Maputo city	
	Half of growth rate on master plan	Peak Demand [MW]	Half of growth rate on master plan	Peak Demand [MW]	Half of growth rate on master plan	Peak Demand [MW]	Half of growth rate on master plan	Peak Demand [MW]
2016		22.0		57.0		165.0		217.0
2017		23.0		60.0		207.0		219.0
2018		34.0		59.0		214.0		324.0
2019		31.0		66.0		191.0		325.0
2020		33.7		69.0		210.7		295.7
2021	4.9%	35.4	4.6%	72.2	5.5%	222.2	4.4%	308.8
2022	4.8%	37.0	4.4%	75.4	5.0%	233.3	4.3%	322.0
2023	4.6%	38.7	4.3%	78.6	4.6%	244.1	4.1%	335.2
2024	4.5%	40.5	4.1%	81.8	4.3%	254.6	4.0%	348.4
2025	4.2%	42.2	4.0%	85.0	4.0%	264.8	3.8%	361.8
2026	4.1%	43.9	3.8%	88.2	3.8%	274.9	3.7%	375.4
2027	4.0%	45.7	3.7%	91.5	3.6%	284.8	3.6%	389.1
2028	3.9%	47.5	3.6%	94.8	3.4%	294.6	3.6%	403.0
2029	3.8%	49.3	3.5%	98.2	3.3%	304.2	3.5%	417.1
2030	3.8%	51.1	3.5%	101.6	3.1%	313.8	3.4%	431.4
2031	3.6%	53.0	3.4%	105.1	3.0%	323.3	3.4%	446.0
2032	3.6%	54.9	3.3%	108.6	2.9%	332.9	3.3%	460.8
2033	3.5%	56.9	3.3%	112.1	2.9%	342.4	3.3%	475.9
2034	3.4%	58.8	3.2%	115.7	2.8%	352.0	3.2%	491.3
2035	3.4%	60.8	3.1%	119.3	2.7%	361.6	3.2%	507.0
2036	3.3%	62.8	3.1%	123.0	2.7%	371.3	3.2%	523.1
2037	3.4%	64.9	3.1%	126.8	2.6%	381.0	3.1%	539.5
2038	3.3%	67.1	3.0%	130.7	2.6%	390.8	3.1%	556.4
2039	3.3%	69.3	3.0%	134.6	2.5%	400.7	3.1%	573.7
2040	3.2%	71.5	3.0%	138.6	2.5%	410.7	3.1%	591.4
2041	3.1%	73.7	2.8%	142.4	2.5%	421.1	2.9%	608.7
2042	3.1%	76.1	2.8%	146.4	2.5%	431.4	3.0%	626.9

Source：JICA Study team



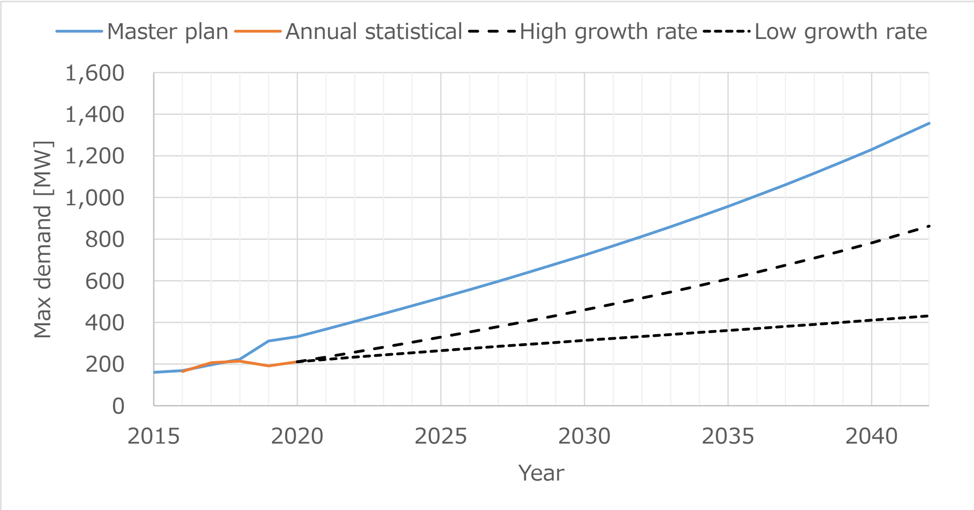
Source：JICA Study team

Figure 3.3-7 Inhambane Master Plan and Data and Future Demand Projections



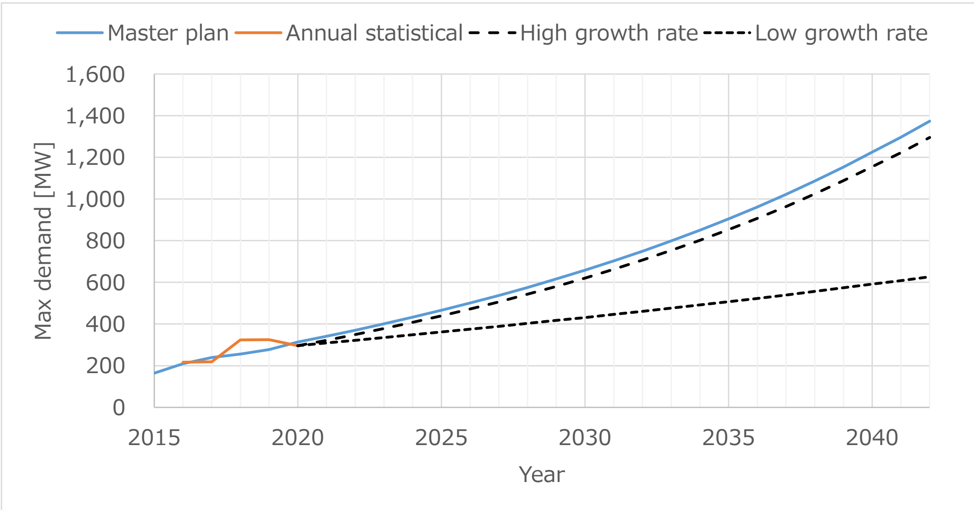
Source：JICA Study team

Figure 3.3-8 Gaza Master Plan and Data and Future Demand Projections



Source：JICA Study team

Figure 3.3-9 Maputo province Master Plan and Data and Future Demand Projections



Source：JICA Study team

Figure 3.3-10 Maputo city Master Plan and Data and Future Demand Projections

3.4 Electricity Availability of the Southern System

(1) Power plants and generation capacity of the Southern grid

The power plants and generation capacity of the southern grid are summarized in Table 3.4-1, which shows the generation plans identified in the Master Plan and this study. The supply capacity of the southern grid will increase to 864.5 MW in 2024. As for other power source development, several renewable energy sources of around 30 MW appear to be planned for development; the total output of power plants owned by EDM is 345.4 MW (including CTRG), while IPPs supply 519.1 MW, with the supply capacity from IPPs being larger. In addition, the Temane power plant, which is scheduled to start operation in 2024, is expected to be a major supply source for the southern grid. Beluluane Thermal Power and Inhambane Wind Power Plant, which are EDM's priority projects as described in Chapter 7, are still in the early planning stages and have been removed from the power generation plan. It was also assumed that Beluluane Thermal Power would not affect the supply-demand balance of the southern grid because it is planned to supply power to industrial customers as base load power for industrial activities in the Beluluane Industrial Park.

Table 3.4-1 Power plants and generating capacity supplying electricity to the southern grid

Operation Start	Plant Name	Owner	Type	Installed Capacity [MW]	Supply Power to EDM Grid [MW]	Operation Type
1984	Corumana	EDM	Hydro	16.6	8.0	Base Load
1991	CTM GT	EDM	Thermal Gas Turbine	24.0	18.0	Peak
2008	Xai-Xai	EDM	Thermal Diesel Engine	3.6	3.0	Peak (Emergency)
2014	Temane	EDM	Thermal Gas Engine	11.6	10.7	Base Load
2014	CTRG	EDM Sasol	Thermal Gas Engine	175.0	150.0	Base Load
2015	Inhambane	EDM	Thermal Diesel Engine	4.6	1.8	Peak (Emergency)
2016	Gigawatt	IPP	Thermal Gas Engine	121.0	120.0	Base Load
2017	Kuvaninga	IPP	Thermal Gas Engine	40.0	40.0	Base Load
2018	CTM CC	EDM	Thermal Combined Cycle	110.0	106.0	Base Load
2024	Temane	IPP	Thermal Combined Cycle	420.0	407.0	Base Load
Total					864.5	

Source: MME Integrated Master Plan Mozambique Power System Development, November 2018
JICA Study Team

(2) Electricity demand and availability in the South

The electricity demand for each of the southern regions was assumed in the previous section, and from that electricity demand, the entire southern region was assumed to be the sum of the electricity demand areas of Inhambane, Gaza, Maputo province, and Maputo city. The results are shown in

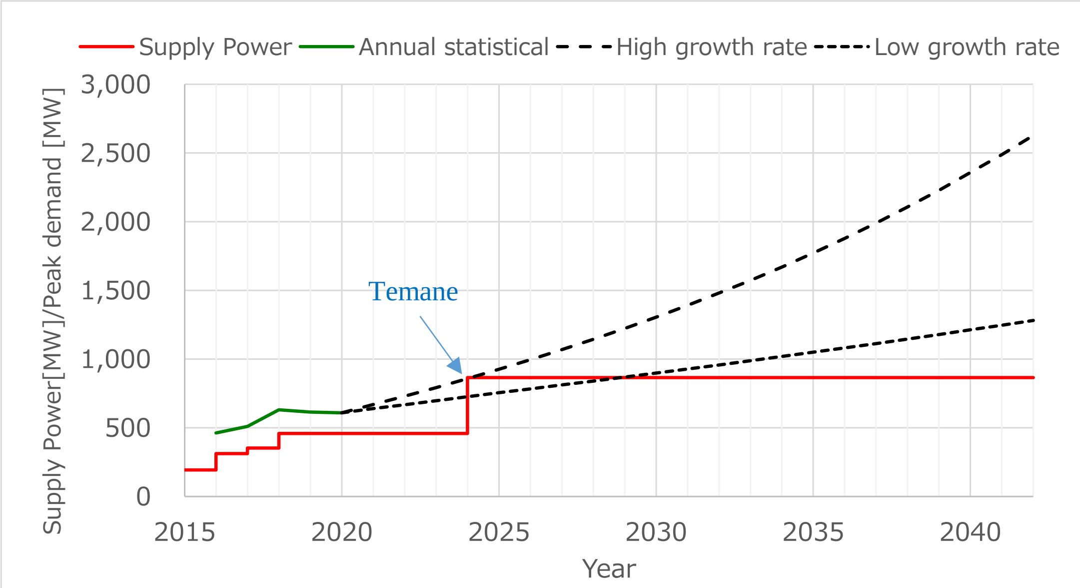
Table 3.4-2, which shows actual electricity demand based on statistical data for the period 2016-2020 and two cases of electricity demand for the period 2021-2042: High growth rate and Low growth rate. The relationship between the supply capacity of the southern region and the electricity demand shown in this table is shown in Figure 3.4-1.

The actual electricity demand and supply through 2020 shows that electricity demand exceeds electricity supply capacity. The shortfall is covered by electricity supply from South Africa: the startup of the CTM thermal power plant in 2018 has increased electricity supply capacity, but electricity demand has increased accordingly, equivalent to this power output. For this reason, electricity supply from South Africa has remained roughly the same even after the CTM thermal power plant is put into operation. In the future, electricity demand in the southern region is expected to increase, and when the Temane thermal power plant starts operation in 2024, supply capacity and electricity demand are expected to be equal or exceed supply capacity and electricity demand. However, supply capacity is then expected to fall below electricity demand again in 2025 or 2030, requiring additional electricity supply.

Table 3.4-2 Actual and projected electricity demand in the southern region

Year	Peak Demand of High growth rate [MW]	Peak Demand of Low growth rate [MW]	Supply Power [MW]
2016	461.0	461.0	311.5
2017	509.0	509.0	351.5
2018	631.0	631.0	457.5
2019	613.0	613.0	
2020	609.1	609.1	
2021	668.0	638.5	
2022	728.9	667.7	
2023	792.1	696.6	
2024	857.3	725.3	864.5
2025	925.0	753.9	
2026	995.1	782.5	
2027	1,068.0	811.1	
2028	1,143.8	839.9	
2029	1,222.5	868.8	
2030	1,304.6	898.0	
2031	1,390.1	927.4	
2032	1,479.4	957.2	
2033	1,572.5	987.3	
2034	1,669.8	1,017.8	
2035	1,771.4	1,048.8	
2036	1,877.7	1,080.3	
2037	1,989.2	1,112.3	
2038	2,106.1	1,145.0	
2039	2,228.5	1,178.2	
2040	2,357.1	1,212.2	
2041	2,488.5	1,245.9	
2042	2,627.9	1,280.7	

Source: JICA Study Team



Source: JICA Study Team

Figure 3.4-1 Southern Region Supply Capability and Southern Region Electricity Demand Projections

Although the operation of the Temane thermal power plant in 2024 will improve the power supply capacity in the southern region, power demand is expected to grow after that, so appropriate power supply planning according to future power demand is necessary to ensure a stable power supply in the southern region of Mozambique without being affected by the power situation in other countries. In addition, since it takes a long time from planning and survey to the start of power plant operation, it is necessary to start planning for thermal power plants and power plants using renewable energy now for actual power plant construction. In parallel, transmission lines and substations need to be strengthened with respect to power transmission and distribution facilities.

Chapter 4
Power Development Plan for Southern System

Chapter 4 Power Development Plan for Southern System

4.1 Implementation status of the power development plan in the southern system

＜Temane Thermal Power Plant＞

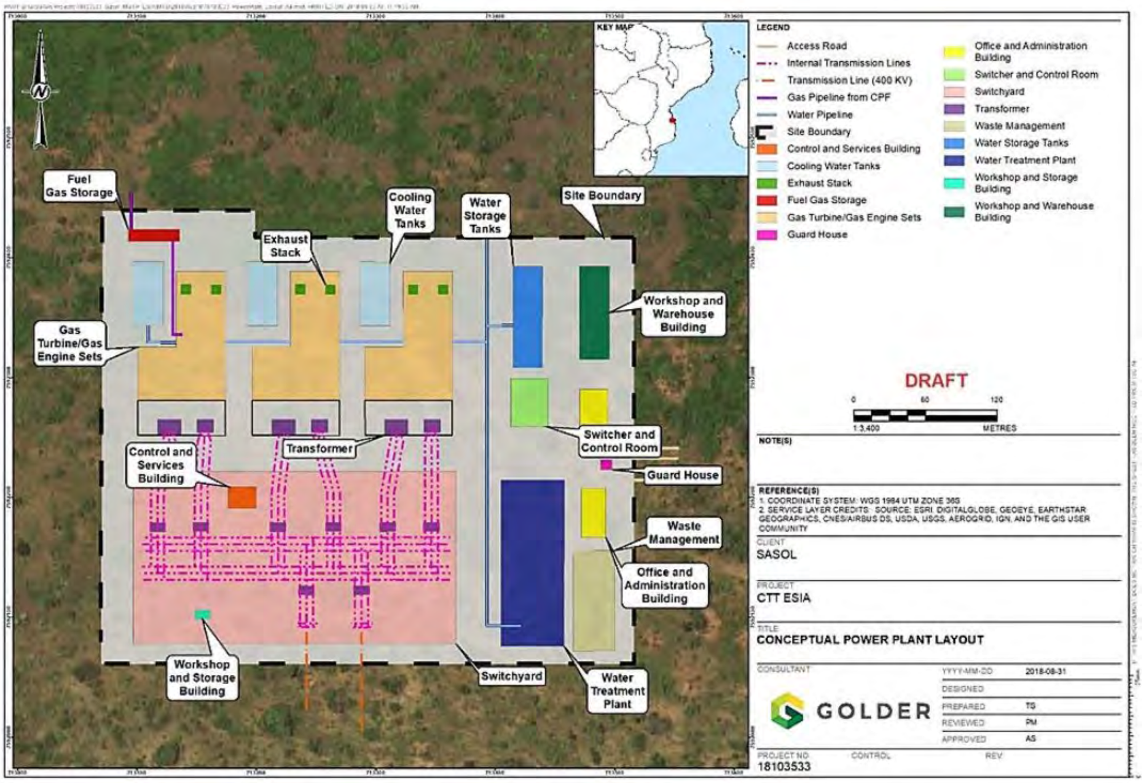
As part of the power development in the southern grid area, a project to construct the Temane Thermal Power Plant is underway. Table 4.1-1 shows some information about the project and Figure 4.1-1 shows a conceptual diagram of the plant. The project aims to increase the supply of low-cost electricity in Mozambique to meet the growing domestic demand and to increase the electrification rate throughout the country. This power plant is a natural gas combined cycle thermal power plant with an output of 420 MW, construction of which will start in Q3 2021 and commissioning in Q3 2023. In the Pande - Temane gas field near the construction site, 15 gas deposits are under development by China Petroleum Pipeline (CPP), and it was agreed in 2016 to allocate 23 PJ of natural gas per year from this field to the Temane power plant. Figure 4.1-2 shows a schematic diagram of the Pande-Temane gas field.

This project is also part of the Temane Regional Electricity Project, which includes the construction of the Temane Thermal Power Plant, a 563 km long single 400 kV transmission line between Maputo and Vilanculos (near Temane), and technical assistance to related organizations.

Table 4.1-1 Temane Thermal Power Plant Construction Plan

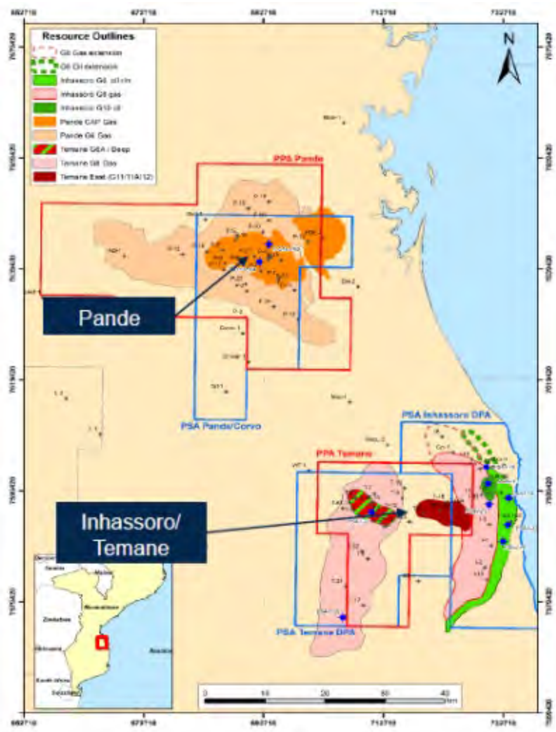
Power Plant Name	Temane Thermal Power Plant （or Central Termica de Temane）
Place	Temane, Inhambane Province
Generating Method	Natural Gas Fired Combined Cycle Power Plant
Output	420MW
Construction Period	2021Year Q3～2023 Year Q3 Plan
Fuel Supply	Supplied from Pande-Temane Gas Field (23 PJ/Year)
Project Owner	Mozambique Power Invest ：85％ Sasol Africa Proprietary Limited：15％
Project Cost	US$ 760 million
Contractor	TSK（Construction）、Siemens（Procurement）、 Golder Associados Moçambique（Environmental Assessment Company）、 Norconsult（Technical Consultant） Royal HaskoningDHV（Environmental Consultant）

Source：IFC, EDM



Source：Central Térmica de Temane Project – Visual Impact Assessment

Figure 4.1-1 Conceptual diagram of Temane thermal Power Plant



Source：Instituto Nacional de Petroleo

Figure 4.1-2　Conceptual diagram of Pande-Temane Gas field

4.2 Issues of power development in the southern system

(1) Stagnant demand growth

In the master plan developed in 2018, demand in Mozambique was assumed to grow steadily, and the power development plan was designed to meet that demand. However, as described in Chapter 3, demand in Mozambique has been stagnant since 2016, and is far below the demand assumptions of the master plan. This is due to the uncovering of hidden debts, riots in the north, damage from a powerful cyclone, and the spread of COVID-19. The following two points have had a particular impact on the southern region.

① Revealing hidden debt problems

In 2016, Mozambique was found to have a hidden debt of approximately $1.9 billion. This led to the suspension of support from the IMF and international donors, resulting in a 75% drop in Mozambique's GDP in 2016 compared to the previous year. The economy was hit hard and demand creation stalled. This problem remains unresolved, and Mozambique's reputation as an extremely high credit risk continues to make it difficult to obtain loans.

② Spread of COVID-19

Since the beginning of 2020, COVID-19 infection has been spreading worldwide. In April of the same year, an outbreak was reported in Mozambique, and a temporary lockdown policy was implemented. In August 2021, the number of infected people per day reached a peak of approximately 2,000. The impact of COVID-19 pandemic has resulted in a stagnation of economic activities in the country. In addition, there have been restrictions on personnel and their activities to prevent the spread of the disease, and there have been delays in the expansion and reinforcement of power transmission and distribution networks.

(2) Impact of dependence on HCB and IPP

As of 2020, the share of electricity generated by EDMs in Mozambique is about 12.5% of the total, which is significantly lower than that of HCB (52.1%) and IPP (34.6%). In order to meet domestic electricity demand, EDMs need to purchase electricity from HCBs and IPPs, but the purchase from IPPs is particularly expensive and has a negative impact on EDMs' finances. Table 4.2-1 shows the debt held by EDMs from 2009 to 2019; power generation by IPPs started in earnest in 2015, but EDMs at that time did not have sufficient funds for power purchase, and the debt ballooned from 2015 to 2016. The huge amount of debt reduces EDM's credibility and increases its investment risk, which greatly affects its ability to raise funds for future power development projects.

Table 4.2-1 EDM debt amount and lenders

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HCB	470	1,123	1,424	1,404	1,624	1,753	4,184	5,673	799	3,105	5,406
IPP's	0	0	0	40	57	62	1,527	7,894	10,985	13,998	14,507
Others	1,188	1,708	1,499	1,639	2,102	3,047	4,306	10,385	8,740	6,474	5,981
Debt Total	1,658	2,831	2,923	3,083	3,783	4,862	10,017	23,952	20,524	23,577	25,894
Growth		71%	3%	5%	23%	29%	106%	139%	-14%	15%	10%

Source：EDM BUISNESS PLAN 2020-2024

(3) Condition of maintenance equipment

EDM owns power plants in different parts of Mozambique, and therefore it is necessary to allocate materials and equipment to each of them to manage the power plants. Table 4.2-2 shows the number and condition of heavy equipment and vehicles owned by EDMs power generation division. The 33 units of heavy equipment and vehicles are owned by the power generation division as of 2019, but 33% of them (11 units) are in bad condition. In the future, it will be necessary to allocate financial resources for vehicle maintenance and expansion.

Table 4.2-2 Number and condition of heavy equipment and vehicles owned by the EDM power generation sector.

	Special Machines	Light Vehicle	Heavy Vehicle	Total
Good Condition	2	15	5	22
Bad Condition	-	7	4	11
Total	2	22	9	33

Source：EDM BUISNESS PLAN 2020-2024

4.3 Future plans for power development in the southern system

＜Power Development Plan in EDM Priority Project List＞

According to the list of high priority projects obtained from the EDM grid planning office, there are 19 power development projects currently planned in Mozambique, of which the following three are planned or underway in the southern grid region.

① Massingir 18 MW and/or Mapai Hydro Power Plant, 75 MW
② Beluluane Thermal Power (Gas), 2000 MW
③ Inhambane Wind Power Plant, 30 MW

The following is a list of three projects that are planned or underway in the southern grid region.

① **Massingir / Mapai hydro power plant**

Overview： This is a plan to construct hydroelectric power plants in Massingir and Mapai, respectively, in northern Gaza. The Mapai project was financed by AfDB in September 2015 and an environmental assessment was conducted in 2017. In July 2021, there was also an announcement by the Council of Ministers that the selection of potential partners for the implementation of the Mapai Dam Project through a public-private partnership is underway. On the other hand, there are no major developments in the Massingir project.

Output： Massingir 18 MW, Mapai 75 MW

Purpose： Improving grid stability and reliability in northern Gaza; supplying power to ProEnergia and projects in northern Gaza.

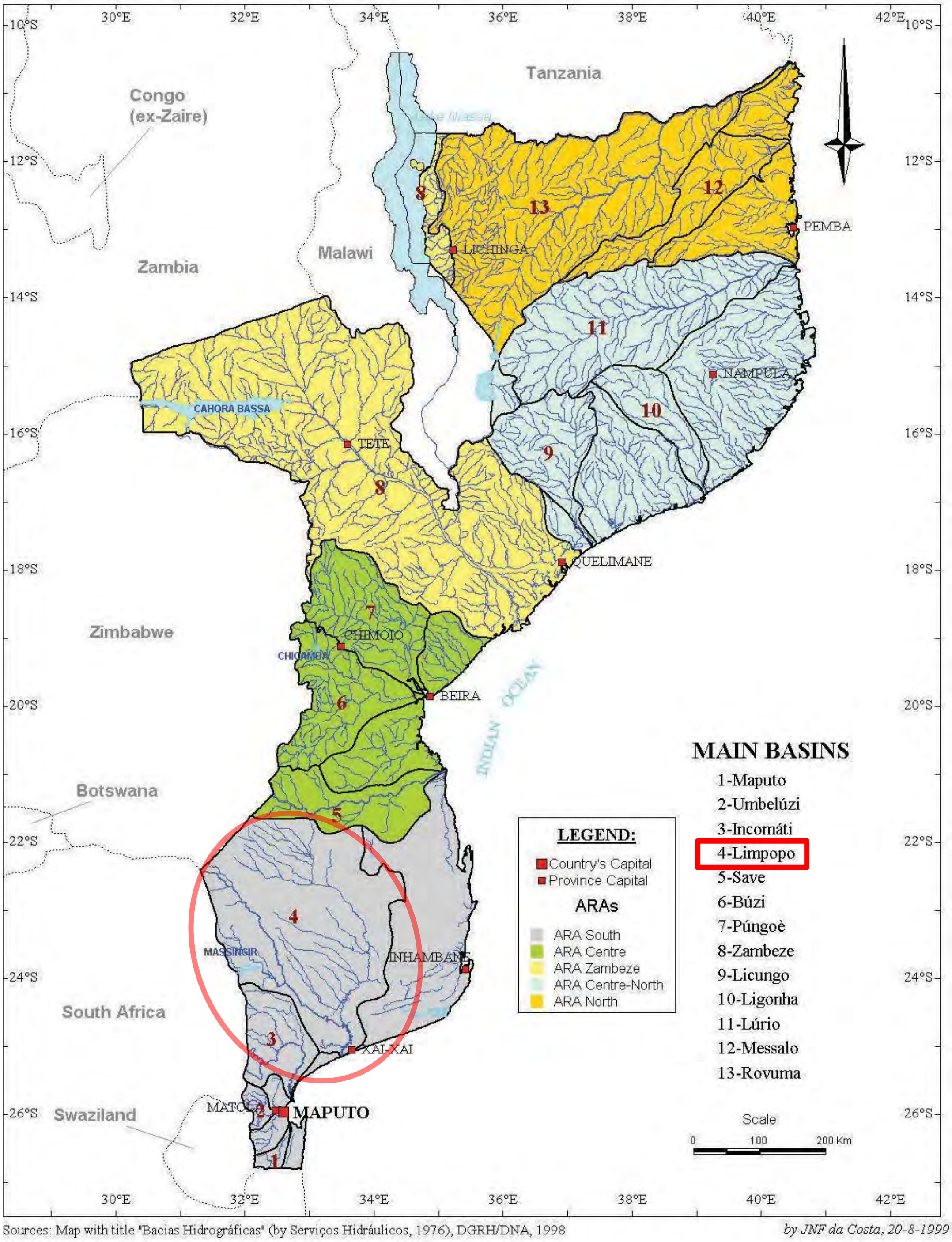
Place： Limpopo River Basin, Gaza Province, Southern Mozambique

Donor：AfDB

Supplement：The Limpopo River flows through Botswana, South Africa and Zimbabwe to the Indian Ocean. According to the literature as of 2018, most of its water demand is used for irrigation, and development in the power sector is still in its infancy. The capacity of the Massingir dam (2,800Mm^3) is the largest in the basin within Mozambique.

Source：https://www.worldatlas.com/maps/mozambique

Figure 4.3-1 Planned site for Massingir / Mapai hydro power plant



Source : Main river basins of Mozambique by DNA (World Bank 2005)

Figure 4.3-2 Major rivers and their basins in Mozambique

② Beluluane thermal power station

Overview : The plant will be located in Beluluane Industrial Park, 30 km west of Maputo, and the entire project is expected to take about five years to complete. The project will be divided into several phases, with the first phase, a 500 MW power plant will be constructed. In addition to the construction of the thermal power plant, the project also includes the installation of a Floating Storage and Regasification Unit (FSRU) at the port of Matola and the laying of a gas pipeline, with an overall project cost of USD 2.8 billion. The construction and operation of the project will be carried out by Central Térmica de Beluluane, which was awarded the contract by the Mozambican government. This project is part of a plan to use domestic natural gas, but imported gas will be used at the beginning of operation. Once the LNG project at the Rovuma gas field, located off the coast of the northern state of Cabo Delgado, is operational, the project will switch to domestic gas. The reason for the initial use of imported gas is that the natural gas produced from the Pande-Temane gas field has already been determined for use in export to South Africa and for other projects in Mozambique. A contract has been signed between Gigajoule, which operates natural gas infrastructure in southern Africa, and France's Total to import 200 million tons of natural gas per year, which will be used at the start of operations. In the future, when the 'Electrical Backbone' project connecting the north and south of Mozambique is completed, it will be possible to supply electricity from Beluluane to other areas.

Output : 2,000 MW

Purpose : Supply of electricity to the Beluluane Industrial Park. Enhancing the supply of electricity in Mozambique and for export to SAPP. Use of domestic natural gas.

Place : The Beluluane Industrial Park is a free trade zone located in the most industrialized and productive region of Mozambique. It has more than 35 companies from 15 different counties, including the Mozal aluminum smelter. It is one of the largest industrial employment providers in Maputo Province.

Source : google Earth

Figure 4.3-3 Beluluane industrial park location map

Source：FURTHER AFRICA

Figure 4.3-4 Beluluane industrial park

③ Inhambane wind power plant

Overview : There is a movement to introduce new renewable energy throughout Mozambique, with plans to introduce solar power in the central and northern regions and wind power in the southern regions. This has the aim of introducing carbon-free energy and ensuring energy diversity in Mozambique. The Inhambane wind farm project is one of the first utility-scale wind farms in Mozambique. It will be built in the Inhambane area with an energy storage facility and is being funded by the U.S. Trade and Development Agency (USTDA). The FS study will be conducted by DNV GL Energy USA.

Output： 30MW

Purpose： Diversification of the energy matrix; enhancement of the power available in the EDM grid.

Donor：USTDA

Place： Near Praia da Rocha, Inhambane Province

Source：https://www.worldatlas.com/maps/mozambique

Figure 4.3-5　Planned Inhambane wind power plant construction site

Chapter 5
Transmission and Transformation Facilities Improvement Plan for Southern System

Chapter 5 Transmission and Transformation Facilities Improvement Plan for Southern System

5.1 Implementation status of transmission and substation facilities improvement in the southern system

(1) Southern Region Transmission and Transformation Facilities Plan in 2025

The southern Mozambique region planned by EDM for 2020 and 2025 was compared and examined, and the Southern Region Transmission and Transformation Facility Plan as of 2025 was extracted.

a. System configuration

- EDM proposes a grid plan to avoid overloading in both 2020 and 2025 by switching the grid and increasing the capacity of the existing 60 kV transmission system.

b. Construction of new 400kV Temane power plant to Chibuto transmission line and Chibuto substation：**Pink Area**

- By 2025, the Temane power plant will be constructed in a 200MW x 1 and 100MW x 3 configuration, and will transmit power to the southern region via a 320km transmission line.

c. 400kV Maputo-Matalane transmission line, 400/66kV Matalane substation ：**Red Area**

- By 2025, a new 400 kV Maputo-Matalane transmission line and a 400/66 kV, 120 MVA x 2 bank Matalane substation will be built to transmit power from the Temane power plant to the Maputo substation.

d. Construction of new 275/66kV Maputo substation：**Blue Area**

- By 2025, a new 275/66kV, 120MVA x 2-bank Maputo substation is planned to be built near the Maputo substation.

e. Construction of a new 66kV transmission line：

- Along with the construction of new lines c and d above, a new 120 MVA 66 kV transmission line is planned to be constructed to supply electricity to Maputo city.

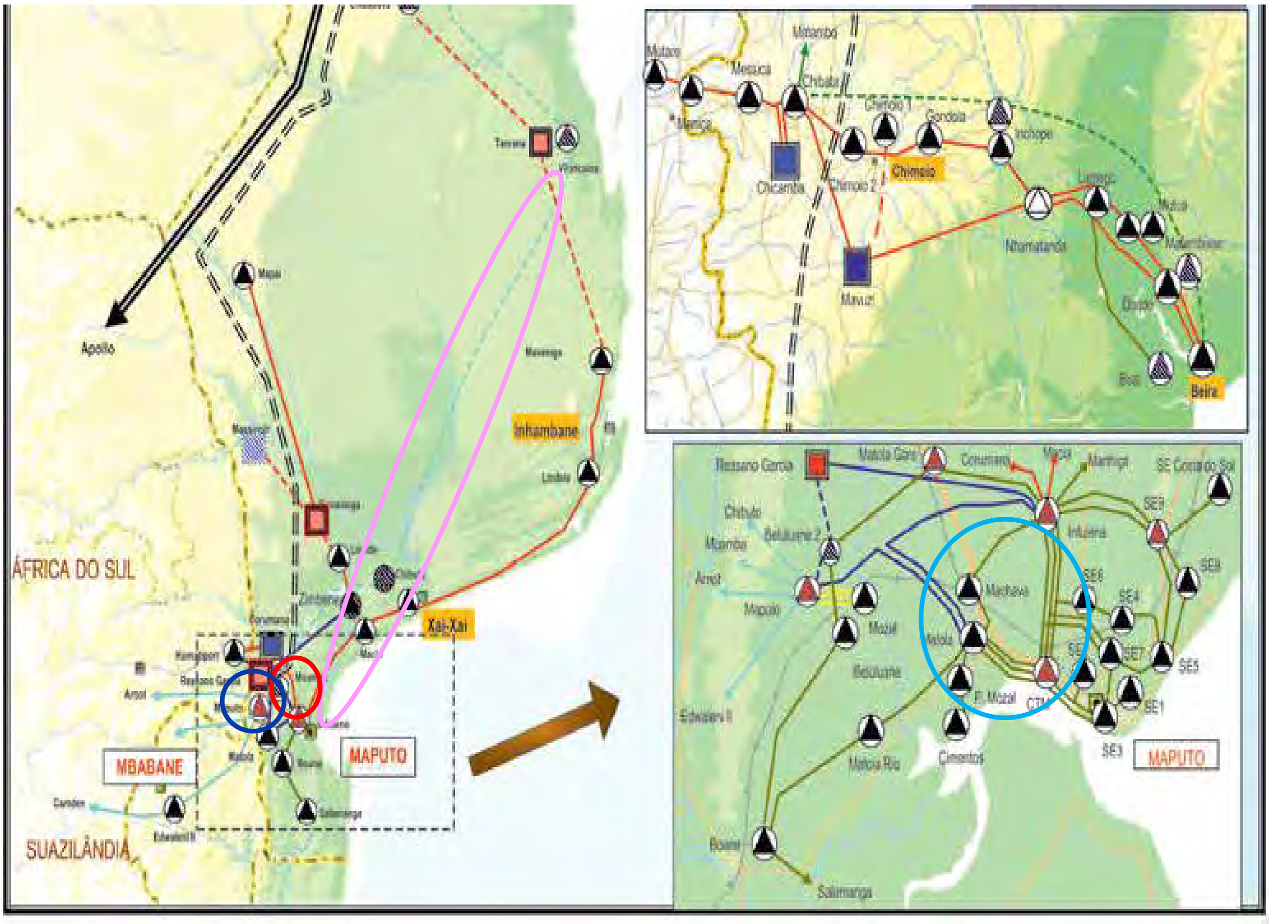
f. Construction of new substations for 66/33kV distribution：

- Three new 66/33kV distribution substations are planned to be constructed to supply electricity to Maputo city.

g. Increasing the capacity of existing 66kV transmission lines：**Light Blue Area**

- The existing 66kV transmission lines between Infulne and CTM and between Matola and CTM are planned to increase their transmission capacity from 33or50MVA to 120MVA by 2025.

Figure 5.1-1 shows the planned location of the transmission and substation facilities in the southern region.



Source：JICA Study Team

Figure5.1-1 Location of planned transmission and substation facilities in the southern region

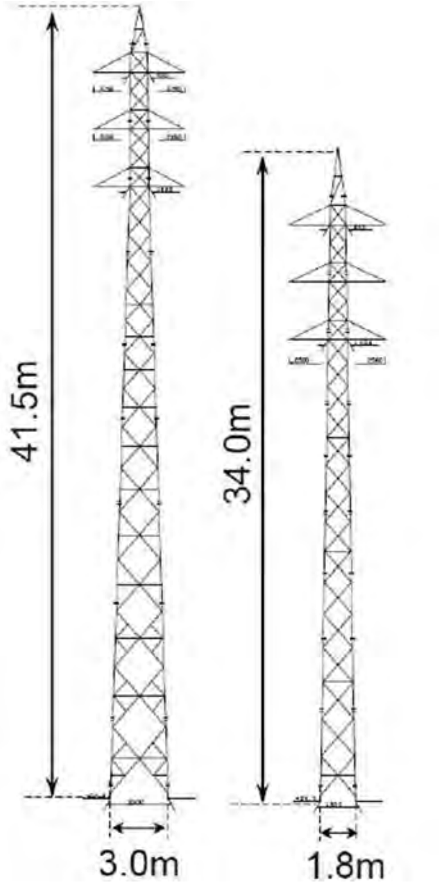
5.2 Issues in planning transmission and substation facilities in the southern system

In order to accurately respond to the increasing power demand in the southern region, it is necessary to steadily upgrade the backbone system and 66kV transmission and substation facilities in accordance with the 2025 Transmission and Transformation Facilities Plan as soon as the Temane Power Plant begins operation.

The issues and proposed measures to achieve these goals are as follows.

(1) Improvement of transmission and substation facilities for the core system and 66kV transmission and substation facilities

When the subject transmission and substation facilities have to be newly constructed in a dense residential area, the substation site can be reduced by applying GIS equipment. For power transmission towers, it is possible to reduce the site area by applying narrow-roofed towers and four-line towers.



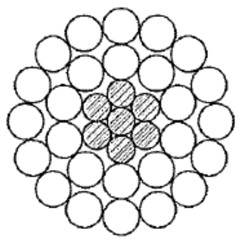
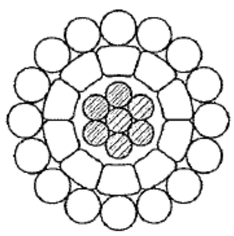
Source：JICA Study Team

Figure 5.2-1 Example of 66kV narrow-roofed steel tower

(2) Increasing the capacity of existing 60kV transmission lines

In order to increase the capacity of an existing transmission line, it is generally necessary to replace the wires and carry out associated work such as raising the tower and reinforcing the tower. This requires a long stoppage of the transmission line. Here, we introduce a measure to replace the existing power lines with Gap power lines. With this measure, the transmission capacity can be increased by a factor of 1.5 or more using the same size and weight of wire as the current one, without changing the wire slack.

Table 5.2-1 Examples of Gap Conductors

Description		Unit	ACSR Squab	GZTACSR 290 mm^2
Construction		Nos/mm	26/3.874 - AL 7/3.012 - ST	16/3.7 – ZTAL[*2] 10/TW[*1] – ZTAL[*2] 7/2.7 - EST[*3]
Nominal Diameter		mm	24.53	23.3
Min. breaking load		kN	107.87	105.3
Cross sectional area	AL	mm^2	306.5	286.6
	Core		49.88	40.08
	Total		356.4	326.7
Nominal weight		Kg/km	1239	1132
DC Resistance at 20 °C		Ohm/km	0.09422	0.1027
Modulus of elasticity		GPa	82.0	79.5
Co-efficient of linear expansion		/°C	19.0×10^{-6}	19.3×10^{-6}
Current capacity		A	746 A at 90 °C	1263 A at 210 °C
Sag of 350m span		m	10.78 m at 90 °C	10.78 m at 210 °C
Cross sectional view		-		

: JICA Study Team

(3) Construction of new substations for 66/33kV distribution

Three new substations for power distribution are planned to be built by 2025, but it may be effective to install mobile substations on a temporary basis.

: Manufacturer's materials

Figure 5.2-2 Example of mobile substation

5.3 Future plans for transmission and substation facilities in the southern system

EDM is planning seven new transmission and substation projects after 2025 to meet the steadily growing electricity demand in the southern region.

If the transmission and substation projects through 2025 proceed smoothly, it will be effective to prioritize and implement the following projects ① through ④, which are designed to supply electricity through interconnection with neighboring districts.

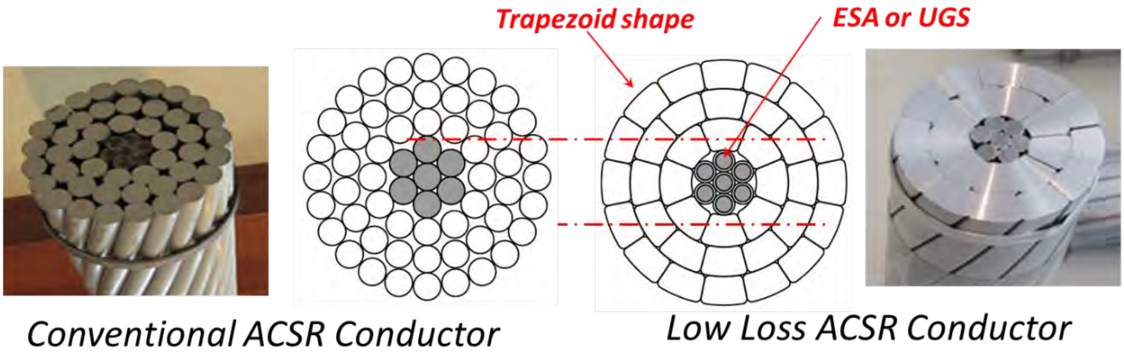
① 400kVMaputo-Salamanga T/L, 400/66kVSalamango S/S

② 66/33kVPonta de Ouro S/S

③ 66/33kVKatembe S/S

④ 110kVVilanculos-Massinga T/L

Among these projects, for projects ① and ④, which involve the construction of new long-distance transmission lines, the use of low-loss power lines may reduce long-term operating costs if the power flow become large. Also, for ①, which requires the expansion or construction of new backbone substations, the application of GIS equipment may be advantageous if there are limitations on the substation site.



: JICA Study Team

Figure 5.3-1 Example of low-loss conductor shape

In addition, considering the increase in power demand in the southern region after 2026 (High Case) as described in Chapter 3, the expansion of the Maputo thermal power plant (106 MW) near the CTM substation after 2026 will be effective as a base power source in the southern region in addition to the power supply from the Temane power plant.

If this Maputo power plant is expanded, and if the existing 66kV transmission line between Infulune and CTM is reinforced to 120MVA as planned, it will be able to supply power to Maputo city as planned. However, if these lines have not been reinforced, it will be necessary to reinforce the existing 66kV transmission lines in conjunction with the new construction of the next Maputo unit, and in this case, the aforementioned replacement with Gap lines will be very effective.

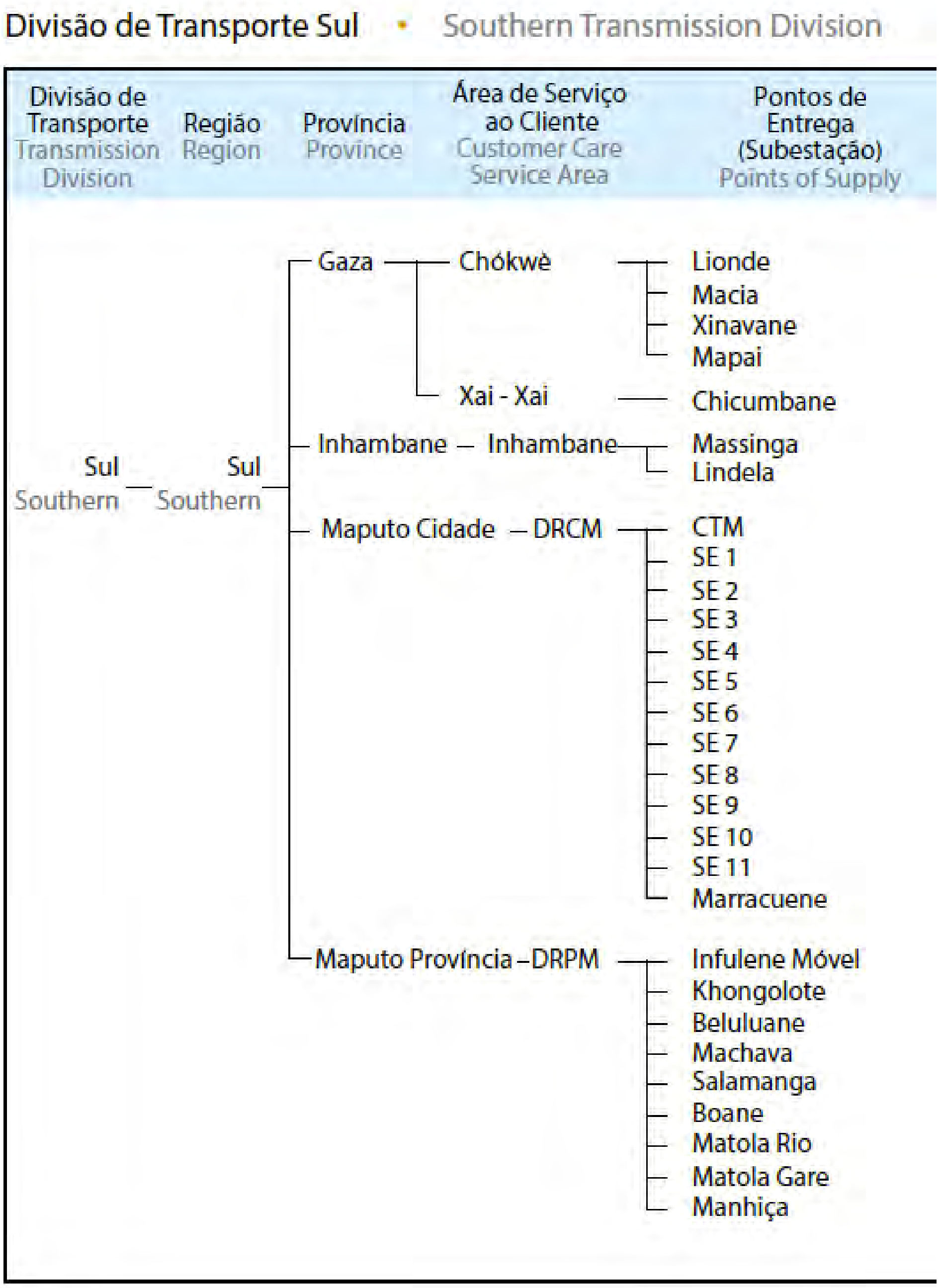
Chapter 6
Power Distribution Improvement Plan for Southern System

Chapter 6 Power Distribution Improvement Plan for Southern System

6.1 Implementation status of the power distribution improvement plan in the southern system

(1) Status of power distribution facilities

Distribution facilities in the southern system in this report are considered for facilities in Gaza (Chokwe, Xai-Xai), Inhambane, Maputo Cidade (Maputo City), and Maputo Provincia (Maputo Province) based on the regional classification in EDM southern transmission sector (Figure 6.1-1).



Source : EDM Annual Stastical Report

Figure 6.1-1 Regional Classification in EDM Southern Transmission Sector

Table 6.1-1 and Figure 6.1-2 show the status of medium voltage distribution lines from 2009 to 2020, showing that the medium voltage distribution lines in each province have been extended year by year to meet the steady increase in demand.

Table 6.1-2 and Figure 6.1-3 show the number of distribution transformers from 2009 to 2020, and Table 6.1-3 and Figure 6.1-4 show the trend of distribution transformer capacity from 2009 to 2020. As with the medium voltage distribution lines, the number and capacity of distribution transformers in each province have been steadily increasing.

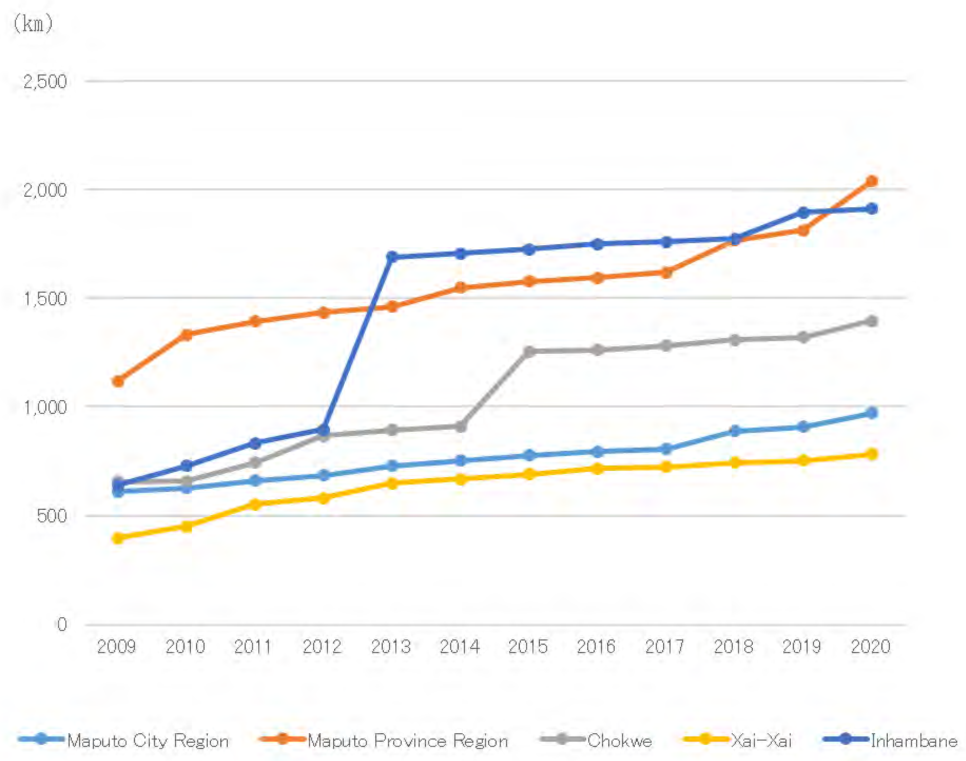
In an interview with the EDM System Planning Department, the department commented that although the budget is limited, they are working hard to respond to the increased demand and replace old equipment.

Table 6.1-1 Medium voltage distribution line extension from 2009 to 2020

(km)

Service Customer Area	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Maputo City Region	610	629	662	685	730	754	778	796	807	890	909	973
Maputo Province Region	1,120	1,334	1,393	1,435	1,461	1,548	1,578	1,595	1,619	1,766	1,812	2,038
Chokwe	657	660	744	867	894	912	1,256	1,264	1,283	1,309	1,321	1,397
Xai-Xai	397	451	553	582	649	670	691	718	726	745	755	784
Inhambane	639	730	833	896	1,690	1,707	1,726	1,749	1,760	1,775	1,895	1,913
South Region	3,423	3,804	4,185	4,465	5,424	5,591	6,029	6,121	6,196	6,484	6,692	7,104
Total EDM	9,252	10,387	11,847	12,922	14,384	15,268	16,663	17,078	17,517	18,741	19,486	20,348

(Source：EDM Annual Stastical Report)



Source：Prepared by JICA Study Team

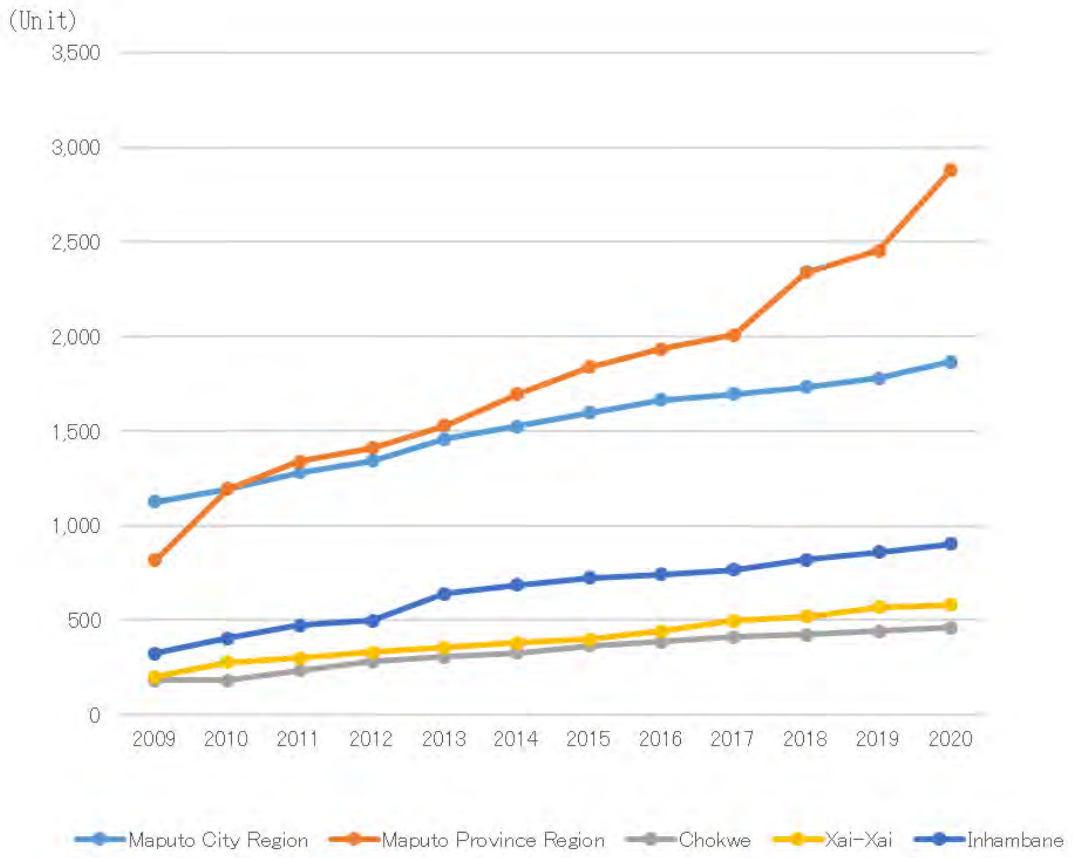
Figure 6.1-2 Medium Voltage Distribution Line Extension in the South from 2009 to 2020

Table 6.1-2 Changes in the number of distribution transformers from 2009 to 2020

(Unit)

Service Customer Area	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Maputo City Region	1,127	1,195	1,280	1,342	1,456	1,527	1,596	1,666	1,697	1,732	1,778	1,865
Maputo Province Region	816	1,193	1,339	1,410	1,528	1,697	1,839	1,935	2,008	2,340	2,455	2,880
Chokwe	182	182	236	281	306	328	364	387	410	423	442	460
Xai-Xai	200	279	301	330	354	381	399	443	499	519	569	580
Inhambane	324	404	473	499	639	686	723	741	766	819	859	903
South Region	2,649	3,253	3,629	3,862	4,283	4,619	4,921	5,172	5,380	5,833	6,103	6,688
Total EDM	4,692	5,497	6,140	6,717	7,538	8,358	9,217	9,910	10,552	11,342	11,943	13,111

Source：EDM Annual Stastical Report



Source：Prepared by JICA Study Team

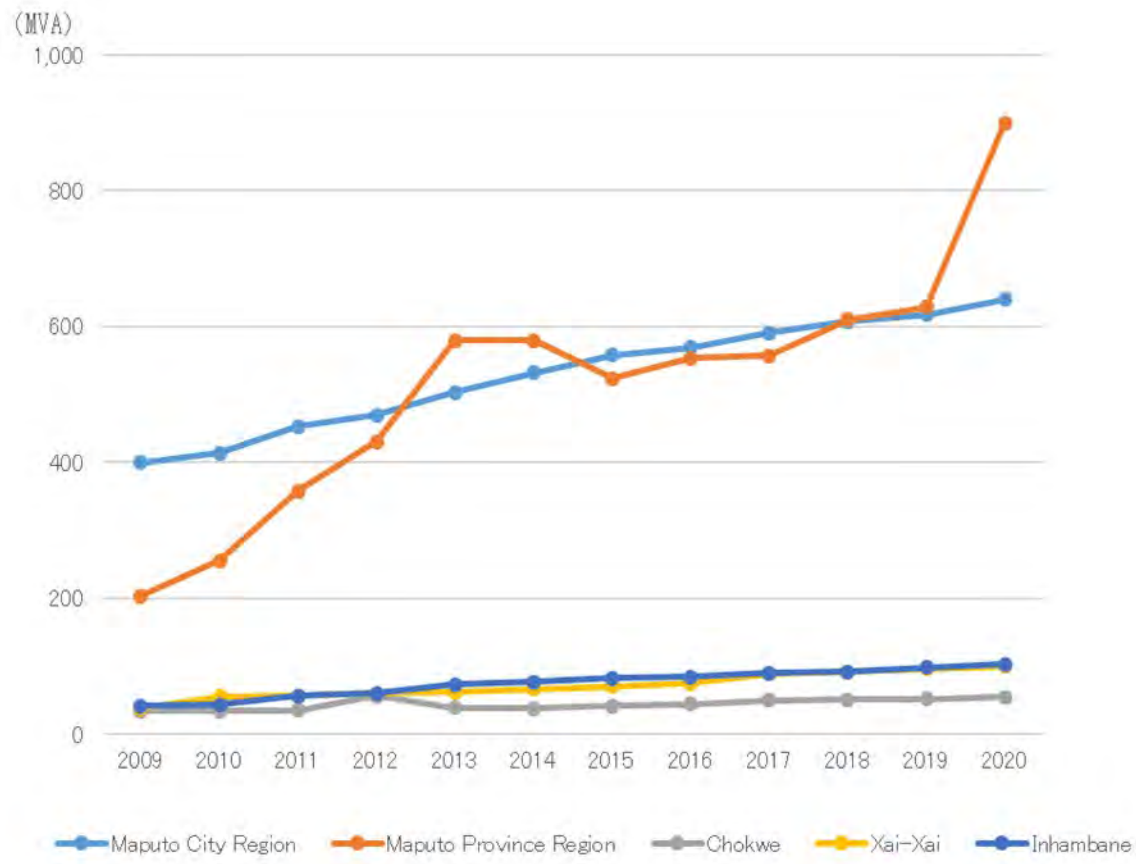
Figure 6.1-3 Number of distribution transformers in the South from 2009 to 2020

Table 6.1-3 Changes in distribution transformer capacity from 2009 to 2020

(MVA)

Service Customer Area	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Maputo City Region	400	414	453	470	503	532	558	569	591	608	618	640
Maputo Province Region	204	256	358	431	580	580	524	554	557	610	629	900
Chokwe	34	34	35	57	39	38	42	45	50	51	52	55
Xai-Xai	38	56	57	60	62	67	71	75	89	92	97	100
Inhambane	42	44	57	60	73	77	83	85	90	92	99	103
South Region	718	804	960	1,078	1,256	1,295	1,278	1,328	1,378	1,453	1,494	1,798
Total EDM	1,244	1,337	1,521	1,722	1,985	2,079	2,160	2,326	2,448	2,614	2,716	2,984

Source：EDM Annual Stastical Report



Source：Prepared by JICA Study Team

Figure 6.1-4 Changes in distribution transformer capacity in the South from 2009 to 2020

(2) Maintenance status of vehicles for distribution work

In order to examine the possibility of using Japanese technology, which will be discussed later, the status of vehicles owned in the power distribution sector is shown in Table 6.1-4.

The branches that serve Maputo City, Maputo Province, and other southern region have 350 vehicles, and 31 are large vehicles ("Viatura Pesada" in the table) such as vehicles for distribution work. Eight of these large vehicles (26%) are in poor condition, and also 23% (= 200 units/858 units) of other equipment are in some kind of defective condition, suggesting that many of the vehicles are in need of repair or replacement.

Table 6.1-4 Vehicles owned by the EDM power distribution department (top: in good condition, bottom: in poor condition)

Fleet of vehicles and heavy equipment:

Fleet of Vehicles and Heavy Equipment by Business Unit in Good Condition

FUNCTION	DIRECÇÃO	Maquinas Especiais e Atrelados	Motociclo	Quadri-ciclos	Viatura Ligeira	Viatura Pesada	Total
DISTRIBUTION	Central Region	2	83	1	124	17	227
	Maputo City		9		95	9	113
	Maputo Province	2	2		64	6	74
	Northern Region	7	7	8	117	11	150
	South Region	3	13	5	62	8	91
	Headquarters				3		3
Sub- Total A)		14	114	14	465	51	658

Fleet of Vehicles and Heavy Equipment by Business Unit in Bad Condition

FUNCTION	DIRECÇÃO	Maquinas Especiais e Atrelados	Motociclo	Quadri-ciclos	Viatura Ligeira	Viatura Pesada	Total
DISTRIBUTION	Central Region	2	4		62	8	76
	Maputo City				13	3	16
	Maputo Province				19	3	22
	Northern Region	1	8		35	7	51
	South Region	3	2		27	2	34
	Headquarters	6	14		1		1
Sub- Total B				0	157	23	200
Total Geral (A+B)		20	128	14	622	74	858

Source：EDM Business Plan 2020-2024

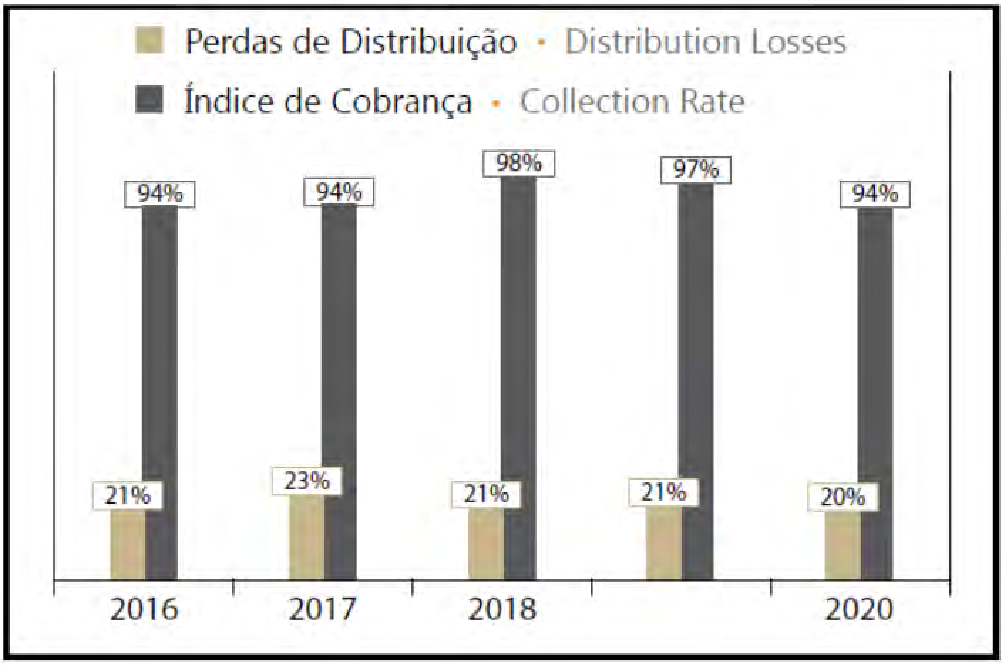
6.2 Issues of power distribution development in the southern system

(1) Power distribution loss in the southern system

One of the top priorities for economic and social development in Mozambique is the stable supply of electricity in urban areas and the promotion of electrification in rural areas. As mentioned in section 6.1, EDM has been working hard to expand the power distribution system to meet the strong demand for electricity. However, the expansion of the distribution system may not be able to keep up with the growth of electricity demand, which averaged more than 10% a year until a few years ago (although it was about 6% in the most recent years). As a result, while the EDM power distribution division is working hard to respond to the increase in demand and replace old equipment, it is facing various problems, such as excessive voltage drop in long-distance distribution lines, longer restoration times in the event of power outages, and an increase in the power distribution loss ratio.

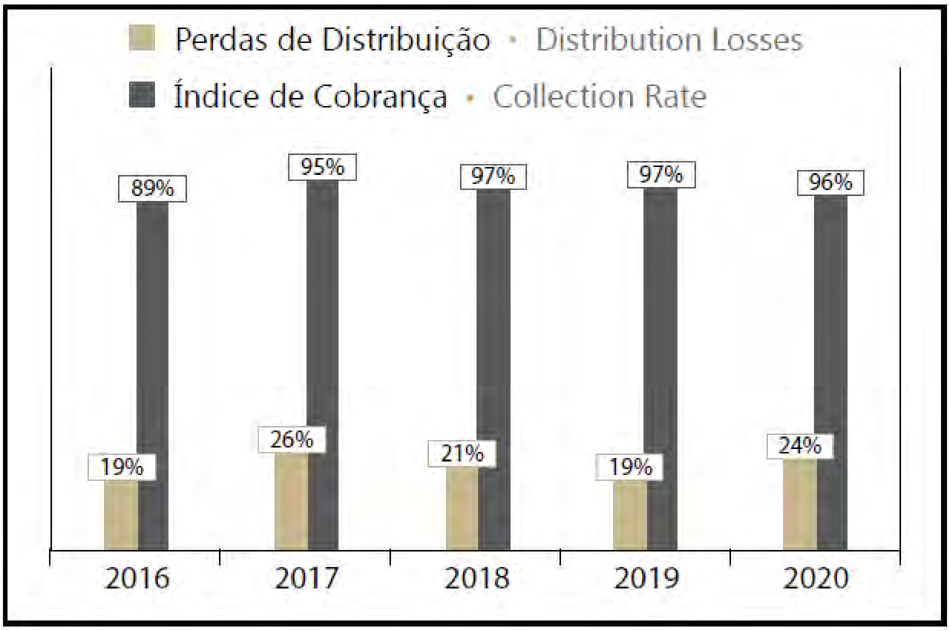
Among the above issues, JICA Study Team now focuses on distribution loss, which is recognized as a particularly important issue in EDM. Figure 6.2-1 to Figure 6.2-5 show the trend of distribution loss ratio and rate recovery ratio from 2016 to 2020 in the southern grid.

Looking at the trend of distribution loss rate, Maputo City and Maputo Province have been changing at a large level of over 30% in recent years. In other provinces, the distribution loss rate is as high as 10 to 20%. The figures confirm that the reduction of the loss ratio is one of the important management issues that EDM is currently facing.



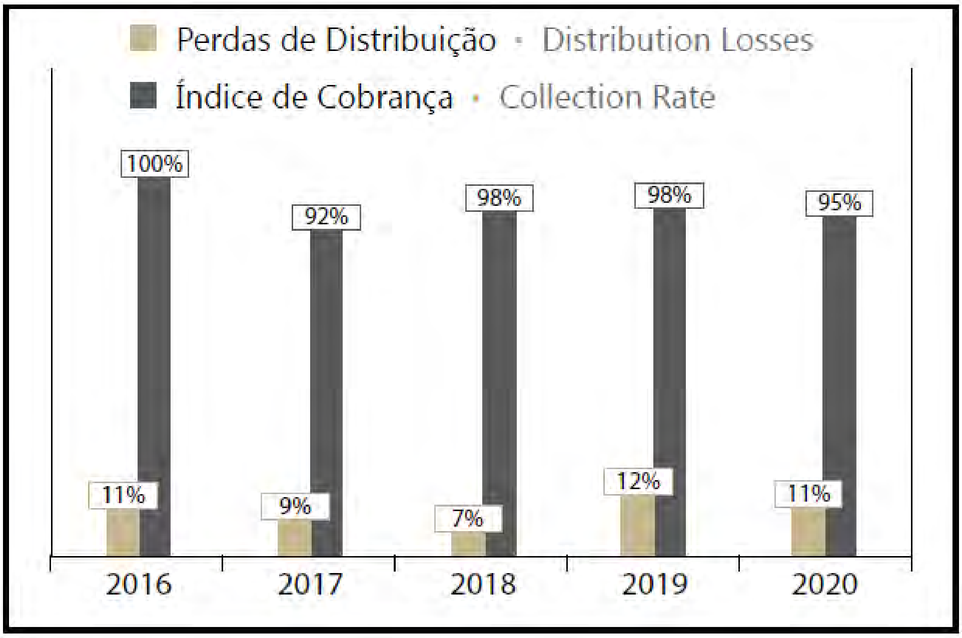
Source：EDM Annual Stastical Report

Figure 6.2-1 Distribution Loss Ratio and Collection Rate in Inhambane from 2016 to 2020



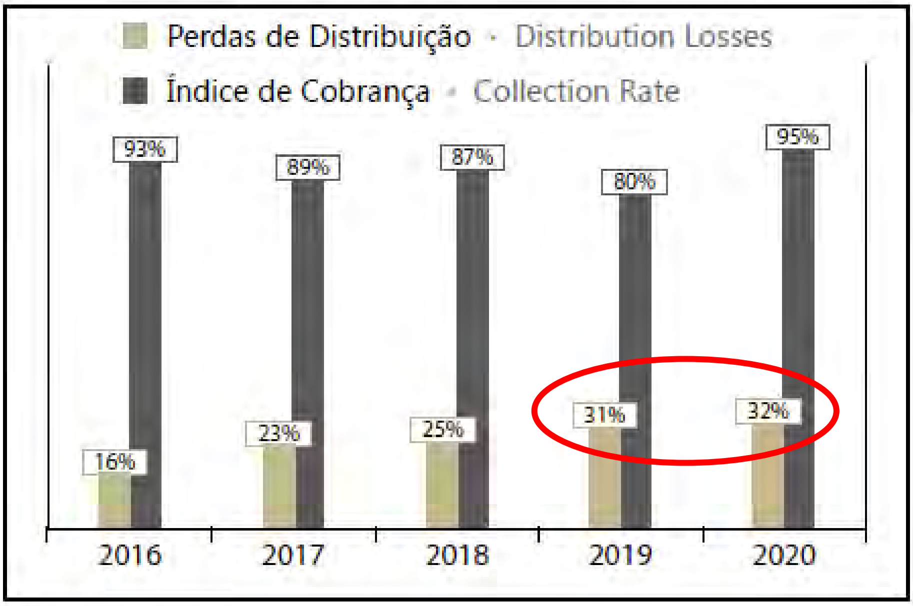
Source：EDM Annual Stastical Report

Figure 6.2-2 Distribution Loss Ratio and Collection Rate in Xai-Xai from 2016 to 2020



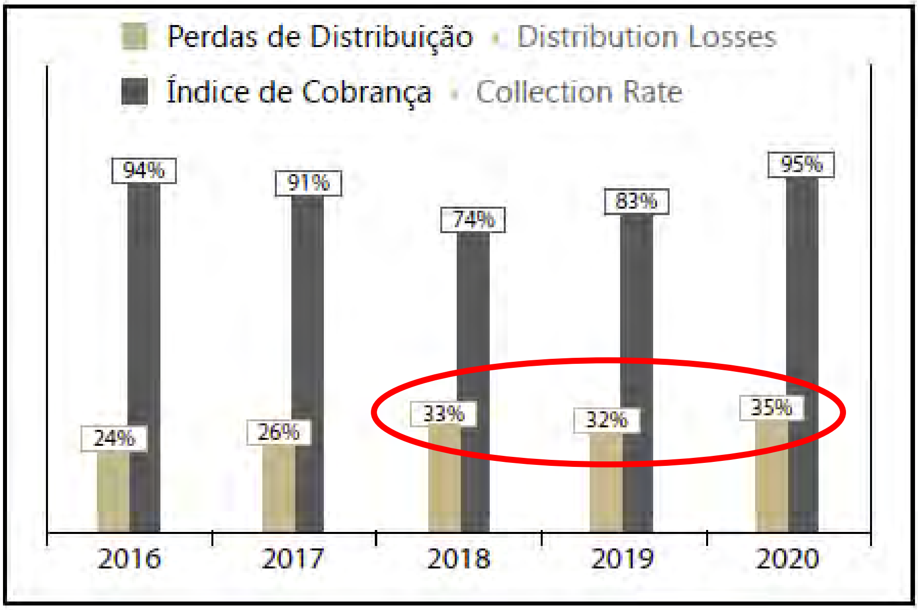
Source：EDM Annual Stastical Report

Figure 6.2-3 Distribution Loss Ratio and Collection Rate in Chokwe from 2016 to 2020



Source：EDM Annual Stastical Report

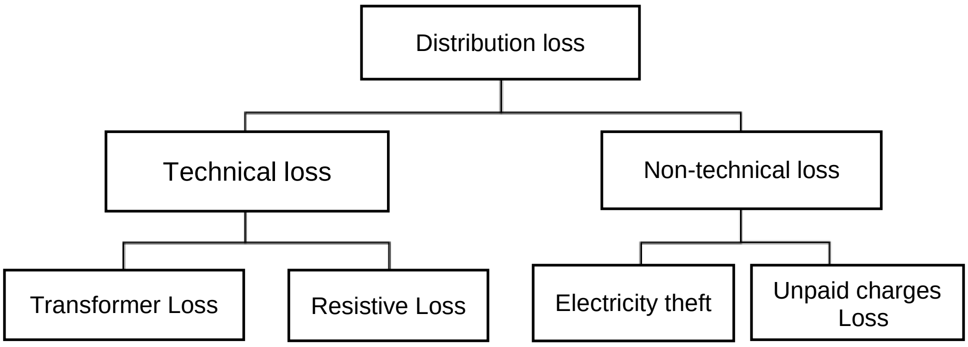
Figure 6.2-4 Distribution Loss Ratio and Collection Rate in Maputo Province from 2016 to 2020



Source：EDM Annual Stastical Report

Figure 6.2-5 Distribution Loss Ratio and Collection Rate in Maputo City from 2016 to 2020

The types of power distribution losses can be categorized as shown in Figure 6.2-6.



Source：prepared by JICA Study Team

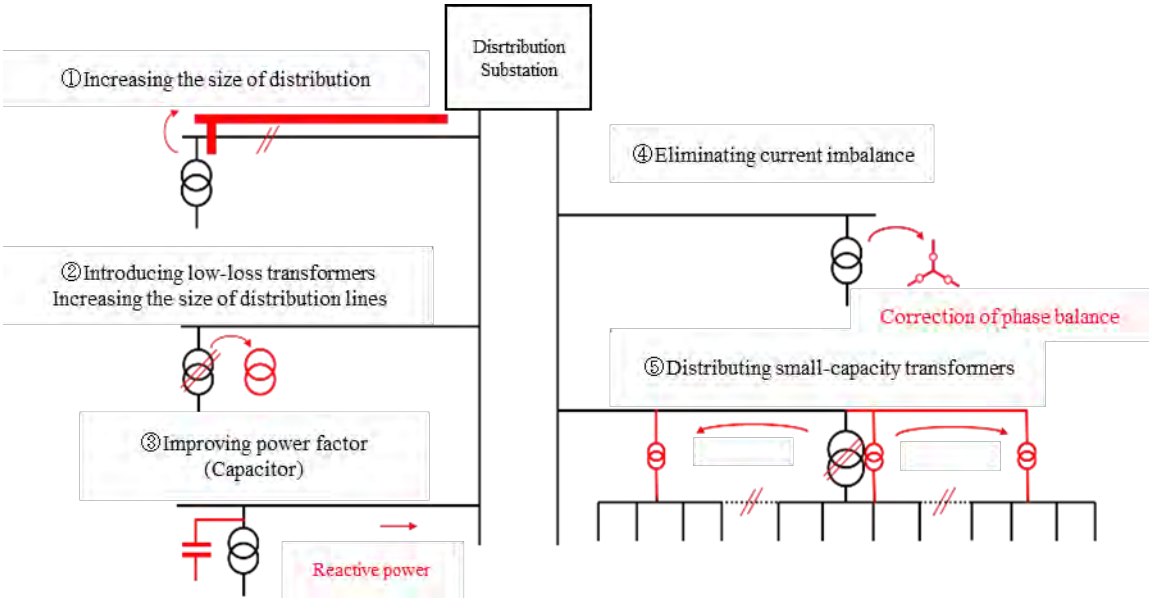
Figure 6.2-6 Classification of power distribution losses

Among technical losses, resistive losses are losses caused by the electrical resistance of power lines, and are proportional to the square of the amount of current. In general, developing countries are unable to reinforce power transmission and distribution lines even when power demand increases, and often have no choice but to supply power under high load operation or overload conditions, or to temporarily extend power distribution lines without considering the reduction of power distribution losses, resulting in a large amount of resistance loss.

In addition, iron loss in transformers is the loss generated in the iron core of the transformer, and it continues to be generated 24 hours a day when the transformer is charged, regardless of the size of the load. Compared to previous products, the iron loss of recent silicon steel plate transformers has decreased considerably, but transformers using amorphous metals in their iron cores can be expected to further reduce iron loss.

On the other hand, non-technical losses are mainly caused by electricity theft, non-receipt of charges, and exemption from charges. Theft of electricity is the illegal use of electricity by consumers without going through a meter, which does not show up in the amount of electricity sold measured by the meter. Unpaid bills include those where the utility company is unable to collect bills for the electricity used by the meter, and those caused by incorrect metering due to faulty meters.

If large reductions in technical losses are to be expected, it is necessary to implement measures to reduce these losses, such as boosting the voltage in the entire area. In addition, the following measures can be considered: increasing the size of distribution lines, introducing low-loss transformers such as amorphous transformers, improving the power factor by installing capacitors, eliminating current imbalance, and distributing small-capacity transformers such as "multi-transformer system" (Figure 6.2-7).



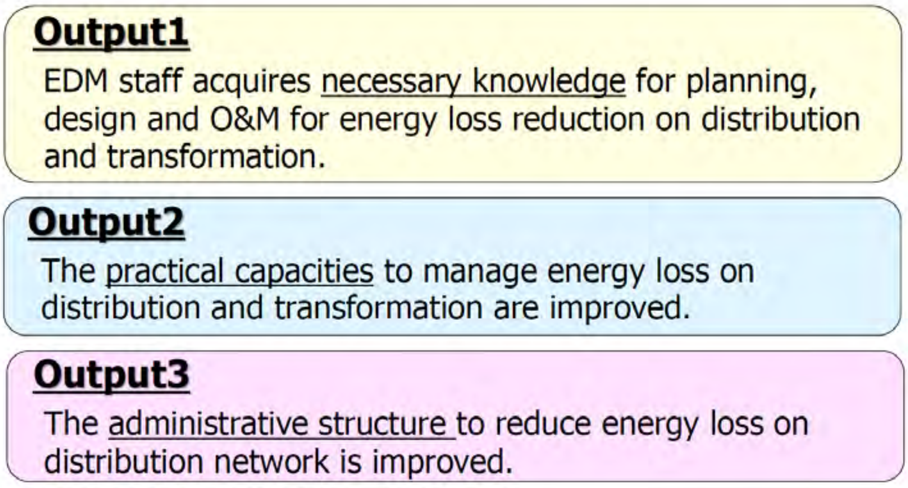
Source : Prepared by JICA Study Team

Figure 6.2-7 Technical loss reduction measures

A JICA technical cooperation project (Distribution Loss Improvement Project) has been implemented to reduce distribution losses. So, JICA Study Team confirmed the followings as of November 2021 by interviewing Chubu Electric Power Company: (1) the current status of the pilot project for reducing technical and non-technical losses, and (2) the status of technical and non-technical losses in power distribution (for the last five years) and future prospects.

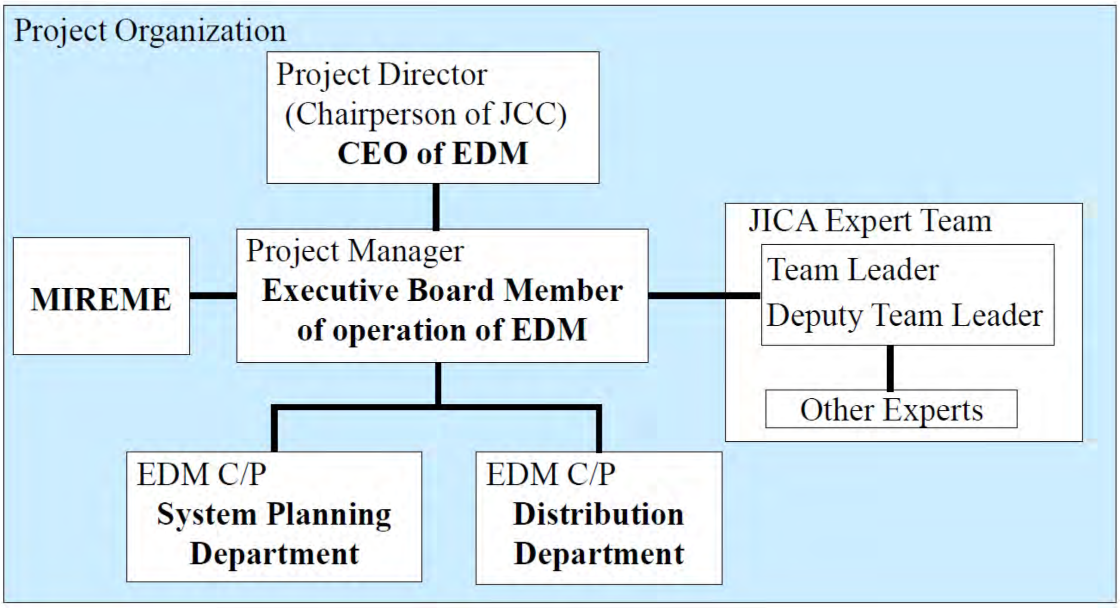
① Overall project outline

- The period of the JICA technical cooperation project is three years, from March 2020 to March 2023. As shown Figure 6.2-8, the objectives of the project are for EDM to acquire the necessary knowledge for loss reduction in the planning, design, operation, and maintenance of facilities (Output 1), to improve the practical capability for loss reduction (Output 2), and to improve the management structure for loss reduction (Output 3).
- The organizational structure and working group structure for project promotion are shown in Figure 6.2-9 and Figure 6.2-10, respectively.



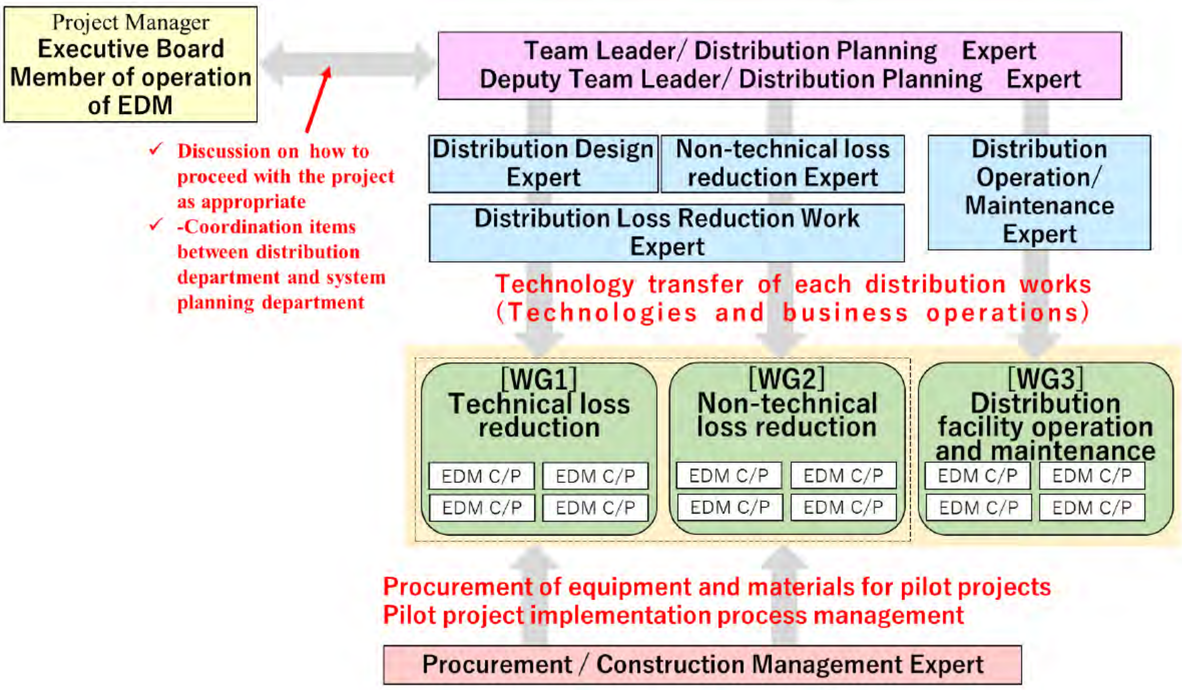
Source：JICA technical cooperation project (Chubu Electric Power Co., Inc.)

Figure 6.2-8　Objectives of the JICA Technical Cooperation Project



Source：JICA technical cooperation project (Chubu Electric Power Co., Inc.)

Figure 6.2-9　Organizational structure of JICA technical cooperation projects

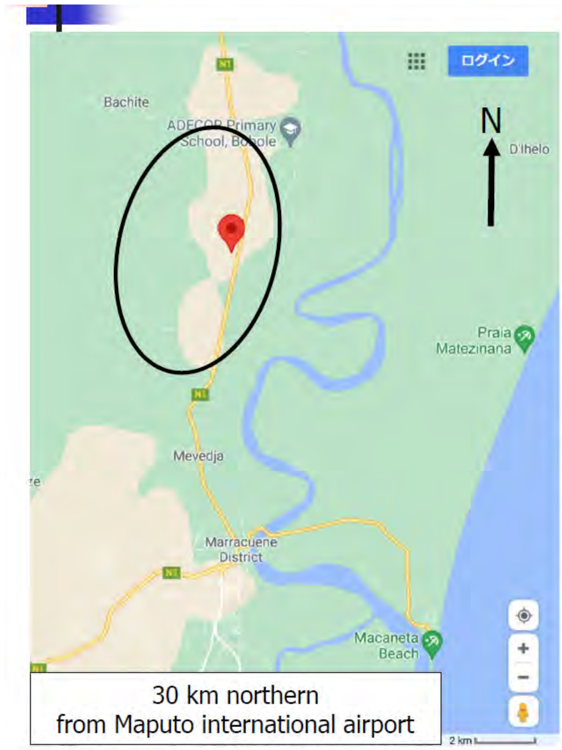


Source：JICA technical cooperation project (Chubu Electric Power Co., Inc.)

Figure 6.2-10　Working Group of JICA Technical Cooperation Project

② Current Status of Pilot Projects for Reducing Technical and Non-Technical Losses

- As shown in Figure 6.2-10, WG1 is working to reduce technical losses, WG2 is working to reduce non-technical losses, and WG3 is working to improve power distribution operations and facility maintenance operations.
- The goal of WG1 is to introduce a multi-transformer system and to reduce technical losses by improving the load balance of the three phases. The pilot project was initially planned to be implemented at several locations, but after discussions with EDM and JICA, it was decided to be implemented at a single location (EDM's transformer number PT-92R), 30 km north of Maputo International Airport (Figure 6.2-11). The implementation schedule of the pilot project is also shown in Figure 6.2-12.



Information of the Candidate No.1 Site:
PT-92R (ID of MV/LV Transformer)

Area				
Province	District	Town	Longitude	Latitude
Maputo	Marracuene	Eduardo Mondlane	-25.65	32.671

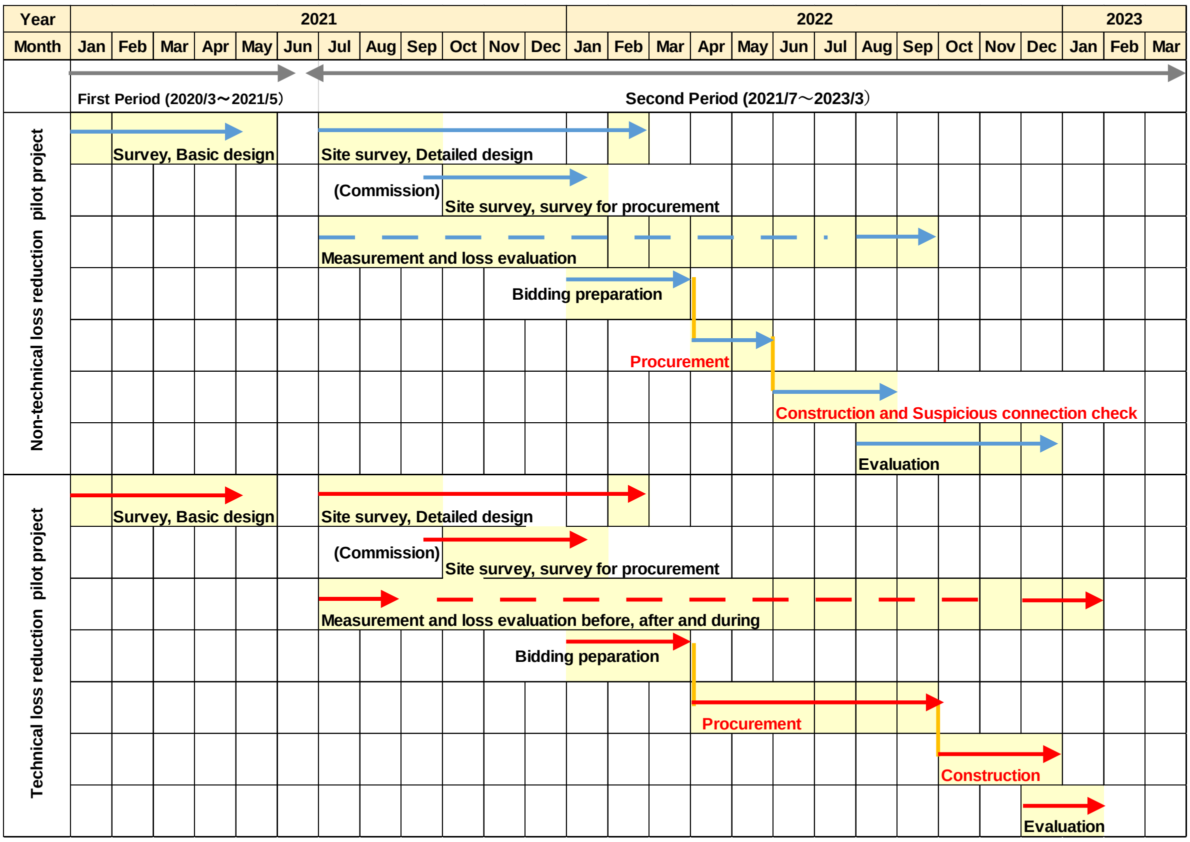
MV/LV transformer				
ID	Transformation ratio	Capacity	Manufacture year	Installation year
PT 92R	33/0.4 kV	500 kVA	2017	2017

LV line	
Total length	Longest length from transformer to an end
17,000 m	2,500 m

Load		
Rated current	Measured (Max.) load current	Load rate (Max. usage rate)
722 A	586 A	81%
Assumed load increase rate for FY2021	Max. load current in FY2021	Load rate in FY2021
10%	645 A	89%
Assumed load increase rate for FY2022	Max. load current in FY2022	Load rate in FY2022
10%	709 A	98%
Assumed load increase rate for FY2023	Max. load current In FY2023	Load rate in FY2023
10%	780 A	108%

Source：JICA technical cooperation project (Chubu Electric Power Co., Inc.)

Figure 6.2-11 Potential pilot project site for technical loss reduction



Source：JICA technical cooperation project (Chubu Electric Power Co., Inc.)

Figure 6.2-12 Implementation schedule for the pilot project (As of September 2021)

- WG2 is planning to install a "split meter" on the top of a utility pole (Figure 6.2-13) to prevent electricity theft at the same location as WG1, since the currently installed prepaid meters may be used improperly. Procurement of materials for all of these projects is still in progress.

Source：JICA technical cooperation project (Chubu Electric Power Co., Inc.)

Figure 6.2-13 Installation example of a split meter

③ Status of technical and non-technical losses in power distribution

- Chubu Electric Power Co. said that the data for 2020 was still being confirmed, but the forecast was for 8% technical loss (EDM seems to have set a certain value) and 16% non-technical loss, for a total of 24%.
- By promoting the JICA technical cooperation project at a point (EDM transformer number PT-92R) located 30 km north of Maputo International Airport, as mentioned above, and by implementing the same measures in other areas, the future distribution loss ratio is targeted to be as shown in Table 6.2-1.

Table 6.2-1 Transition of distribution loss ratio from 2009 to 2019 and future targets

Transition of distribution loss

Year		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Loss		23%	20%	19%	17%	15%	18%	18%	21%	22%	24%	24%
	Tech	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Non-tech	15%	12%	11%	9%	7%	10%	10%	13%	14%	16%	16%

Distribution loss target (technical + non-technical)

Year	2019	2020	2021	2022	2023	2024	2025
Loss	24%	22%	21%	20%	19%	18%	16%

Source：JICA technical cooperation project (Chubu Electric Power Co., Inc.)

(2) Work safety for power distribution equipment

Refer to Appendix-2.

6.3 Future plans for power distribution improvement in the southern system

(1) Power Distribution Improvement Plan for Southern System

According to the list of high priority projects planned for 2021-2030 obtained from the EDM System Planning Department, 17 projects are listed in the power distribution sector. Of these, six projects are in the southern region.

Looking at these six projects, they all have the purpose as follows.

- Reduction of technical losses
- Reduced outage time (improved supply reliability)
- Connection of new customers

In addition, the scope of each project to achieve the above objectives is as follows

- Construction and rehabilitation of medium voltage and low voltage distribution lines
- Installation of power distribution transformers
- Connection of new customers, construction of street lights and their control units etc.

(2) Possibility of introducing vehicles for power distribution work

As described so far, EDM has been using trucks with cranes, which are vehicles with some shared functions, but they have some problems such as limited functions, insufficient number of deployment, and a considerable number of vehicles in poor condition as described in 6.1.

On the other hand, as the power demand is expected to continue to increase in the future, it is necessary for EDM to improve safety and productivity for the ever-increasing construction and maintenance work of power distribution lines, for which zero accidents is the highlight of EDM's activity plan.

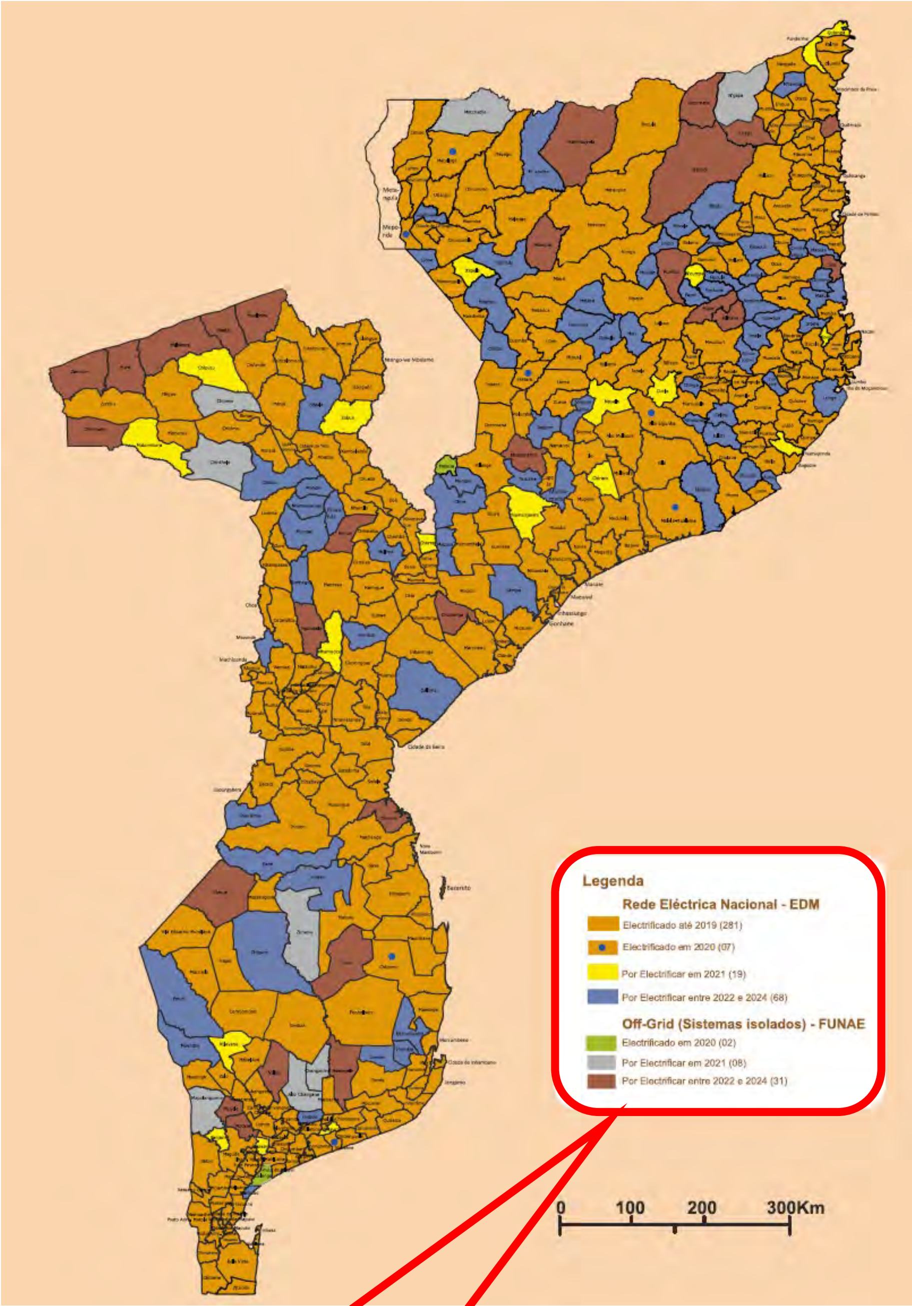
As the first step to achieve this, the introduction of new vehicles for distribution work, which reflect the experience and know-how of Japanese electric power companies and distribution work contractors, is considered to be effective. This point will be discussed in detail in Chapter 8.

(3) Current status and future plans for promoting electrification

Figure 6.3-1 shows the status and future plans for the promotion of electrification. The division of roles between EDM and FUNAE is as follows: EDM promotes "on-grid electrification," i.e., electrification by extending the existing distribution system to non-electrified areas, while FUNAE is in charge of "off-grid electrification," i.e., electrification for people living in remote areas that cannot be connected to the existing system. In order to avoid overlap between the electrification plans of EDM and FUNAE, the Ministry in charge acts as a coordinator and holds coordination meetings twice a month with the companies concerned.

FUNAE mainly deals with the electrification of suburban areas, providing electricity for people's daily lives (especially for cooking) and work, as well as electricity for the operation of public institutions such as schools, hospitals, and health centers through solar power and small-scale hydroelectric power generation. There are 48 micro-grids operated by FUNAE across the country, which are managed by the respective municipalities. There are 48 micro-grids managed by FUNAE nationwide, which are managed by municipalities, and other mini-grids are managed by FUNAE, with the largest class being 550 kW for solar and 6 kW for hydro.

FUNAE receives support from European countries such as the UK, Sweden, Belgium, Italy, and Spain, and the priority of electrified areas is decided by the government. In addition, when an area is to be electrified, whether it is to be on-grid or off-grid electrification, the National Energy Strategy confirms that areas more than 30 km away from the existing grid are considered to be off-grid electrified areas.



Source：EDM Annual Stastical Report

Figure 6.3-1 Status of Electrification Promotion in Mozambique and Future Plans

Chapter 7
Future Development Possibilities in the Electricity Sector in Mozambique

Chapter 7 Future Development Possibilities in the Electricity Sector in Mozambique

In this section, the study team will summarize the studies conducted to date and discuss the potential for development in Mozambique electric power sector.

In this survey, the study team learned from EDM that there is a strong desire to provide support for the development of a revised master plan for the entire Mozambique, including a review of the plan due to the impact of the corona disaster. In addition, when interviewed about priority projects, the survey respondents explained that many of the projects are located in a wide range of areas within Mozambique and that many of them are related to the country as a whole. The study team believe that this should be taken into account in the future development of the power sector.

7.1 Power Development

Based on the power supply capacity of the southern system in Chapter 3, the actual power demand and power supply through 2020 shows that power demand has exceeded power supply capacity and is expected to continue to fall short in the future. Currently, the shortfall is covered by electricity supply from South Africa, and although the power supply capacity of the southern region will improve with the start of operation of the Temane thermal power plant in 2024, an appropriate power supply to meet future power demand is required to ensure a stable power supply for the southern region of the Mozambique. However, in order to ensure a stable power supply in the southern region of Mozambique without being affected by the power situation in other countries, an appropriate power supply plan that meets future power demand is necessary.

There are three ways to meet the shortfall in the future: ①increase EDM's own power generation, ② use IPPs, or ③ use imported power from South Africa.

A comparison of the average cost of electricity generation in 2019 in EDM's Business Plan 2020-2024 shows that in-house power supply is 5.7 MT / kWh, IPP 11.11 MT / kWh, and imported power 30.93 MT / kWh. By increasing the use of low-cost in-house power sources and reducing the amount of high-cost imported power and IPP purchases, EDM's financial situation can be expected to improve. Therefore, relying on imported power, which is the most expensive and is affected by the power situation in other countries, should be considered as the last option. In the case of using IPP, the cost is high, and in many cases, contracts in hard currencies such as US dollars or euros are required, which are affected by fluctuations in exchange rates. The highest priority should be placed on increasing in-house developed power generation, which is low-cost and not dependent on other countries or IPPs. However, in the case of long-term investment and development such as electric power facilities, for example, if the operation period of a thermal power plant is 25 years, the initial cost is for the first 3-4 years, and the subsequent fuel cost and operation and maintenance cost are the main cash flow of power generation cost. Even if the cost shift of the initial cost is added to the generation cost of the company's own power supply, it is not expected to reverse the value of the purchase price from imported power or IPPs, to which profits have already been added.

The survey team considered future plans for the development of its own power supply based on the above ideas. According to the EDM, the following three projects are currently planned in the southern region. (See 4.3 Table 4.3-1 for details).

- Massingir 18 MW and/or Mapai Hydro Power Plant, 75MW
- Beluluane Thermal Power (Gás), 2000MW
- Inhambane Wind Power Plant (Jangamo District) 30MW

As shown above, the planned projects are divided into three sectors: hydro, gas, and wind, in line with the recent trend toward diversification of power sources based on decarbonization and renewable energies.

Beluluane Thermal Power is being planned by a private company and is fueled by LNG, which is more than twice as expensive as natural gas, and therefore was not selected as a candidate for new development in this study because it is not in line with EDM's low electricity prices compared to the cost of energy supply. The Inhambane Wind Power Plant was also eliminated from the list of new development candidates because it is already being planned by an international financing institution and its power output is affected by wind strength and other factors, making its power supply unstable. Beluluane Thermal Power and Inhambane Wind Power Plant were also excluded from the power generation plans in Chapter 3 because they are in the early planning stages and their supply capacity is unknown.

As mentioned above, it is necessary to consider the possibility of power development outside of the priority projects in the southern region, and the study team believe that the following two projects are expected to be developed in the Mozambique power sector for the purpose of increasing

EDM's own power production, which are currently anticipated through this study. Regarding (2), the expansion of a large-scale thermal power plant in Maputo, EDM was informed in advance that there is a need to develop a successor project to the "Maputo Gas Combined Cycle Power Plant Development Project," which was funded with official development assistance loan from the Japanese government. The study team was able to hear EDM's high expectations for the project as a candidate for the next phase of development, and the project was selected as a candidate for development in this study because of its potential relevance.

(1) Power Development in the Limpopo River Basin

The project aims to stabilize the grid in the northern part of Gaza Province by increasing the power supply from hydropower that has room for development. In addition to the priority projects of Massingir and Mapai hydropower, there is also the possibility of finding new projects.

Although study team were not able to identified the specific projects that is planning in the future and for which financing has not yet been decided, it is expected that there will be room for development with the cooperation of Japan, as there have been some surveys and searches for partners in recent years.

(2) Expansion of Large Gas-Fired Power Plant in Maputo

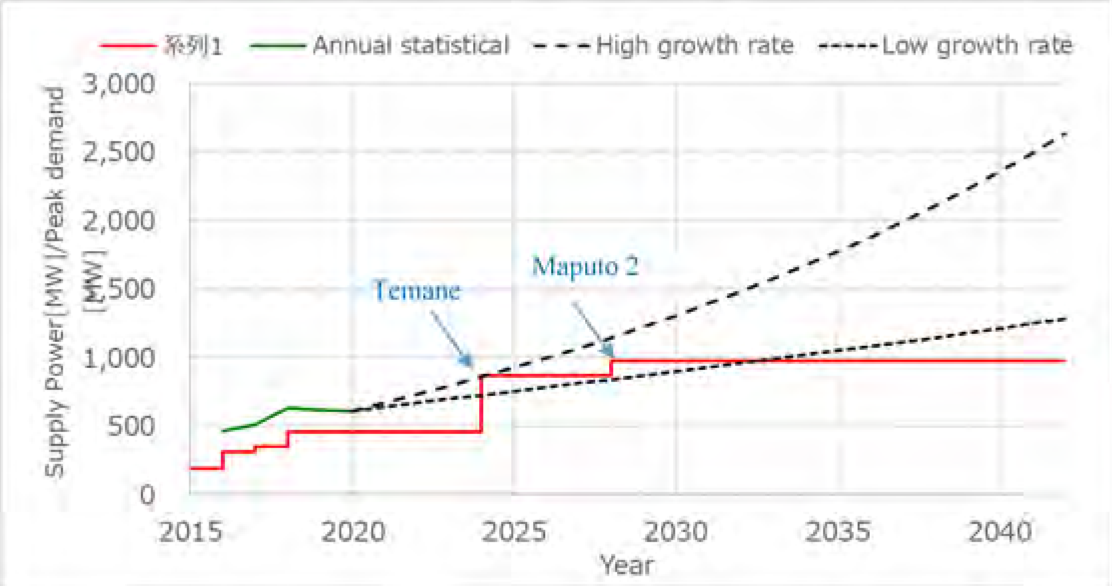
In Maputo, the Maputo Thermal Power Plant (106 MW, gas-fired combined cycle power plant), which was constructed by a consortium of Japanese companies with Japanese yen loans, started operation in 2018 and is meeting the demand in the southern region as a new homegrown power source in a country that is dependent on imported electricity. Recognizing the continued importance of securing power sources in the southern grid, the study team interviewed EDM regarding the construction of a gas-fired power plant (Maputo 2) of similar capacity on a site adjacent to the power plant as part of further power source development in the future. From EDM, "This is a very important project that will improve the stable electricity supply to the southern region. The ongoing electrification project (Energy 4-all - PROENERGIA) connects a large number of new customers per year, and the demand in the southern region is expected to increase in the future due to industrialization processes, agriculture, and tourism activities. Sufficient energy will be available to cover the projected demand. This is a strategic project and could be implemented in the next few years."

More background on the need for Maputo2 as indicated by EDM includes the following current situation.

- The shift to IPPs to meet energy shortages has raised supply costs and has had a negative impact on EDM's financial situation in recent years. As a countermeasure to this problem, it is expected that increasing the amount of electricity generated and exported after meeting the domestic demand for electricity, by constructing more large-scale power sources which use natural gas from the country's own resources will reduce the financial burden.

- Currently, there is a high pressure on coal-based power generation due to the decarbonization movement. In the transitional period until the enhancement of renewable energy is assured, the use of power generation using natural gas with relatively low CO_2 emissions is a realistic measure for Mozambique, which has abundant natural gas resources.

Based on the EDM comments, Figure 7.1-1 shows a hypothetical scenario in which Maputo 2 (106 MW) is commissioned in 2028 after a feasibility study, financing process, bidding, contract negotiations, contract and construction period (30 months). The analysis results show that, under the high demand growth rate, there will be a shortfall of approximately 170 MW of electricity supply capacity even in 2028, when the plant is put into operation.



Source: JICA Study Team

Figure 7.1-1 Supply capacity and electricity demand forecast for the southern region when Maputo 2 is included

Regarding the Limpopo River Basin hydropower (Massingir 18 MW and/or Mapai Hydro Power Plant 75 MW), another candidate for development, it is highly unlikely that the development will be completed within the next few years, as hydropower plants generally take a long time to build. However, even assuming that the plant will start operation in 2028, the same year as Maputo 2, and will generate a total of 93 MW, the power supply is expected to fall short by about 80 MW in the same year. Therefore, the validity of Maputo 2 is confirmed from a supply and demand perspective.

The proposal to build the next unit adjacent to the existing power plant will have the following advantages.

/ The site is in the suburbs of Maputo, the capital of Mozambique, and is close to demand areas.

/ The site necessary for the expansion of Unit 2 has already been secured on the site.

/ The site is located near the capital city of Maputo and is close to the demand area.

/ Gas receiving facilities and power transmission and substation facilities can be shared with the existing power plant (capacity needs to be considered).

/ The city water supply pipes are adjacent to the power plant (the amount of water needs to be confirmed).

/ If the GT is the same type as the existing power plant, spare parts can be shared.

/ The site of the power plant is large enough for easy installation of materials storage and accommodation facilities for contractors.

/ The plant is adjacent to South Africa, making it easy to procure necessary equipment and materials.

/ There are port facilities nearby, making it possible to unload large equipment.

In order to proceed with the development of Maputo 2, it is necessary to confirm whether the required amount of gas supply can be secured.

In addition, it is necessary to consider whether it is possible to connect the transmission lines to the existing system, and whether it is necessary to include the expansion of transmission facilities in the plan.

As for the securing of water for cooling, there should be no problem by planning equipment that conserves water resources as much as possible, such as adopting an air cooling system for the condenser and lubricating oil cooler and a circulation system for the cooling water system. However, since water for the boiler will also be required, it is important to confirm that the necessary amount of water supply can be secured. To give a concrete example, during the construction of the existing plant, restrictions on water intake were imposed even in Maputo due to the lowering of the dam's water storage capacity, and the supply to the site was often interrupted due to this. Therefore, in order not to affect the construction and commissioning schedule, water was purchased from external sources to cover the shortage during the period when the required amount of water could not be secured. In order to solve this problem and ensure stable operation of the plant in the future, a water treatment facility using groundwater as the water source was installed. Based on this experience, when constructing new power sources in the future, careful consideration should be given to securing the necessary amount of water, including during emergencies.

Appendix-I shows the outline of the proposed project envisioned by Study Team.

Mozambique has developed an Electricity Master Plan (2018) that was reviewed using data as of 2015. However, at present, the power demand growth is slowing down, and the transmission system structure, including the large Temane power plant and the new 400kV long-distance transmission line, as well as the dispatch and distribution facility plans, have changed significantly. In particular, the Temane power plant is expected to be the first power plant to be constructed in the southern region. In particular, the Temane power plant is planned to be connected to the outskirts of Maputo by a long-distance single line transmission line, which will transport about 400 MW of electricity at the time of maximum demand in 2025. In general, power systems with large-capacity long-distance transmission lines may have problems with transient stability of the power system, and the failure of these lines may cause large-scale blackouts. Possible measures to solve these problems include developing power plants near demand areas, increasing the number of generators, increasing the number of transmission lines, and planning measures to deal with transmission line failures. The study team believe that such considerations need to be fully explored in the Second Electricity Master Plan and other documents.

7.2 Power Transmission

In this report, Study Team discussed the transmission and substation facility plan as of 2025 in the southern region (see Chapter 5). If the development is completed as planned as of 2025, the next stage will require cooperation with adjacent regions.

In this section, among the projects listed in chapter 5 that are planned for 2025 and beyond, the two projects, Limporo River Basin transmission line development and Vilanculos~Massinga transmission line project, which are expected to be relatively large in scale and important for long-distance transmission lines that will be connected to other provinces in the system, are the two projects that may be eligible for assistance in the future. Limmporo River basin power development project will require expansion and new construction of backbone substations.

When new power sources are installed in the southern area in the future, it will be necessary to reinforce the existing transmission lines. There is a method of reinforcing the existing transmission lines by replacing only the electric wires without rebuilding the existing towers, and this method can shorten the construction period and reduce the construction cost. In this method, the construction period can be shortened and the construction cost can be reduced. In addition, by using a wire that increases the power transmission capacity by raising the temperature of the wire, it may be possible to carry out the power line replacement work without reinforcing the existing tower.

7.3 Power Distribution

The following two projects are considered to be prioritized in the power distribution.

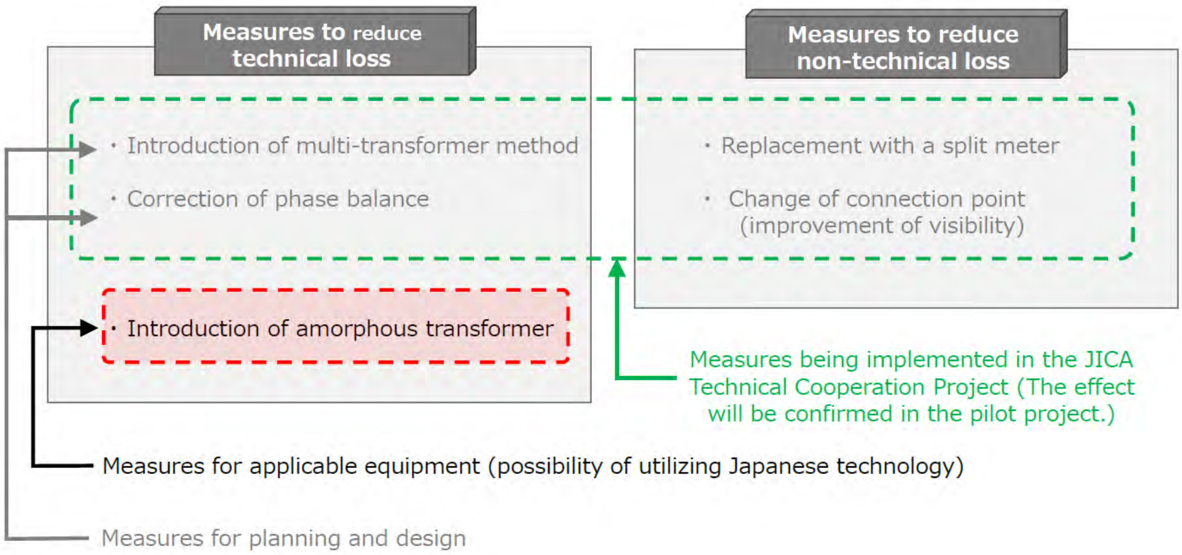
- Reduction of power distribution losses (In addition to the results of the JICA technical cooperation project currently underway, measures to reduce power distribution losses by introducing amorphous transformers should be deployed in a model area set up in Maputo City.)
- Improvement of safety and productivity in power distribution construction (introduction of vehicles for distribution work)

The reasons why these are considered "priority" are described below.

(1) Reasons why reducing power distribution losses is prioritized

- Reducing power loss has the same effect as building a new power plant to increase supply capacity.
- Reduction of power loss is one of the items highlighted in EDM's "Activity Plan and Budget 2021" and is a current management issue for EDM.
- In the list of high-priority projects planned for 2021-2030 obtained from EDM System Planning Department (17 projects in the power distribution sector), the content is common to all projects.
- JICA is currently implementing a JICA technical cooperation project (Distribution Loss Improvement Project) focusing on loss reduction, and the content of the project will be established in EDM in the future, which is expected to promote the project smoothly.

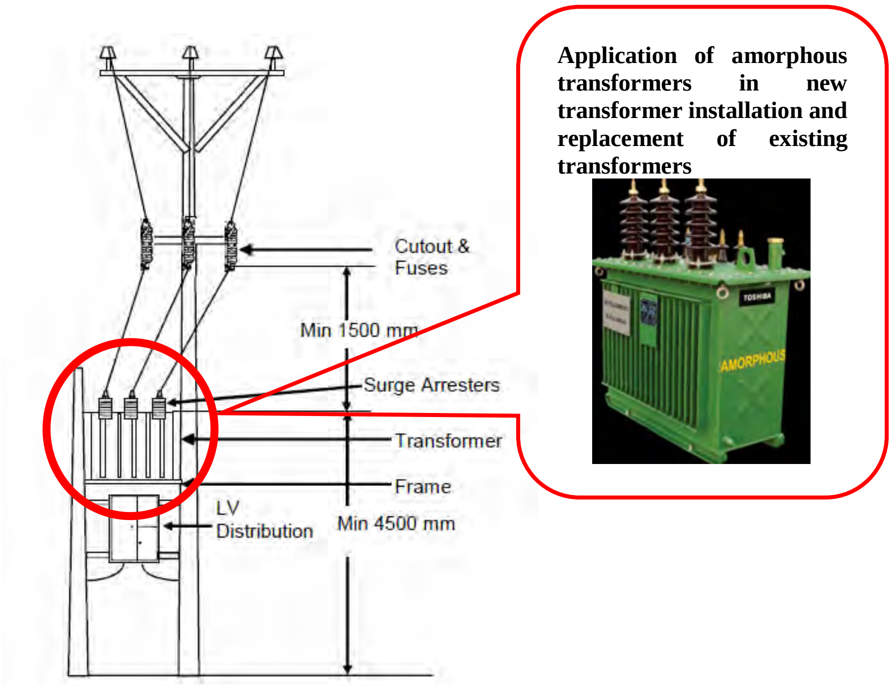
In line with the above, as a measure to utilize Japanese technology, which will be discussed later in Chapter 8, amorphous transformers are added as a "Measure of applicable equipment" as shown in Figure 7.2-2. It is expected that a significant loss reduction effect will be achieved by focusing on a certain area in Maputo city.



Source: JICA Study Team

Figure 7.2-1 Possibility of JICA's Cooperation (Adding Amorphous Transformers to the Measures of Current JICA Technical Cooperation Project)

For reference, an image of a 33/0.4kV pole mounted transformer installation is shown in Figure 7.2-3.



Source: EDM Material

Figure 7.2-2 Installation Image of 33/0.4kv Pole Mounted Transformer

(2) Reasons why improving safety and productivity in distribution construction (introduction of vehicles for power distribution work) is prioritized.

- In EDM's "Activity Plan and Budget 2021", "zero accident" is one of the highlighted items, and it has become EDM's current management issue.
- According to EDM's Business Plan 2020-2024, there are a significant number of large vehicles in poor condition.
- No major changes are expected in the status of vehicles for distribution work since the implementation of JICA's "Preparatory Survey for the Project to Strengthen the Power Transmission and Distribution Network in the Nacala Corridor, Mozambique" in 2014 (the number of vehicles deployed is not sufficient).
- According to the experience of Japanese electric power companies, the introduction of vehicles for distribution work contributes greatly to the improvement of safety and productivity during construction and maintenance work.

As a first step to realize safety and productivity improvement in distribution line construction, which will be increasingly increased with the future increase in demand for electric power, JICA Study Team believes that the introduction of vehicles for distribution work with high functionality that reflects the experience and know-how of Japanese electric power companies and distribution work contractors will be very effective.

One possible scheme is to use (1) as a main project, and to introduce vehicles of (2) when constructing the distribution facilities in the project of (1).

7.4 Other Donors' Trends

As one of the ways to learn about the current trends of other donors, Study Team interviewed a representative of AfDB.

AfDB's assistance to Mozambique is aimed at addressing the country's overarching development challenges of widespread poverty and inequality, and creating the necessary jobs to reduce them effectively and sustainably.

Though their main focus is on the agriculture and construction sectors, they also cite motivating the private sector through investments in energy and transportation infrastructure as one of the areas they support.

Poverty is a more serious issue in the northern part of the country, and the AfDB's support is currently focused on the northern region.

The above is the information we got from AfDB. Other recent developments in other donor cooperation include off-grid electrification by the World Bank, strengthening of EDM's operational capacity, enhancement of power distribution network, construction of solar power plants by Norway, and implementation of F/S for power grid development.[1]

In this study, we attempted to collect and organize information on the current EDM development plans and narrow down the list to those with the highest feasibility in order to draw up concrete scenarios for the future. However, since the current progress status of the prioritized development plans varies, study team was not able to systematically organize the information in the limited survey period. Our future task is to obtain more detailed and accurate information on the development plans, such as whether they are still under discussion on the table, whether negotiations with investors have started, and whether some of the projects are expected to be feasible.

[1] FY2020 Ministry of Foreign Affairs of Japan ODA Evaluation "Evaluation of Grant Aid Individual Projects (Economic and Social Development Plan for Mozambique)" (2021)

As mentioned above, Mozambique as a whole is facing urgent issues of poverty and access to electricity, and therefore, the AfDB, the World Bank, and donors (Norway, Sweden, etc.) tend to focus their aid on the northern areas of the country.

On the other hand, the southern area of the country, which appears to be relatively well developed in terms of industry, is still remain a room for development. It is essential to solve the issue of getting rid of the current dependence on imported electricity and construct a stable power system in parallel with the development of the rural areas.

Chapter 8
Possibility of using Japanese technology

Chapter 8 Possibility of using Japanese Technology

Regarding the possibility of using Japanese technologies, we discussed the Japanese technologies that could be used to address the issues faced by EDM. If there were any points to be noted or conditions to be met when using Japanese technology, Study Team clarified them and proposed the possibility of application.

8.1 Power Generation

EDM Issues : Development of power sources close to demand area (near Maputo), and development of original, cost effective power sources that effectively use natural gas from Mozambique.

Technology: Combined cycle power generation

Japan's advantage: Mozambique's first combined-cycle power generation plant, manufactured in Japan, is highly competitive. High reliability.

Note: Efficiency can be improved by sharing spare parts with the existing plant. In this regard, Japanese manufacturers have an advantage.

Source: Manufacturer's data

Figure 8.1-1 Maputo combined cycle power plant

8.2 Transmission

EDM issues: To reduce power loss by 31%, power transmission loss is reduced by increasing the voltage of power transmission facilities and increasing the size of power lines.

Technology: Gap conductor : When replacing power lines

Low-loss conductor (LL conductor): When installing new transmission lines

Japan's advantage: Japanese manufacturers have a large number of export achievements.

Note: It will be difficult to secure superiority over manufacturers from other countries if conditions such as manufacturing experience and delivery record are not set at the time of procurement.

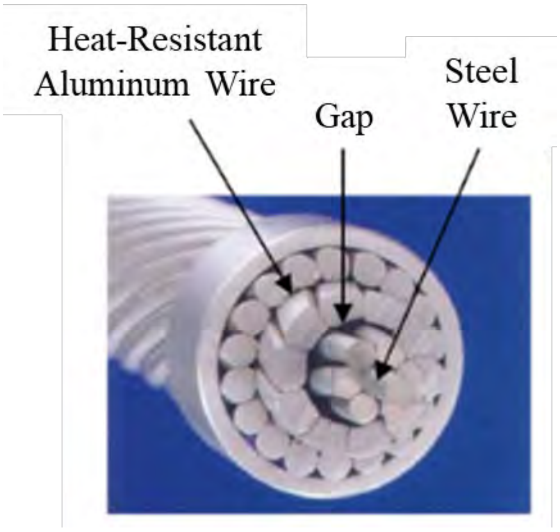


Figure 8.2-1 Gap conductor

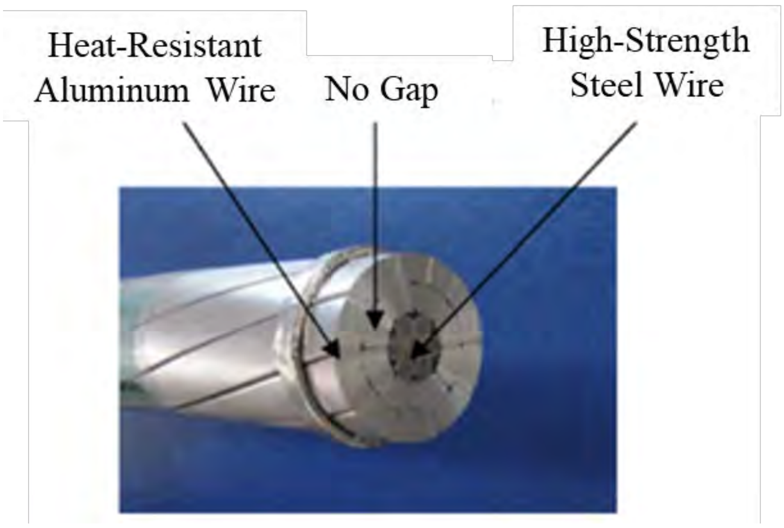


Figure 8.2-2 Low-loss conductor

8.3 Power Transformation

EDM issues: Availability of substation sites in urban areas (smaller substation sites)

Technology: Outdoor GIS Equipment

Japan’s advantage: Gas leak rate conditions.

Note: There must be a rational reason for using outdoor GIS equipment (expansion in narrow existing outdoor substations, prevention of salt damage along the coast, etc.).

EDM issue: Emergency response to planned new substation construction

Technology: Mobile Substation

Japan’s advantage： Japan has a track record of introducing this technology in Mozambique.
High reliability.

Note: Mobile substations made in other countries are also used in Mozambique. It is necessary to compare the maintainability and failure rate of the equipment.

Source: Manufacturer's data

Figure 8.3-1 Mobile substations

8.4 Power Distribution

(1) Amorphous transformer

・EDM issue: The power distribution loss ratio in recent years has been over 30%, and has remained at a fairly high level in recent years. From the perspective of the future low-carbon society, reducing the loss ratio is one of the most important management issues that EDM is currently facing.

・Technology: Amorphous transformer (iron loss is about 1/3 of that of conventional silicon steel plate transformers)

・Japan's advantage: Japan has price competitiveness based on loss optimal design, and has a large number of exports to Africa and other countries. The factory is located overseas, but the main materials are made in Japan in consideration of quality and cost, and the company maintains its superiority through design and quality control measures.

・Note: There are manufacturers of amorphous transformers in other countries, but they are often inferior to Japanese products in terms of quality. It is necessary to set conditions in terms of manufacturing experience and technology when bidding. In addition, when adopting this transformer, the size and weight are generally a little larger than those of conventional silicon steel plate transformers, so a feasibility study should be conducted to ensure the introduction of this transformer, referring to current EDM distribution standards for transformer design and construction. In addition, since the price is generally slightly higher, it is necessary to conduct a comprehensive review and discussion with EDM, including target loss value.

Figure 8.4-1 Appearance of an amorphous transformer

(2) Vehicle for distribution work (Insulated bucket truck)

・EDM issue: In addition to the fact that there are a considerable number of vehicles in poor condition, that the number of vehicles used for work at height for power distribution is insufficient, and that fall accidents have occurred during work at height, it is necessary to improve safety and productivity in the increasing number of power distribution line works.

・Technology: Vehicle for distribution work (Insulated bucket truck)

・Japan’s advantage: Japanese power companies and distribution work contractors have an advantage in operational performance and safety design, reflecting their experience and know-how.

・Note: Since copies of Japanese products are available in other countries, it is necessary to set conditions such as years of manufacturing experience at the time of procurement. In addition, since Japanese products have many functions to improve safety and productivity, it is necessary to provide sufficient training to users (EDM) prior to the introduction, as well as to establish methods for maintenance, and for responding to any malfunctions or problems that may occur.




Source: Manufacturer's material

Figure 8.4-2 Comparison of the appearance of a vehicle for distribution work (Top: EDM's current vehicle, Bottom: Japanese product)

Appendix-1: Maputo 2

The project outline, project cost estimation of Maputo 2, which is the successor project to the "Maputo Gas Combined Cycle Power Plant Project (Maputo 1)" funded by JICA ODA Load, were presented.

1. Project Outline

Project Outline is as follows:

Name: Maputo 2 Thermal Power Plant

Location CTM (Blue frame is existing area (Maputo 1), red frame is additional area (Maputo 2)

Configuration: 2-2-1, two sets of Gas Turbine/ Generator (GT/G) 40MW, two sets of dual pressure HRSG's one Stem Turbine (ST/G) 26MW

Substation: 66kV Isolated Air Substations

Fuel: Natural Gas

Fuel Source: Temane (Inhambane Province)

Capacity: 106Mw at ambient temp.28 ℃

Net Efficiency: 50.2%

2. Project Cost (For Reference Only)

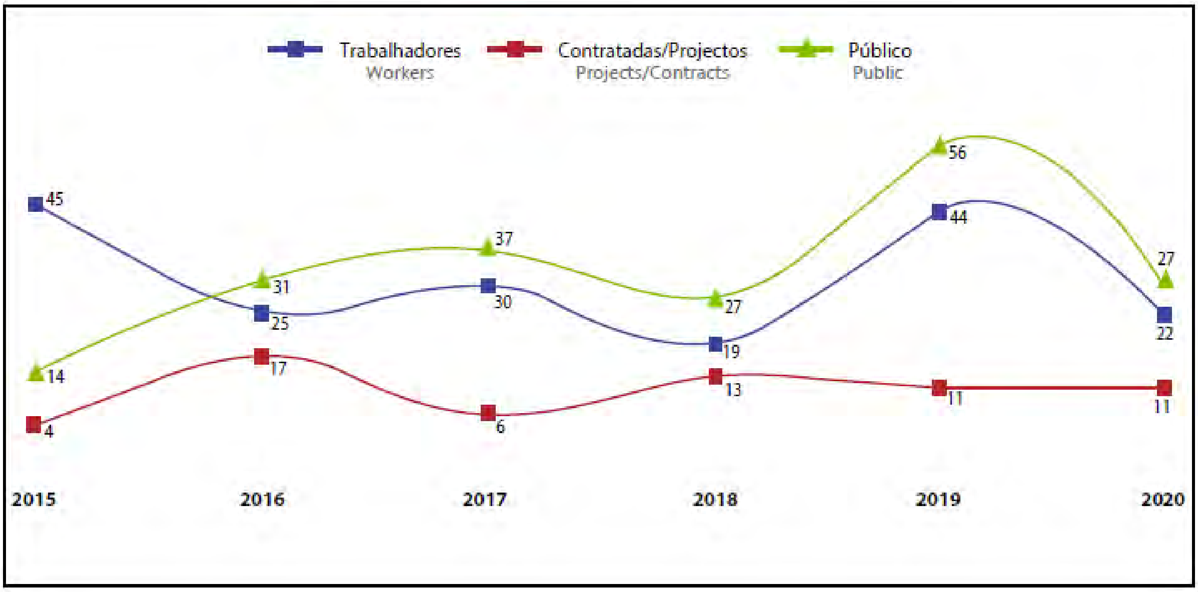
The project cost estimate is summarized in the following table.

Finance Portion	Cost (Million USD)
Power plant construction and associated works (EPC cost)	137,100
LTSA, training and spare parts	27,600
Consulting services	11,300
Contingency	5,300
Total of Finance Portion	181,300
Non Eligible Portion (site preparation, administration cost and tax)	10,600
TOTAL	**191,900**

NOTE: EPC Cost, LTSA, and Consultant services were estimated based on actual contract basis. And Non Eligible Portion referred to the cost of the stage of JICA Feasibility Study.

Appendix-2: Work safety for power distribution equipment

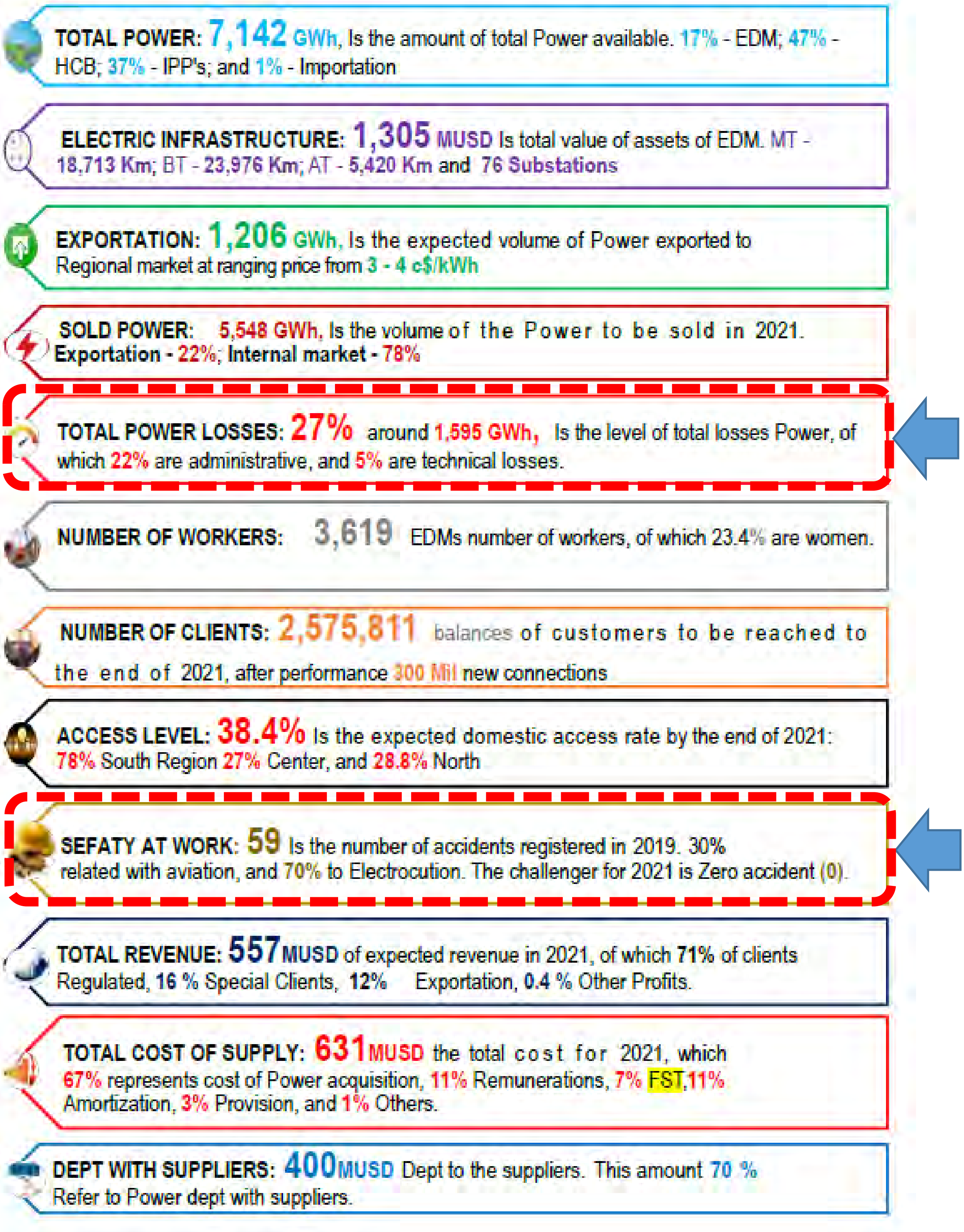
Turning to the safety aspect of EDM (the number of accidents), as a resource for the study of the potential use of Japanese technology described below, Figure 6.2-14 shows that there are about 30 to 50 accidents involving employees and contracted construction companies every year.



: EDM Annual Stastical Report

Figure 6.2-14 Number of Accidents in EDM

In response to the above situation, EDM is working to reduce the number of accidents to zero in 2021 as one of the highlights of EDM's action plan (Figure 6.2-15).



Source：EDM Activity Plan and Budget 2021

Figure 6.2-15　Key items in the EDM Activity Plan

Since the above data is for EDM as a whole and not only for the power distribution division, the following is a summary of the information and opinions obtained during the previous survey on the needs for vehicles for distribution work at a power distribution maintenance center of EDM Nacala branch in the northern part of the country and at EDM head office.

- JICA Study Team visited the distribution maintenance center of the Nacala branch office to check the vehicles used for construction and maintenance of distribution lines, and according to EDM, they usually use trucks with cranes (Figure 6.2-16). The truck's crane can be equipped with three types of equipment: bucket, auger, and pole lifter, depending on the purpose of the work (Figure 6.2-17).
- As described above, the EDM has vehicles with some function, but because it is a shared type, the functions related to each construction are extremely limited. This may not be a problem when the amount of construction work is small and a reasonable amount of time is required for each work, but in order to carry out a large amount of power distribution line construction work without delay in response to the steady increase in power demand, it is essential to improve the productivity of construction work. For this purpose, the use of high-performance vehicles dedicated to distribution line work is an effective measure based on the past experience of Japanese electric power companies.

Source: [Left] EDM, [Right] JICA Study Team

Figure 6.2-16 EDM's power distribution work (left) and truck for distribution work (right)


Source: JICA Study Team

Figure 6.2-17 Bucket (left) and auger (right) to be installed on EDM's truck with crane

- The EDM Nacala branch has a large area under its jurisdiction, but it has only one truck with a crane (same as other branches). This truck with a crane is necessary for transporting heavy items such as transformers and poles, as well as for installing buckets and augers for work at high elevations, but the number of trucks is not sufficient.
- When the above truck (bucket for working at height) is not available, the worker uses a pole lifter (indicated by the yellow circle in the figure below) or a ladder, as shown in Figure 6.2-18. The EDM power distribution department considers work safety as a top priority, and the number of fall accidents related to working at height in the power distribution department (11 in 2013) can be reduced if the number of construction vehicles is increased. Table 6.2-2 shows the status of accidents related to work at height in EDM power distribution division in 2013.

Source: EDM material

Figure 6.2-18 EDM power distribution workers working on a utility pole

Table 6.2-2 Status of accidents related to work at height in the power distribution sector (2013)

Cause of accident	Nakara Branch Office	Overall distribution sector
Falling from a rotten wooden pole	0	2
Fall during logging operation	0	2
Falling from a ladder	1	7
Total	1	11

Source: Compiled by JICA Study Team from EDM materials

It is unlikely that the safety and accident situations in power distribution work have changed significantly, and the effectiveness of vehicles for distribution work in improving safety and productivity is likely to be the same as it was at the time of the Nacala branch office survey.

Table 6.2-3 shows statistical data on accidents that occurred in southern Mozambique between 2018 and 2021.

Table 6.2-3 Statistics on accidents that occurred in the Southern Region

ACCIDENT STATUS of SOUTHERN REGION of MOZAMBIQUE															
Ano	Afectados	DTSU	Custormer Services Areas												
			Chókwé	Xai- Xai	Inhambane	Vilanculo	Ka Mubucuana	Ka Mavota	Ka Maxaquene	Ka Nfhumo	Ka Guava	Matola	Infulene	Boane	Machava
2018	Workers		1				1	1	1						
	Sub Contractor														
	Public	1	1	1			1					1			2
2019	Workers	1					2			1	2		1	1	1
	Sub Contractor		1									1	1		
	Public	1	1		1										1
2020	Workers	1	1				1				1	1	1	2	1
	Sub Contractor		1										2	1	1
	Public	1			1							1	3	1	
2021	Workers	1	6	2	1	1	2			1	1		2	1	2
	Sub Contractor			1	1								1		
	Public	1	1	1			1	1		2	1		3	2	2

Source: EDM material